



# Transforaminal endoscopic lumbar discectomy: learning curve of a single surgeon

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**Background:** Transforaminal endoscopic lumbar discectomy (TELD) has well-recognized advantages and disadvantages in the literature. Some of the mentioned disadvantages are insufficient discectomy, higher recurrence rate and long learning curve (LC). The objective of this study is to describe the LC and analyze the survival rate of patients operated through TELD.

**Methods:** Retrospective study of 41 cases operated through TELD by the same surgeon from June 2013 to January 2020, with a minimum follow-up of 6 months. Demographic data and information on operative time (OT), complications, hospital stay, hernia recurrence and reoperations were collected. LC of the TELD was analyzed using a cumulative sum (CUSUM) test for parameter stability for linear regression coefficients, using the CUSUM from recursive residuals.

**Results:** Thirty-nine patients, 24 men (61.54%) and 15 women (38.46%), were included in the present cohort, and a total of 41 TELD were performed. The average OT was 96 minutes (SD =30) and the CUSUM of the recursive residuals shows learning of the TELD in the case 20. The mean OT in the first 20 cases was 114 minutes (SD =30) versus 80 minutes (SD =17) in the last 21 cases ( $P=0.0001$ ). The rates of recurrent Dh were 17%, and 12% need reoperation.

**Conclusions:** We consider that the LC of TELD requires operating 20 cases to perform the procedure with a significant reduction in OT, with minimal rates of reoperation and complications.

**Keywords:** Transforaminal endoscopic lumbar discectomy (TELD); learning curve (LC); operative time (OT); disc herniation (Dh)

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## Introduction

Disc herniation (Dh) is a common cause of back pain and leg pain (1). In the presence of a neurological deficit or failure of conservative treatment (2), the indication for surgery takes on greater value.

In 1934, Mixter and Barr were the first to treat Dh surgically by performing a laminectomy and an open discectomy (3), a procedure that, with the introduction of the microscope, was redefined as microdiscectomy (Md) (4). In 1988, Kambin reported the first endoscopic intraoperative visualization of a Dh (5). Due to technological advances (different angle lenses and working channels for different instruments), the procedure became more refined and, in 1997, the first endoscopic discectomy was described (6).

Although Md is considered the gold standard for the surgical treatment of lumbar Dh (1), Transforaminal Endoscopic Lumbar Discectomy (TELD) has become popular among spine surgeons in recent years.

Less soft tissue trauma, with consequent less intraoperative blood loss; less postoperative pain; and shorter surgical times (ST), and the association of this with a reduction in hospital stay and faster functional recovery with earlier return to work activity (7,8), are some of the benefits mentioned of TELD. Among the described potential disadvantages are insufficient discectomy, a higher recurrence rate, a long learning curve (LC) (9) and a greater exposure to radiation (10).

The aim of our study is to determine the LC in TELD performed by a single surgeon. We present this article in accordance with the STROBE reporting checklist (available

at <https://jss.amegroups.com/article/view/10.21037/jss-22-54/rc>).

## Methods

### *Patient population*

The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Institutional ethics board of Clínica Universidad de los Andes (No. CUA2020-12) and individual consent for this retrospective analysis was waived. Retrospective review of 41 cases operated through TELD by the same spine surgeon due to primary or recurrent lumbar Dh, between June 2013 and January 2020. Patients older than 18 years of age were included, with a minimum follow-up of 6 months. Patients with moderate or severe scoliosis, central spinal stenosis, segmental instability, and involvement of more than two levels were excluded.

### *Surgical technique*

TELD was performed in a standard manner/as a standard procedure, under sedation and local anesthesia. Guided through fluoroscopy, in a transforaminal direction, a spinal needle (18G) was positioned until reaching the retrodiscal space, through Kambin's triangle, without exceeding the medial limit of the ipsilateral pedicle. Subsequently, a guide wire was placed inside the spinal needle, and after making a 7–10 mm skin incision, a working channel was prepared by means of progressive dilation, until a working cannula with a beveled end was placed. Optionally, a foraminotomy was performed in some patients using manual trephines to facilitate the placement of the working cannula. Through a working cannula and under direct vision of the endoscope with a 35° angle lens, the herniated disc material was resected using endoscopic forceps until verifying the adequate decompression of both the emerging and the descending roots of the level operated.

### *Data collection*

The clinical records of each of the patients who met the inclusion criteria were reviewed from the database of the spine team at Hospital del Trabajador and Clínica Universidad de los Andes, and the following data was collected: sex, age, comorbidities, tobacco use, presence

### Highlight box

#### Key findings

- We believe that an adequate learning curve for TELD is reached after 20 cases.

#### What is known and what is new?

- TELD is an effective treatment for the management of herniated discs, however it is technically demanding, presenting a long learning curve.
- After the first 20 cases, a significant reduction in operative time is achieved, with minimal rates of reoperation and complications.

#### What is the implication, and what should change now?

- We recommend to first start the learning curve of TELD in soft, foraminal hernias located in L4-L5 or proximal segments.

**Table 1** Demographic, clinical and imaging variables

| Variables                       | Data          |
|---------------------------------|---------------|
| Age (years), mean (SD)          | 50.10 (15.58) |
| Sex, n (%)                      |               |
| Female                          | 15 (38.46)    |
| Male                            | 24 (61.54)    |
| Comorbidities, n (%)            |               |
| No comorbidities                | 22 (56.41)    |
| Hypertension                    | 2 (5.13)      |
| Hypothyroidism                  | 2 (5.13)      |
| Hypertension and diabetes       | 3 (7.69)      |
| Hypertension and hypothyroidism | 2 (5.13)      |
| Other comorbidities             | 8 (20.51)     |
| Smoking, n (%)                  |               |
| No                              | 28 (71.79)    |
| Yes                             | 11 (28.21)    |
| Symptoms, n (%)                 |               |
| Sciatica                        | 25 (60.98)    |
| Cruralgia                       | 16 (39.02)    |
| Level, n (%)                    |               |
| L1-L2                           | 1 (2.44)      |
| L2-L3                           | 3 (7.32)      |
| L3-L4                           | 9 (21.95)     |
| L4-L5                           | 17 (41.46)    |
| L5-S1                           | 11 (26.83)    |
| Location, n (%)                 |               |
| Central                         | 1 (2.44)      |
| Lateral recess                  | 17 (41.46)    |
| Foraminal                       | 17 (41.46)    |
| Extraforaminal                  | 1 (2.44)      |
| Lateral and foraminal recess    | 1 (2.44)      |
| Foraminal and extraforaminal    | 4 (9.76)      |
| Laterality, n (%)               |               |
| Left                            | 26 (63.41)    |
| Right                           | 15 (36.59)    |
| Hd episode, n (%)               |               |
| First episode                   | 30 (73.17)    |
| First recurrence                | 9 (21.95)     |
| Second recurrence               | 2 (4.88)      |
| Surgical time (min), mean (SD)  | 96 (29.85)    |

of sciatica or cruralgia, first episode of Dh or recurrence, pathological correlation (location, level, and laterality of Dh) according to lumbar magnetic resonance imaging (MRI), OT and days of hospitalization.

### Statistical analysis

Demographic variables were summarized. A simple linear regression was performed between the OT and the number of operated cases, evaluating their association. The LC of the TELD was analyzed using a CUSUM test for parameter stability for linear regression coefficients, using the CUSUM from recursive residuals introduced in Brown, Durbin and Evans [1975] (11). Continuous and normally distributed variables were compared with the Student's *t*-test and for the dichotomous variables, Fisher exact test was used.

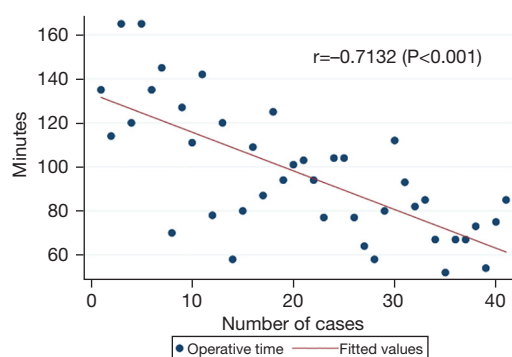
The frequency of both intraoperative and postoperative complications was evaluated.

All the analysis was conducted using Stata 15 (StataCorp LLC, College Station, TX, USA).

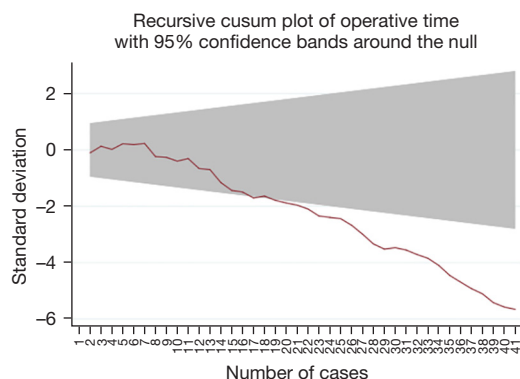
### Results

Thirty-nine patients, 24 men (61.54%) and 15 women (38.46%), were included in the present cohort. A total of 41 TELD were performed (two subjects were operated in two different occasions, due to a new Dh developed at a different level, which is why they were considered as different cases). The mean follow-up period was 44 months, ranging from 6.6 to 85.6 months. The mean age was 50.1 (SD =15.6) years at the time of the intervention. More than half of the sample (22 patients) did not present morbid history, 2 (5.1%) reported being hypertensive, 2 (5.1%) were hypothyroid and 13 (33.3%) indicated a combination of these or other conditions (benign prostatic hyperplasia, depression, hepatitis, etc.). Only 11 individuals (28.2%) were tobacco users, however, only one of them indicated smoking 20 cigarettes a day, while the rest did not exceed 5 cigarettes a day (*Table 1*).

While 73.17% (n=30) of the cases corresponded to the first episode, 26.83% (n=11) were recurrences. The segment most frequently affected was the L4-L5 in 41.46% of the cases, followed by the L5-S1 level in 26.83%. The location of the Dh was mainly at the lateral and foraminal recess, representing 41.46% in both cases, which reflected symptoms of sciatica in 60.98% (n=25) and cruralgia in 39% (n=16) of the sample.



**Figure 1** Surgical time graph. Linear reduction in time related to the increase in the number of surgeries performed.



**Figure 2** Recursive CUSUM plot of operative time shows that the plot of the recursive cusum process crosses the 95% confidence bands in the 20<sup>th</sup> case, which means that the learning of the TELD has been reached. TELD, transforaminal endoscopic lumbar discectomy.

The OT showed a linear regression in relation to the increase in cases (*Figure 1*) reaching an average of 96 minutes (SD =29.85) and the CUSUM of the recursive residuals shows learning of the TELD in the case 20, as shows the CUSUM plot with the 95% confidence bands (*Figure 2*). When distinguishing between the first 20 cases and the last 21, the OT was 114 minutes (SD =30) and 80 minutes (SD =17), respectively, showing a statistically significant decrease ( $P<0.001$ ) in these last 21 cases. Moreover, the operated level shows a statically significant difference ( $P=0.035$ ), revealing that the most operated levels for the first 20 cases were L4-L5 and L5-S1, and for the last 21 cases were L3-L4 and L4-L5. The recurrent Dh rates were 17%, and 12% required reoperation. It is worth mentioning that the last recurrence occurred in the

**Table 2** Comparison between the first 20 TELD versus the last 21

| Variables                          | First 20      | Last 21         | P value |
|------------------------------------|---------------|-----------------|---------|
| Age (years), mean $\pm$ SD         | 46.5 $\pm$ 17 | 53.9 $\pm$ 13.2 | 0.14    |
| Sex, n [%]                         |               |                 | 0.33    |
| Female                             | 6 [30]        | 9 [47]          |         |
| Male                               | 14 [70]       | 10 [53]         |         |
| Smoking—yes, n [%]                 | 8 [40]        | 3 [16]          | 0.15    |
| Symptoms, n [%]                    |               |                 | 0.20    |
| Sciatica                           | 14 [70]       | 9 [47]          |         |
| Cruralgia                          | 6 [30]        | 10 [53]         |         |
| Level, n [%]                       |               |                 | 0.035   |
| L1-L2                              | 0 [0]         | 1 [5]           |         |
| L2-L3                              | 0 [0]         | 3 [14]          |         |
| L3-L4                              | 3 [15]        | 6 [29]          |         |
| L4-L5                              | 8 [40]        | 9 [43]          |         |
| L5-S1                              | 9 [45]        | 2 [9]           |         |
| Location, n [%]                    |               |                 | 0.63    |
| Central                            | 0 [0]         | 1 [5]           |         |
| Lateral recess                     | 10 [50]       | 7 [33]          |         |
| Foraminal                          | 7 [35]        | 10 [48]         |         |
| Extraforaminal                     | 0 [0]         | 1 [5]           |         |
| Lateral and foraminal recess       | 1 [5]         | 0 [0]           |         |
| Foraminal and extraforaminal       | 2 [10]        | 2 [9]           |         |
| Laterality, n [%]                  |               |                 | 0.11    |
| Left                               | 10 [50]       | 16 [76]         |         |
| Right                              | 10 [50]       | 5 [24]          |         |
| Dh episode, n [%]                  |               |                 | 0.86    |
| First episode                      | 14 [70]       | 16 [76]         |         |
| First recurrence                   | 5 [25]        | 4 [19]          |         |
| Second recurrence                  | 1 [5]         | 1 [5]           |         |
| Post TELD recurrence, n [%]        | 5 [25]        | 2 [9]           | 0.24    |
| Reintervention, n [%]              | 3 [15]        | 2 [9]           | 0.66    |
| Surgical time (min), mean $\pm$ SD | 114 $\pm$ 30  | 80 $\pm$ 17     | 0.001   |

TELD, transforaminal endoscopic lumbar discectomy; SD, standard deviation.

23<sup>rd</sup> case, just after reaching the learning of the TELD. Only two postoperative radiculitis were recorded as a post-procedure complication. The rest of the variables are showed in *Table 2*.

## Discussion

The current trend towards minimally invasive approaches has made endoscopic procedures, such as TELD, very popular among spine surgeons, showing similar results to Md. Ruetten *et al.* (12), in their prospective and randomized study, concluded that although both techniques have comparable clinical results, Md was associated with a higher rate of minor complications, such as bleeding, delayed wound closure, superficial infection, and transitory urinary retention. Apart from that, they were able to demonstrate that the TELD showed a lower level of postoperative pain and a shorter work disability. A systematic review and meta-analysis carried out by Kamper *et al.* (13) established that there were no differences in clinical results between both techniques, neither in rates of reoperation nor in complications. On the contrary, another more recent meta-analysis showed a statistically significant benefit in the clinical results in favor of TELD, in addition to better OT and a shorter hospital stay (14).

Regarding cost-effectiveness, a clinical study reported higher costs for TELD compared to Md, but based its analysis only in direct medical costs, surgical instruments and reoperations (15). By analyzing the associated socioeconomic costs, such as missed working days, it was possible to determine that the cost-effectiveness of TELD compared to Md is similar (16) and even better after 1-year of follow-up (17).

The benefits mentioned can be explained by the surgical technique itself, which implies a smaller incision, less damage to the local muscles and less bleeding, which will lead to less post-operative pain and early rehabilitation and return to work (18,19).

By analyzing our series of cases, we were able to determine a LC like that reported by other authors. In the study by Lee *et al.*, it was reported that after operating on 17 patients, the OT, as well as complications and the recurrence rate, decreased significantly (20). Another study in which 60 cases operated through TELD were analyzed also concluded that among the first 10 to 20 patients, an adequate LC of the technique was achieved (21). On our part, when distinguishing between the first 20 and the last 21 operated patients, we could observe a statistically significant decrease in OT ( $P=0.0001$ ), and after the 23<sup>rd</sup> case we didn't observe a recurrent Dh. Regarding complications, these occurred in the 14<sup>th</sup> and 22<sup>nd</sup> cases, like that of other reports (22,23).

A proper selection of patients is crucial to avoid complications associated with LC. In our cases, there was

a statistically significant difference regarding the operated level ( $P=0.035$ ), and therefore, we recommend facilitating the development of this at an early stage, performing TELD in primarily soft foraminal hernias (24,25) located in L4-L5 or proximal segments, or in L5-S1 with iliac crests below the L5 pedicle (26,27), and in patients without advanced degenerative disease.

The limitations of our study reflect its retrospective nature, and the limited number of patients, approximately 6 or 7 per year, which could influence the LC, and the possibility that certain recurrences or complications have not been investigated, as this study was not carried out in a closed health system and patients may have consulted other clinical centers after the follow-up carried out.

## Conclusions

In this series, the LC of the TELD required to operate 20 cases to show a significant reduction in mean OT (from 114 to 80 minutes), with minimal rates of reoperation and complications, therefore, we believe that an adequate LC is achieved from the first 20 patients. The operational level must be considered, favoring LC for TELD at levels L4-L5 or higher.

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## Footnote

*Reporting Checklist:* The authors have completed the STROBE reporting checklist. Available at <https://jss.amegroups.com/article/view/10.21037/jss-22-54/rc>

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*Conflicts of Interest:* All authors have completed the ICMJE uniform disclosure form (available at <https://jss.amegroups.com/article/view/10.21037/jss-22-54/coif>). The authors have no conflicts of interest to declare.

*Ethical Statement:* The authors are accountable for all aspects of the work in ensuring that questions related

to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Institutional ethics board of Clinica Universidad de los Andes (No. CUA2020-12) and individual consent for this retrospective analysis was waived.

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