ORIGINAL ARTICLE

The Learning Curve of Minimally-Invasive Lumbar Microdiscectomy

Gregory S. McLoughlin, Daryl R. Fourney

ABSTRACT: ***Object:*** The safe integration into practice of a new surgical technique requires an appreciation of the learning curve. The object of this study was to assess the learning curve for minimally invasive microdiscectomy (MIM) utilizing a tubular retractor system. ***Methods:*** A prospective evaluation of a single surgeon's first 52 consecutive MIM cases for radiculopathy secondary to single-level posterolateral lumbar disc herniation was performed. The learning curve was assessed using operative time, conversion to open rate, complications, and length of hospitalization. ***Results:*** The duration of operative time decreased over the course of the study (range, 49-151 min). By case 15, operative time was typically 60 min or less. There was only one conversion to an open procedure (Case 2). Complications occurred in three cases. All but nine patients were discharged home on the day of surgery. ***Conclusion:*** The learning curve for MIM was demonstrated. Further assessment of this curve for a large group of surgeons is necessary before a randomized controlled trial comparing standard microdiscectomy to MIM can be conducted.

RÉSUMÉ: Courbe d'apprentissage de la microdiscectomie endoscopique. ***Objectif :*** L'intégration sûre d'une nouvelle technique chirurgicale dans la pratique courante repose sur une bonne estimation de la courbe d'apprentissage. Le but de cette étude était d'évaluer la courbe d'apprentissage de la microdiscectomie endoscopique (MCE) à l'aide d'un système tubulaire de rétraction. ***Méthodes :*** Il s'agit d'une évaluation prospective de 52 cas consécutifs de MCE exécutées par le même chirurgien pour radiculopathie secondaire à une hernie discale postérolatérale à un seul niveau. La courbe d'apprentissage a été évaluée en considérant le temps opératoire, le taux de recours à la chirurgie conventionnelle, les complications et la durée d'hospitalisation. ***Résultats :*** La durée du temps opératoire a diminué au cours de l'étude (plage de 49 à 151 minutes). À partir du 15e cas, le temps opératoire était habituellement de 60 minutes ou moins. On n'a eu recours à la chirurgie conventionnelle que chez un seul patient (le deuxième). Trois patients ont présenté des complications. Tous les patients sauf neuf sont retournés à domicile le jour même. ***Conclusion :*** Nous avons décrit la courbe d'apprentissage de la MCE. Il faut évaluer cette courbe chez un échantillon de grande taille avant de procéder à une étude contrôlée randomisée comparant la microdiscectomie standard à la MCE.

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Since the introduction of the tubular retraction system in 1997 by Foley and Smith,[1] interest in this minimally-invasive access technique for lumbar microdiscectomy has grown steadily. Proponents of minimally-invasive microdiscectomy (MIM) claim that the procedure results in less pain due to the muscle-splitting technique of the tubular retractors rather than the conventional sub-periostial muscle dissection.[2] Other advantages are reported to include earlier mobilization, reduced post-operative length of stay, and reduced intraoperative blood loss. Although well-controlled randomized trials are lacking, reported outcomes seem to be at least equivalent to those observed for the conventional open lumbar microdiscectomy technique.[3]

Learning the MIM technique poses several challenges. Proper placement of the tubular dilators, recognition of anatomical landmarks, and the use of instruments through the

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tubular retractors represent some of the challenges a surgeon must overcome.

Appreciation of the learning curve assists the surgeon wishing to safely integrate the technique into practice. The purpose of this study was to analyze and quantify the learning curve for MIM using a tubular retractor system.

Material and Methods

We prospectively evaluated a single surgeon's (D.R.F.) first 52 consecutive cases of MIM for symptomatic posterolateral lumbar disc herniation. The surgeon had several years experience with the open microdiscectomy technique prior to the study. All patients failed at least eight weeks of conservative therapy. Patients were provided with the option of undergoing the procedure using the conventional open technique or MIM. Informed consent for the procedure was obtained. Patients were excluded from the study if they presented with a far lateral disc herniation, multilevel disc herniation, cauda equina syndrome or for re-operation at the same level.

Data collected on each patient included demographic data, spinal level and location of disc herniation, length of hospitalization, intraoperative complications, conversion to open rate, and operative time.

Operative technique

For all cases, the primary surgeon of the study (D.R.F.) performed the procedure. Residents were available to assist. Intravenous cefazolin (or clindamycin in the setting of a penicillin allergy) was administered preoperatively to all patients. Following the administration of a general anesthetic, patients were placed in a kneeling position upon the Jackson table (OSI, Union City, CA). Neuromonitoring was not routinely used. Localization of the spinal level was performed using fluoroscopy. The skin was infiltrated with 0.5% sensorcaine and 1:100 000 epinephrine. Under fluoroscopic guidance, a Kirschner wire (K-wire) was placed approximately 1.5 cm from the midline on the symptomatic side to rest on the junction of the facet and the inferior aspect of the rostral lamina of the disc level. A 2 cm skin incision was made over the K-wire's puncture site. A series of tubular dilators (METRx, Medtronic Sofamor Danek, Memphis, TN) were placed over the Kirschner wire, dilating the lumbodorsal fascia. This facilitated placement of an 18 mm diameter tubular retractor that was secured to the operating table. With the tubular retractor in correct position, the interlaminar space was exposed. The margins of exposure were the inferior lamina of rostral vertebra superiorly, the superior lamina of the caudal vertebra inferiorly, and the medial aspect of the facet joint laterally. The spinous process of the rostral vertebra lies medial to the tubular retractor and was not visualized. A final x-ray film, confirming the position of the retractor, was routinely obtained.

The microscope was used to visualize the operating field for the remainder of the procedure. A surgical drill and a bayoneted 3-mm Kerrison punch was used to perform the hemilaminotomy and flavectomy. This exposed the thecal sac and the compressed nerve root. The epidural veins were coagulated using bipolar electrocautery. The nerve root was gently retracted and the discectomy performed. Once the discectomy was completed and hemostasis obtained, the retractor was removed under direct visualization. Closure consisted of absorbable sutures for the lumbodorsal fascia and dermis. Surgical staples were used to approximate the skin edges. A sterile dressing was applied. The operative time was recorded from the skin puncture with the Kirschner wire to application of the dressing.

Results

The patient population consisted of 20 females and 32 males. The mean age was 40 years (range, 18-74 years). The level of the symptomatic disc herniation was as follows: L3/4, 2 patients; L4/5, 22 patients; L5/S1, 28 patients (Figure 1). Twenty patients underwent right-sided microdiscectomy while 32 patients underwent the procedure on the left.

Complications occurred in three patients (Cases 2, 8, and 26). In Case 2, a dural tear occurred when the K-wire used for localization punctured the thecal sac. This prompted a

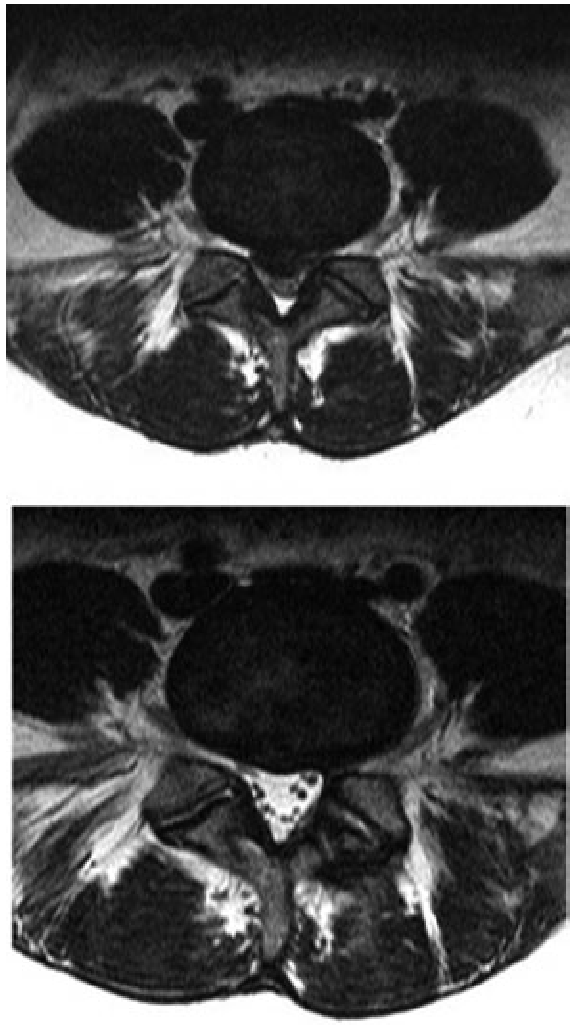

Figure 1: *MRI of a study patient demonstrating a posterior L5-S1 disc herniation (top). Postoperative MRI of the same patient after MIM (bottom).*

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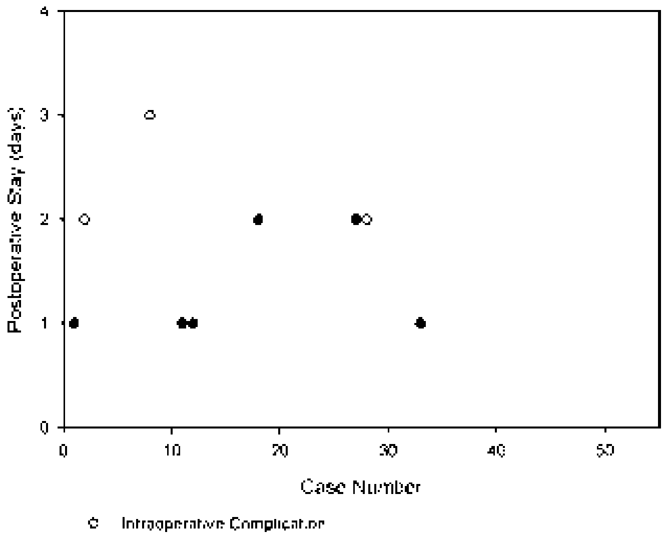

Figure 2: *Postoperative length of hospital stay. Cases 2, 8, and 28 were each associated with a complication.*

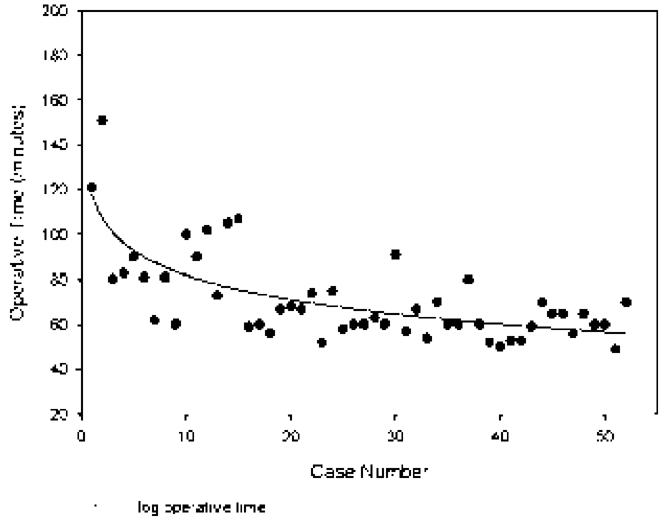

Figure 3: *Operative time for each case. As the number of cases increased, the operative time decreased as a result of improved efficiency. The steady state occurred at approximately Case 15.*

conversion to open in order to facilitate primary dural closure. This was the only case in the series that was converted to an open procedure. A dural tear resulting from K-wire placement also occurred in Case 8; primary closure through the tubular retractor was performed using a single 6-0 prolene suture. For both cases, the CSF leak was visualized through the tubular retractor alerting the surgeon to the durotomy.

In Case 26, a root sleeve tear occurred, although the arachnoid remained intact and cerebrospinal fluid leak was not observed. The blood loss for all cases was minimal, limited to an estimated 1-5 few cubic centimeters.

All but nine patients were discharged home on the day of surgery. Case 1 was admitted because the MIM same-day discharge policy had not yet been implemented at that time. Cases 2, 8, and 26 were admitted for 48-hours of bedrest secondary to the dural tear. Cases 11, 12, 18, and 27 were admitted for pain control. All four of these patients had been consuming high doses of narcotics preoperatively. Case 33 was admitted overnight because a snowstorm precluded a safe journey home. Figure 2 illustrates the length of hospitalization for each case.

Mean operative time was 71 minutes (range, 49-151 min). Figure 3 demonstrates the learning curve for MIM, with respect to operative time. By approximately Case 15, an operating time of 60 minutes or less was typical.

Discussion

The benefits of describing the learning curve for a given procedure are twofold. Firstly, it provides valuable information for surgeons who decide to learn a new procedure. For all types of operative procedures, surgeons need to be aware of the key learning points and strategies to avoid operative complications. If the new procedure is relatively simple or is only a minor extension of a familiar technique, then the surgeon could anticipate the safe integration of the new procedure into practice within a relatively short period of time. Procedures with a steeper or longer curve may require more involved learning strategies, including practice in cadaver labs and performing several cases with an experienced surgeon. Secondly, the learning curve may affect the results of clinical studies. Valid comparisons to conventional techniques can only be made after the surgeon has reached the steady state of the learning curve. Otherwise, the bias may be towards false negative results regarding the efficacy of the new technique.

Nowitzke[4] has previously reported the learning curve for microendoscopic MIM. The technique differs from MIM with respect to the use of a flexible endoscope rather than a microscope to visualize the surgical field through the tubular retractor. Nowitzke reported that the asymptote (the “steady state” of results that can be expected after climbing the learning curve) for microendoscopic MIM was about 30 cases. This is roughly double the number of cases needed to reach the asymptote in our experience. The difference may be that neurosurgeons are already familiar with use of the operating microscope while the endoscope provides additional learning challenges. Although the endoscope provides a larger field of view in many cases, it is not a three-dimensional image.[5]

Although a couple of dural tears secondary to the K-wire were encountered early in the series, the rate of complications was comparable or better than published microdiscectomy series.[6,7] With increased experience, increased efficiency and shorter operative times did not produce an increase in complications, consistent with reports from other authors.[8,9] Although postoperative pain or disability outcome measures were not obtained, in our experience most patients undergoing MIM do very well. This is fostered as the surgeon gains more experience and intraoperative complications are kept to a minimum.

Specific learning tasks for MIM include correct placement of the K-wire, accurate positioning of the retractor, and working through the narrow confines of the tube. With regards to K-wire placement, care must be taken not to medialize its trajectory too much. To avoid dural puncture or injury to the nerve root, the tip of the K-wire must never descend lower than the level of the lamina. This is especially true at the L5/S1 level where the interlaminar space is wide. It is recommended to insert the blunt end of the K-wire rather than the sharp end, to further reduce this risk. Lateral fluoroscopy is necessary to monitor the descent of the K-wire. Anteroposterior fluoroscopy can be used to visualize the medial position of the K-wire, although in our experience this is not routinely used.

The correct position of the tubular retractor over the interlaminar space is of paramount importance. The retractor should dock between the base of the spinous process of the rostral vertebra medially and facet joint laterally. This relationship should be confirmed visually and tactilely with a blunt-tipped probe, because the dilators can accidentally migrate to the contralateral side during placement. With correct placement the rostral and caudal laminae are exposed superiorly and inferiorly, respectively. The medial aspect of the facet joint is also visualized. The tubular retractor can be ‘wanded’ to facilitate exposure. This involves repositioning the retractor by adjusting its angulation. It is important to realize that small angular adjustments in the direction of the tube result in large linear changes at the tip.

Custom bayoneted instruments facilitate their use through the tubular retractor. A drill extension may be necessary when performing the hemilaminotomy. Epidural bleeding is managed with bayoneted bipolar electrocautery. In one case of durotomy, we were able to successfully suture the tear through the retractor. With increased experience, both the surgeon and the operative team gain familiarity with the specialized instruments, draping, and fluoroscopy required to perform MIM, improving the overall “flow” of the operative procedure.

While the surgeon climbs the learning curve, it is advised that use of the tubular retractor system be limited to patients with single-level lumbar disc herniations. As one becomes more comfortable with the technique, the versatility of the system can be explored. The authors have employed minimally-invasive tubular retractor systems for multi-level microdiscectomy, the decompression of lumbar stenosis, posterior cervical microforaminotomy, and transforaminal lumbar interbody fusion.

The learning curve for a new surgical technique has important implications with regards to training, patient safety, and assessing the efficacy of the procedure. Operative times for MIM were reduced as the surgeon became more experienced with the technique. The asymptote was about 15 cases, or roughly half the number of cases needed for microendoscopic MIM. Some key learning points include correct placement of the K-wire and retractor, identifying anatomical landmarks, and making fine adjustments to the angle of the retractor throughout the case to gain the best exposure.

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References

1. Foley K, Smith M. Microendoscopic discectomy. Tech Neurosurg. 1997;3:301-7.
2. Huang TJ, Hsu RW, Li YY, Cheng CC. Less systemic cytokine response in patients following microendoscopic versus open lumbar discectomy. J Orthop Res. 2005;23(2):406-11.
3. Javedan S, Sonntag V. Lumbar disc herniation: microsurgical approach. Neurosurgery. 2003;52(1):160-3.
4. Nowitzke AM. Assessment of the learning curve for lumbar microendoscopic discectomy. Neurosurgery. 2005;56(4):755-62.
5. Perez-Cruet MJ, Foley KT, Isaacs RE, Rice-Wyllie L, Wellington R, Smith MM, et al. Microendoscopic lumbar discectomy: technical note. Neurosurgery. 2002;51(5 Suppl):129-36.
6. Kraemer R, Wild A, Haak H, Herdmann J, Krauspe R, Kraemer J. Classification and management of early complications in open lumbar microdiscectomy. Eur Spine J. 2003;12:239-46.
7. Perez-Cruet M, Fessler R, Perin N. Review: complications of minimally invasive spine surgery. Neurosurgery. 2002;51(5 Suppl):26-36.
8. Nakagawa H, Kamimura M, Uchiyama S, Takahara K, Itsubo T, Miyasaka T. Microendoscopic discectomy (MED) for lumbar disc prolapse. J Clin Neurosci. 2003;10(2):231-5.
9. Wu X, Zhuang S, Mao Z, Chen H. Microendoscopic discectomy for lumbar disc herniation: surgical technique and outcome in 873 cases. Spine. 2006;31(23):2689-94.