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Using intraoperative foraminoplasty in the prophylaxis of dysesthesia in transforaminal endoscopic discectomies of the lumbar spine

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ABSTRACT

Background: Postoperative nerve root injury with dysesthesia is the most frequent sequela following lumbar endoscopic transforaminal discectomy. At times, it may be accompanied by transient and rarely by permanent motor weakness. The authors hypothesized that direct compression of the exiting nerve root and its dorsal root ganglion (DRG) may play a role by manipulating the working cannula or endoscopic instruments.
Objective: To assess whether intraoperative Foraminoplasty can help prevent nerve root injury by the initial placement of the endoscopic working cannula and the directly visualized video endoscopic procedure.
Methods: The authors performed a retrospective chart review of 65 (35 female and 30 male) patients who underwent transforaminal endoscopic decompression for failed non-operative treatment of lumbar disc herniation from 2012 to 2020. The patients' age ranged from 22 to 86 years, with an average of 51.75 years. Patients in the experimental group (32 patients) had intraoperative foraminoplasty in the surgical approach, and in the control group (32 patients) did not. The SSEP and TCMEP data were analyzed and correlated to the postoperative course, including dysesthesia and clinical outcomes using modified Macnab criteria, Oswestry Disability Index (ODI), visual analog scale (VAS) for leg and back pain.
Results: The surgical levels were L4/L5 in 44. 6%, L5/S1 in 23.1% and L3/L4 in 9.2%. Of the 65 patients, 56.9% (37/65) had surgery on the left, 36.9% (24/65) on the right, and the remaining 6.2% (4/65) underwent bilateral decompression. Postoperative dysesthesia occurred in 2 patients in the experimental and six patients in the control group. In the experimental foraminoplasty group, a foraminoplasty was performed before advancing the endoscopic working cannula via the transforaminal approach into the neuroforamen to avoid an impeding nerve root injury and postoperative dysesthesia.
Conclusion: In the Present study, foraminoplasty enabled the intraoperative prevention of DRG compression during the initial transforaminal placement of the endoscopic working cannula. Future studies with more statistical power will have to investigate whether employing foraminoplasty to avoid intraoperative compression of the exiting nerve root is really predictive of lower postoperative dysesthesia rates in patients undergoing videoendoscopic transforaminal discectomy.

Key Words: Herniated Disc, Videoendoscopy, Foraminoplasty, Spine

Introduction

Videoendoscopy for the treatment of lumbar herniated discs is now common with favorable clinical results comparable to microdiscectomy and a low rate of complication rate [1][2]. The transforaminal approach is frequently applied to the endoscopic treatment of herniated discs mainly at the L3/L4, and L4/L5 level. The approach is also feasible at L5/S1 but may be technically more demanding because of the configuration of the iliac wing, sacralization of the L5 vertebral body, or because of degenerative vertical collapse of the spine [3][4]. Placing the working cannula may be harder at this transitional level due to steeper attack angles making injury more likely to the exiting L5 nerve root. Regardless of the level, additional risks for nerve root injury due to increasing surgery time and more aggressive manipulation may arise if the surgeon is attempting to access a highly stenotic neuroforamen during the endoscopic decompression procedure. Compression of the dorsal root ganglion of the exiting nerve root may occur due to manipulation of the beveled endoscopic working cannula leading to temporary ischemia and postoperative dysesthesias in a percentage considerable number of patients, and foraminoplasty may be a good way to avoid this compression of the root ganglion and avoid post-operative dysesthesia [5][6].

Therefore, the authors decided to retrospectively study the result obtained by making foraminoplasty during transforaminal videoendoscopy in patients who were treated for herniated discs. Ultimately, the authors wanted to study the feasibility of intraoperative foraminoplasty could be predictive of postoperative dysesthesias with the transforaminal endoscopic decompression procedure [7]. If feasible, surgical protocols aimed at lowering the incidence or perhaps even preventing injury to the exiting nerve root DRG could be developed [8].

Materials and Methods

Patients

The charts, imaging studies and neuromonitoring examinations of 65 patients who underwent transforaminal endoscopic discectomy from 2012 to 2020 were retrospectively reviewed. The surgeries were performed by first and second author. There were 35 female (53.8%) and 30 (46.2%) male patients. The average age was 51.75 years ranging from 22 to 86 years with a standard deviation (SDV) of 14.916 and followed normal distribution (Figures 1 and 2). Patients in the experimental group (32 patients) had intraoperative foraminoplasty, and in the control group (32 patients) did not. Age and gender similar rates of comorbidities, and surgical level distribution were matched for both groups (see below). All patients in this consecutive case series provided informed consent and IRB approval was obtained (CEIFUS 106-19). Written informed consent was obtained from the patients for publication of this report and any accompanying images.

Inclusion/Exclusion Criteria

Only patients presenting with radicular pain with a herniated disc confirmed by magnetic resonance imaging (MRI), or computed tomography (CT) were selected for this study. Patients with unmanageable radicular pain unresponsive to a minimum of 12 weeks of medical and interventional conservative care, with a positive *Lasègue's* tension sign, and minimal low back pain were included. A normal preoperative electroneuromyographic study was another prerequisite for study inclusion. Patients with instability, deformity, or any electrodiagnostic abnormality were excluded from the study. Exclusion of patients from the study was prompted by a concurrent diagnosis of infection, tumor or metastatic disease, or any electrodiagnostic evidence of chronic demyelination, or deinnervation in the dermatomes innervated by the affected surgical nerve roots. Exclusion was also prompted if patients displayed any of the following radiographic parameters.

Preoperative Radiographic Evaluation

Radiographic stenosis parameters were also evaluated. These included the posterior intervertebral disc and foraminal height [9]. Cross-sectional imaging showing 15 mm or less for the height of the neuroforamen, 3 mm or less measured as posterior intervertebral disc height, or the width of the neuroforamen was recorded as abnormal [9]. As previously published and validated, diagnostic selective nerve root blocks were used to determine the symptomatic painful level. This protocol was highly relevant in choosing the surgical level(s) in patients with multilevel disease [10-17]. Exclusion of patients from the study was prompted by a concurrent diagnosis of overt spondylolisthesis with more than 3 mm of translational motion on dynamic extension/flexion views. If patients were suspected of having claudication or mechanical back pain symptoms due to severe central stenosis - < 100 mm^2 at the surgical level or from facet arthropathy, they were typically also excluded from the study [18].

Endoscopic Discectomy Procedure

All patients underwent general anesthesia, the surgeries were performed by the first and second author employing the transforaminal "outside-in" technique with the patient in prone position [19]. Serial dilation was employed to place the working cannula. Since patients with bony foraminal stenosis were excluded from the study, a routine foraminoplasty was not necessary, but in the experimental group foraminoplasty was performed in all of them. If bleeding occurred, a radiofrequency probe (Elliquence®) was used for coagulation [20]. The endoscopic decompression procedure was directly visualized throughout the surgery. The location of the herniated disc and the presence of any other anatomical anomalies leading to inflammation or tethering the nerve roots bordering the triangular safe zone at the surgical level were recorded as the authors thought that they potentially could increase the risk of nerve root injury and postoperative development of irritation of the dorsal root ganglion (DRG). Fluoroscopic surveillance images were occasionally taken for orientation and verification of the decompression.

Clinical Follow-Up & Primary Outcome Measures

Primary clinical outcome measures were reductions in the visual-analog scales (VAS) [21] for leg- (VAS-LEG) and back pain (VAS-BACK) ranging from no pain (0) to worst pain (10) and the Oswestry disability index ODI. The ODI is a ten-item composite instrument assessing pain intensity, personal care, and function including walking, lifting, personal care, sitting, standing, sleeping, social interaction and traveling [22][23]. Each ODI item is scored from 0 (no impairment) to 5 (worst impairment). The individual scores are summed and then multiplied by two to obtain the ODI index ranging from 0 to 100. In addition, patients were evaluated using the modified Macnab criteria [24][25]. Postoperatively, patients were seen in follow-up for reevaluation at 6 weeks and then at 3, 12, and 24 months. Any clinical evidence of new onset of dysethetic leg pain due to DRG irritation was recorded.

Postoperative Rehabilitation

Most patients did not require postoperative rehabilitation and supportive care requirements. Study patients treated for any acute onset of dysesthetic leg pain after an initial postoperative period of good pain relief with nonsteroidal anti-inflammatories, gabapentin, and transforaminal epidural steroid injections (TESI) pain syndromes were counted as having an irritation of the dorsal root ganglion (DRG). For the purpose of this study analysis, successful postoperative administration of 1% lidocaine-containing TESI with therapeutic pain relief was considered proof of a DRG irritation due to intraoperative nerve root injury.

Statistical Analysis

For the clinical outcome analysis, descriptive statistics (mean and standard deviation), cross-tabulation statistics of sensitivity, specificity, and measures of association were computed for two-way tables using IBM SPSS Statistics software, Version 26.0. The Pearson X^2 and the likelihood-ratio X^2 tests were used as statistical measures of association between dysesthesia, SSEP, TCMEP neuromonitoring events, and clinical outcome measures. The confidence intervals for the likelihood ratios were calculated using the "log method" according to Liberati & Altman et al. [26].

Results

Sixty-five study patients in total had surgery at 65 levels. There were 32 patients in the foraminoplasty group and 33 patients in the control group. The average postoperative follow-up was 20.55 months, ranging from 12 to 30 months, with a SDV of 7.537 months. Most patients underwent surgery on the left side 56.9% (37/65), whereas 36.9% (24/65) had surgery on the right, and the remaining 6.2% (4/65) of patients underwent bilateral surgery. As expected, the most common surgical segments were L4/L5 in 44. 6%, L5/S1 in 23.1% and L3/L4 in 9.2% of patients, respectively. The surgical level distribution is shown in Table 1. Eight (12.3%) of the 65 patients developed a postoperative dysesthesia from compression of the exiting nerve root and injury to its DRG during initial endoscopic working cannula placement.

Final clinical outcomes were favorable, with 51 (78.5%) patients reporting Excellent and the remaining 14 (21.5%) patients indicating Good Macnab outcomes. At final follow-up, 75% (6 patients) of dysesthesia patient had *Excellent* and the remaining 25% (2 patients) had *Good* Macnab outcomes. At the final follow-up, the ODI improved from 31.71 ± 16.17 preoperatively to 19.02 ± 8.96 postoperatively ($p < 0.0001$). The VAS leg score reduced from 8.86 ± 0.93 before thee endoscopic decompression to 1.15 ± to 1.27 at the final follow-up ($p < 0.0001$). The VAS back score reductions were more modest from preoperative 4.92 ± 1.27 to postoperative 3.2 ± 0.775, respectively ($p < 0.0001$). The results of the paired-T testing with 95% confidence interval numbers are summarized in table 2. The mean ODI reduction was 12.69 ± 13.12 on par with reported MCID reductions reported for the transforaminal endoscopic decompression procedure. The mean VAS leg score reduction was 7.71 ± 1.9, being much larger than the reported MCID with the procedure. The mean VAS Back reduction of 1.72 ± 1.21 did fall short of MCID numbers reported for this outcome tool with the transforaminal endoscopic procedure.

Discussion

One of the most common problems after transforaminal endoscopic decompression is dysesthesia due to compression of the dorsal root ganglion by the working cannula and its manipulation during its initial placement and the discectomy procedure. The senior author reported the incidence of this unavoidable sequala at 12.45% based on a study in 1839 patients with foraminal stenosis being a statistically significant risk factor [1]. Another multicenter study with seven participating surgeons and sites reported the incidence of DRG irritation to be 21.5% and independent of surgical level but to be highly dependent on surgeon skill level with dysesthesia rates varying from 5.0% to 41.2% [27].

While the course of postoperative DRG irritation following a transforaminal endoscopic discectomy is benign and typically self-limiting with a reduced physical activity program, supportive medical and interventional care measures such as gabapentin, pregabalin or a transforaminal epidural steroid injection (TESI), the condition can be quite annoying to patients until it resolves typically 2 to 4 weeks postoperatively [27]. A preoperative education program is required warning patients of the possibility of burning leg pain developing in the dermatome of the exiting nerve root of the surgical level some 5 to 10 days following the transforaminal endoscopic discectomy after an initial pain-free interval. Patients should also be instructed to avoid narcotic pain medication as they are not an effective treatment for this condition and that follow up with their surgeon in the office setting is more appropriate than seeking help in the emergency room where inconsequential imaging studies ultimately do not change management are ordered. The readmission rate to a hospital in the immediate postoperative was reported to 0.87% and compared favorably to the readmission rates reported in traditional microdiscectomy (4.1% to 5.8%). Yeung et al. [28] reported the incidence of postoperative dysesthesia at 9.7% in his series of 176 patients. Nellensteijn et al. [29][30] corroborated these findings in his systematic review carried out in 2010 and concluded that comorbidities might impact the dysesthesia rate [31].

Hence, attempts to minimize the dysesthesia rate following an expertly executed transforaminal endoscopic decompression are highly relevant to the patients' perception of the endoscopic procedure. Patient satisfaction may decrease when a bothersome dysesthesia sets in after an initial 5 to 10 days postoperative interval of pain relief. The authors investigated the feasibility of employing intraoperative neuromonitoring during the initial endoscopic working cannula

position to avoid incidental compression of the exiting nerve root at the surgical level. That part of the procedure is typically not directly visualized. The authors found that neuromonitoring may prevent such compression of the exiting nerve root and resolve it with the better positioning of the working cannula during the initial steps of the endoscopic procedure. The surgeons performed a foraminoplasty involving resection of the tip of the superior articular process with the intent of diminishing the presumed nerve root compression associated with advancing the endoscopic working cannula into Kambin's triangle – the safe zone formed by the exiting- and traversing nerve root and the pedicle of the inferior vertebral body. This has been corroborated by Jun-Song-Yang et al. who stated that foraminoplasty could be essential and necessary to facilitate the approach to a foraminal hernia, avoiding the manipulation and compression of the dorsal root ganglion and the symptomatic compressed nerve roots. The latter are typically inflamed, irritable, and susceptible to additional injury. While the application of foraminoplasty to improve outcomes with the outpatient transforaminal endoscopic decompression procedure is uncommon to current routine clinical practice, it is frequently employed in traditional open- and other forms of minimally invasive spinal surgery in the United States and the world over, the authors had no way to determine whether the risk for postoperative dysesthesia was solely determined by the surgical compression of the exiting nerve root, or whether there were any confounding factors, such as the size and location of the disc herniation, the duration of symptoms, extent of root ischemia, and duration of the neural element compression. Additionally, comorbidities, such as neuropathy, metabolic disease, including diabetes or renal disease, may also have played a role.

The implication is that the use of intraoperative foraminoplasty when applied appropriately can lower the dysesthesia rates with the endoscopic decompression procedure. Future studies should go beyond the scope of this feasibility study in regards to the number of patient as we were unable to demonstrate a statistically significant benefit. Moreover, a more detailed subgroup analysis should be performed to validate further the conclusion of this retrospective study carried on the cases of five surgeons from four countries. Surgeon training and skill level may certainly also impact the dysesthesia rate, and again the authors had no reasonable way to quantify that to facilitate extrapolation of their experience to other clinical sites.

Conclusion

Foraminoplasty enabled the intraoperative prevent of root compression of the exiting nerve root by the endoscope access cannula and by surgical manipulation. Its application resulted in a three-fold reduction of postoperative dysesthesia in patients undergoing videoendoscopic transforaminal discectomy. Further validation studies are required.

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Conflicts: This manuscript is not meant for or intended to push any other agenda other than reporting the clinical outcome data following endoscopic spinal decompression for sciatica-type back and leg pain. The motive for compiling this clinically relevant information is by no means created and/or correlated to directly enrich anyone due to its publication. 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. Indirect conflicts of interest (honoraria, consultancies to sponsoring organizations) also doesn't exist.

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Tables

Table 1: Surgical level distribution in patients who underwent transforaminal endoscopy (n=65)

Level	Number of Patients	Percent	Cumulative Percent
L2-L3	1	1.5	1.5
L3-L4	6	9.2	10.8
L3-L5	4	6.2	16.9
L4-L5	29	44.6	61.5
L4-S1	10	15.4	76.9
L5-S1	15	23.1	100.0
Total	65	100.0	

Table 2: Results of paired T-testing comparing means of preop to postop ODI, VAS-leg and back

	Mean	Standard Deviation	Standard Error Mean	95% Confidence Interval		t	Degree of freedom	Significance (2-tailed)
				Lower	Upper			
ODI-Preop – ODI-Postop	12.692	13.122	1.628	9.441	15.944	7.798	64	< .0001
VAS-Back Preop – VAS-Back Postop	1.723	1.206	150	1.424	2.022	11.523	64	< .0001
VAS-Leg Preop – VAS-Leg Postop	7.708	1.902	236	7.236	8.179	32.677	64	.< .0001

Figures

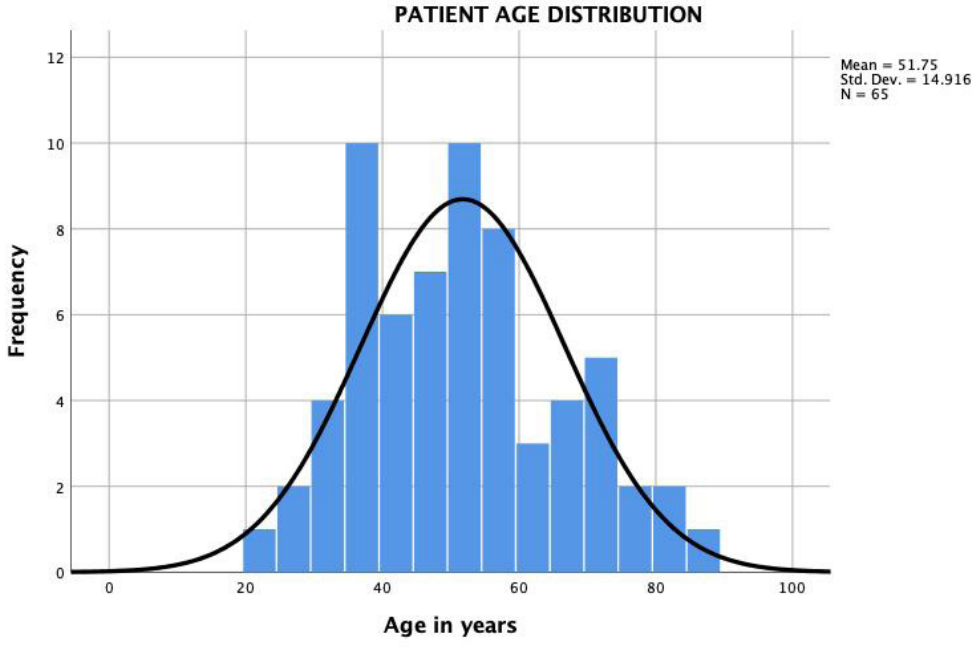

Figure 1: Age Distribution of the 65 study patients with the superimposed expected normal distribution (black line). Patient's age ranged from 22 to 86 years of age and averaged 51.75 years with a standard deviation of 14.916.

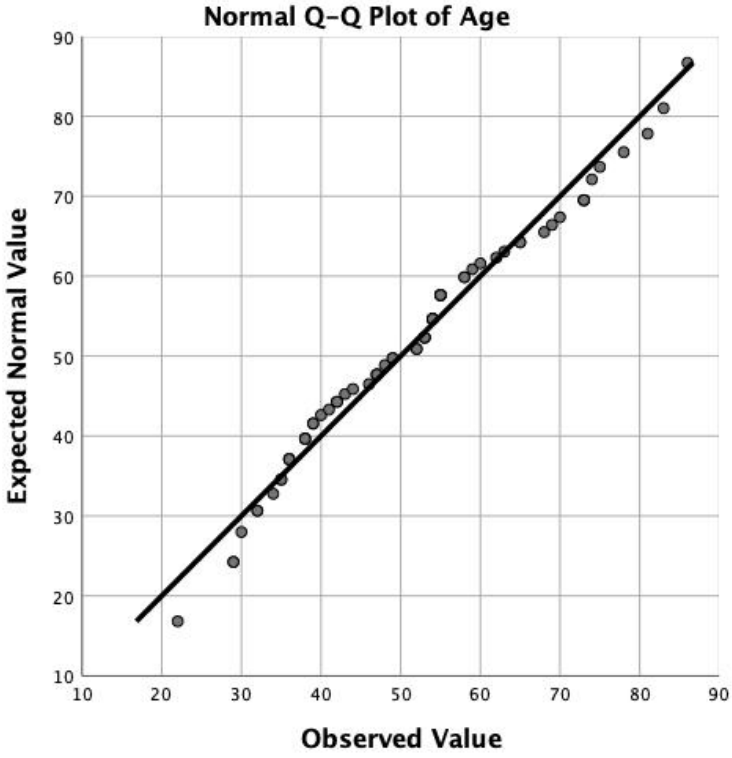

Figure 2: The quantile-quantile plot of the endoscopy study patients' age shows normal distribution. The average age was 51.75 ± 14.916 years ranging from 22 to 86 years.