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Comparison of Microscopic Decompression and Biportal Endoscopic Spinal Surgery in the Treatment of Lumbar Canal Stenosis and Herniated Disc: A One-year Follow-up

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Abstract

BACKGROUND: Microscopic decompression (MD) has been widely used as an alternative to open decompression. Lately, biportal endoscopic spinal surgery (BESS) – a new approach in minimal-invasive spinal surgery – has also been used with good results. Although both groups can achieve adequate lumbar decompression, there is still a lack of evidence regarding their comparison.

AIM: We aim to compare the outcomes of both techniques in a 1-year follow-up.

METHODS: This is a retrospective study in 100 consecutive patients with symptomatic lumbar spine compression due to herniated nucleus pulposus and lumbar canal stenosis that was treated by either BESS or MD. Clinical evaluations using Visual Analog Score (VAS), Oswestry Disability Index (ODI), and SF-36 questionnaire were obtained. Objective data, such as surgery duration, amount of postoperative drain production, and hospital length of stay, were collected. Complications were noted throughout the follow-up time.

RESULTS: The BESS group had a significantly lesser surgical duration, drain production, and length of stay. At 1-year follow-up, both groups achieved significant improvement in VAS, ODI, and SF-36 compared to the preoperative condition. Complications were not observed in the BESS group.

CONCLUSIONS: Both procedures were comparably effective to treat lumbar stenosis. Although this study shows superiority with the BESS technique in immediate and long-term follow-up, the final choice may depend on the surgeon's preference.

Introduction

Over the past few decades, minimally invasive spine surgery (MISS) has been developed as an alternative to traditional open surgery, to treat spinal problems with less injury to the muscles and other normal structures in the spine by directly going to the affected region by advanced technology [1]. Consequently, less postoperative pain, shorter hospital stays, and quicker recovery are expected [2]. MISS developed very extensively with numerous researches demonstrating their superiority over conventional open surgeries [3]. Endoscopic procedure in MISS was firstly described by Kambin *et al*. [4]. in 1988 and now has been developed by advance in technology to be carried out for discectomy, decompression, and even fusion surgery [3].

Microscopic decompression (MD) for the lumbar spine was firstly introduced by Caspar and Yasargil in 1977 [5]. Later on, the technique was refined by Foley and Smith in 1997 by using a tubular retractor system along with a microscope or endoscope and had gained its popularity for the treatment of lumbar decompression [6]. The development of endoscopic surgery in lumbar decompression also has become practical choice for decompression in herniated nucleus pulposus (HNP) as well as in degenerative lumbar canal stenosis (LCS), with various techniques being adopted to address underlying pathologies (uniportal vs. biportal, unilateral vs. bilateral decompression) [7], [8], [9]. A prospective study by Soliman and Ali [10] compares the outcome of LCS surgery using minimally invasive decompression with microscope and the conventional open laminectomy. They found that MD permits safe and acceptable spinal canal decompression in patients with LCS.

More recently, biportal endoscopic spine surgery (BESS), which combines the concept of endoscopic surgery and microscopic surgery, has been introduced for lumbar discectomy, laminectomy, and foraminotomy and demonstrated satisfactory results [11]. A meta-analysis by Chen *et al*. [12] involving 438 patients from six studies suggested that biportal endoscopic technique is a viable option to the microscopic technique for lumbar canal stenosis decompression with a similar profile of surgery duration, clinical outcomes, and complications. However, the evidence of its advantages compared to other MISS for lumbar spine decompression in other cases such as in herniated disc is still lacking [8], [11], [13], [14]. This is a retrospective observational study that included patients who underwent MD and BESS for lumbar decompression for degenerative lumbar canal stenosis and herniated disc (HNP) in Pondok Indah Hospital, Jakarta, Indonesia, with a minimum 1-year follow-up, to compare the clinical efficacies between two procedures.

Methods

Patient selections

There were 147 patients with lumbar stenosis performed with minimally invasive decompression technique in Pondok Indah Hospital, Jakarta, Indonesia, between June 2016 and February 2020. We excluded patients with follow-up periods of less than 1 year and a history of previous spinal surgery, spinal deformity, spondylolisthesis, and other spinal diseases (e.g., ankylosing spondylitis, tumor, infection, fracture) and psychological disorders. We conducted a retrospective study of 100 consecutive patients that met the criteria. Written consent has been received from all patients. Orthopedic spine surgeons performed both surgical procedures within the same time frame of the learning curve. Tubes were used before the introduction of BESS in our institution. STROBE guideline was used in writing this manuscript [15].

Surgical technique

In the MD group, a 1–2 cm skin incision was made with a paramedian approach. A muscle splitting technique was done using the tubular retractor system to expose the lamina at the affected level. Laminectomy or laminotomy with unilateral approach was performed with a high-speed burr either under microscopic view or dry endoscopic view on the pathological side only. Ligamentum flavum was exposed and excised with the Kerrison Rongeur and curette to expose the outer margin of the dural sac. The nerve root and dural sac were retracted to allow access to the pathologic disc and facilitate sequestration removal or discectomy if needed.

In the BESS group, a 1 cm incision for each portal was made, 1 cm lateral to the lamina, generally on the affected size. We performed BESS on the left side or right side of the patient depending on the symptoms if the symptom is unilateral. In bilateral cases, the portal was made on the side of the worst symptom and then extend the decompression across the contralateral lamina. Paraspinal muscles were bluntly detached using a narrow Cobb elevator until touching the bony surface of the lamina up to the lamino-facet joint junction. The position was confirmed with biplanar fluoroscopy. A 0° or 30° endoscope was inserted through the viewing portal under saline irrigation with a pressure of 30–40 mm Hg. Instruments for decompression were inserted through the working portal. Fraying muscle and soft tissue were debrided using a shaver and bipolar radiofrequency cautery. Following the creation of the working space, the laminectomy, flavectomy, and discectomy techniques were similar to that of MD. The bilateral decompression was done in extensive canal stenosis or in a situation when unilateral decompression is not sufficiently releasing the thecal sac. Drains were inserted into the decompression site (epidural) to make sure no hematoma formation or remaining irrigation fluids that potentially create a new compression.

Outcomes measurement

The primary outcomes assessed were the improvement of pain using visual analog score (VAS), quality of life using the Oswestry Disability Index (ODI) [16] and 36-Item Short-Form Health Survey (SF-36) questionnaire. These outcomes were collected in a minimum of 1-year follow-up. The secondary outcomes were surgery duration, drain production, hospital length of stay, and complication.

Statistical analysis

Statistical analysis was performed using SPSS ver. 25 (SPSS Inc., Chicago, IL, USA). Group comparisons were analyzed using the independent t-tests and the unpaired nonparametric Mann-Whitney test. Furthermore, Chi-square and Fisher exact tests were also used to compare categorical outcomes, graphical analyses, and correlational analyses. A $P<0.05$ was considered statistically significant.

Results

There were 46 out of 100 patients (46%) treated with MD, while the rest were treated with BESS. There were no significant differences before treatment for every variable ($p > 0.05$). The demographic of the participants assigned to each treatment group is shown in Table 1. The most common level was L5-S1 (47%), followed by L4-5 (28%). There were 20 patients with more than one level of involvement.

Table 1: Demographic data

Characteristic	MD	BESS	p
Age (mean ± SD)	44.93 ± 12.95	46.33 ± 16.04	0.637[a]
Gender (male: female)	27:19	34:20	0.686[b]
BMI (mean ± SD)	28.10 ± 3.81	27.01 ± 4.48	0.195[a]
Level (percentage of group cases)			
Upper lumbar	4.35	9.26	0.490[b]
Lower lumbar	91.30	83.33	
Single-level	78.26	81.48	0.688[b]
Multi-level	21.74	18.52	
Pain (percentage of group cases)			
Etiology			
HNP	10.87	20.37	0.433[b]
LCS	76.09	68.52	
HNP + LCS	13.04	11.11	
Characteristic			
Back pain	19.57	24.07	0.825[b]
Leg pain	47.83	42.59	
Back+leg	32.61	33.33	
Location			
Right	32.61	22.22	0.136[b]
Left	45.65	55.56	
Both sides	21.74	14.81	
Midline	0	7.41	

[a]Independent *t*-test, [b]Chi-square test, [c]Mann–Whitney. MD: Microscopic decompression, BESS: Biportal endoscopic spinal surgery, SD: Standard deviation, BMI: Body mass index, HNP: Herniated nucleus pulposus, LCS: Lumbar canal stenosis.

Bilateral decompression was done in 57% of the BESS group. There were no significant differences of the pain characteristics for both treatment; etiology (p: 0.433), characteristics (p: 0.825), and location (p: 0.136).

Before treatment, the mean of the patient's pain scale was 7.46 (range: 5–10), and the mean ODI score of 62.32 (range: 30–96). There were no significant differences between the pre-operative pain scale, ODI score, and SF-36 in both groups. Surgery duration and length of stay in each group are similar to those observed in other studies conducted by Kang *et al*. [17] and Park *et al*. [18]. Patients treated with MD had significantly longer surgery duration (mean 76.89 vs. 38.37 minutes, P=0.0) and length of hospitalization (mean 1.16 vs. 0.74, P=0.0). The production of vacuum drainage was evaluated every 8 hours. The vacuum drain output of the BESS group was significantly less than the MD group (25.28±14.39 ml vs. 55.43±9.53 ml, $P\leq 0.001$). In our institution, vacuum drainage is removed if the production was less than 50 ml, or the duration has exceeded 5 days post-operative. There were 78.3% of the MD group had drain removal within the second 8 hours post-operative, whereas 94.4% of the BESS group had drain removal within the first 8 hours. Thus, the BESS group leads the percentage (87.9%) among the patients who had drain removal within the first 8 hours [Table 2].

Table 2: Immediate post-operative outcome

Immediate Outcome	MD	BESS	p
Drain output within 1st 8 h (ml)	55.43 ± 9.53	25.28 ± 14.38	< 0.001[a]
Drain removal within 1st 8 h (%)	12.1	87.9	< 0.001[b]
Surgery duration (min)	76.89 ± 11.69	38.37 ± 6.15	< 0.001[a]
LOS (days)	1.16 ± 0.37	0.74 ± 0.44	< 0.001[a]

[a]Mann–Whitney, [b]Fisher's exact test. MD: Microscopic decompression, BESS: Biportal endoscopic spinal surgery, LOS: Length of stay.

In one-year follow-up, there was a significant improvement in the postoperative VAS and ODI for both groups compared to pre-operative condition (p<0.001). However, BESS patients experienced a higher reduction in VAS compared to the MD group (7.13 (±1.76) vs. 5.30 (±1.68), with p = <0.001. Statistical analysis shows a significant postoperative difference of the VAS and ODI scores for BESS compared to MD, 0.69 (±0.84) versus 2 (±1.63); p <0.001 and 3.74 (±4.77) versus 16.78 (±11.57); p <0.001, respectively. There were significant differences in the quality of life for each component of the SF-36, which is higher in the BESS group compared to the MD group [Table 3].

Table 3: Post-operative outcome comparison

Outcome	MD	BESS	p
VAS	2 ± 1.63	0.69 ± 0.84	< 0.001[a]
Delta VAS	5.30 ± 1.68	7.13 ± 1.76	< 0.001[a]
ODI	16.78 11.57	3.74 ± 4.77	< 0.001[a]
SF-36			
PF	70.33 ± 29.16	89.17 ± 19.76	< 0.001[a]
RP	73.91 ± 36.11	88.89 ± 27.76	0.005[a]
RE	82.59 ± 32.01	98.77 ± 6.35	< 0.001[a]
VT	62.5 ± 20.86	46.39 ± 15.18	< 0.001[a]
MH	58.67 ± 26.4	35.98 ± 19.61	< 0.001[a]
SF	75.68 ± 24.22	81 ± 28.98	0.020[a]
BP	68.75 ± 30.35	86.48 ± 22.27	0.001[a]
GH	62.5 ± 27.92	78.15 ± 17.30	0.005[a]
HC	80.98 ± 26.97	92.13 ± 18.06	0.007[a]
Complication (%)	27.78	0	< 0.001[b]
Residual leg pain	3	0	
Recurrent leg pain	6	0	
Segment instability	1	0	

[a]Mann–Whitney, [b]Fisher's exact test. Delta VAS represents amount of VAS reduction from the pre-operative condition. MD: Microscopic decompression, BESS: Biportal endoscopic spinal surgery, VAS: Visual analog score, ODI: Oswestry disability index, PF: Physical functioning, RP: Role physical, RE: Role functioning emotional, VT: Vitality, MH: Mental health, SF: Social functioning, BP: Bodily pain, GH: General health, HC: Health change, SF-36: Short-form health survey.

All cases of complications occurred in the MD group of patients (27.78% of MD group), which consisted of 10 cases: residual leg pain due to insufficient initial decompression (3 cases), recurrent leg pain (6 cases), and segment instability (1 case) [Table 3]. All of which required revision surgeries, however, only eight patients approved the surgery. Posterior stabilization was done for the instability case.

Discussion

The conventional open surgery, which includes decompressive laminectomy and foraminotomy, with or without discectomy, is still the gold standard therapy for lumbar spine decompression [5], [8]. However, the structural resection to achieve adequate surgical exposure in open surgery may produce iatrogenic instability, which may need additional fusion procedures [11]. Prolonged muscle dissection and retraction also led to muscle atrophy and disturbed arteriolar blood supply, which potentially contributes to postoperative chronic pain [11], [18]. Other disadvantages of open surgery are larger wound, excessive blood loss, epidural fibrosis, longer operative time, residual symptoms, recurrences, and adjacent segment diseases [8], [11].

The minimally invasive spine surgery

MISS aims to achieve decompression while minimizing muscle dissection, disruption of ligament attachment sites, and collateral damage to soft tissues.

Thus, it potentially maintains spinal stability and reduces post-operative pain [8], [13], [17], [17], [20], [21]. The MD procedure is based on microsurgical removal techniques, using standard microsurgical instruments, but manipulation is carried out through a working port created in the paravertebral muscles using tubular retractors and microscopic imaging, which has ×2-10. It is technically demanding and needs surgeon experience [21]. However, its superiorities compared to open surgery were shown in many studies [8], [13], [17], [20], [21].

Endoscopic spinal decompression was introduced using the principle of MISS to save normal surrounding structures [4], [5]. The most important concept of endoscopic spine surgery is minimal normal tissue trauma while maintaining the aim of surgery to effectively overcome spinal pathologies [4], [5]. The ability of the angled endoscope to visualize when decompressing the neuroforamen is an apparent unique benefit of this procedure [4], [5]. Moreover, the structural integrity of the facet can more often be preserved [4], [5]. This appears to be the durable and distinctive benefit of endoscopic decompression [4], [5]. Greater magnifications of the operative field by an endoscope (×30) are technically attributed to difficulties in the early phase of an endoscopic surgeon's learning curve [5], [18]. However, in trained surgeons, it will actually shorten surgery time by creating a clearer and comfortable view to achieve decompression [5], [18]. Therefore, surgical complications may be reduced, and recovery time may be minimized. Other possible drawbacks of endoscopic surgery may be unfamiliar endoscopic equipment handling and angular vision created by a lens of more than 0 degrees [7], [8], [20]. However, those can be overcome with surgeon experience and a thorough understanding of endoscopic anatomy [5], [18].

Intermediate outcomes associated with the MISS technique

In our study, the mean surgery duration of MD was similar to other studies, Wu *et al*. [20] 75±26 minutes, Nakagawa *et al*. [22] 95.3 minutes, and Zhang *et al*. [23] 64.77±17.83. However, MD group had significantly longer surgery duration (mean 76.89 vs. 38.37, P=0.0) and length of hospitalization (mean 1.16 vs. 0.74, P=0.0) compared to the BESS group in our study. In our experience, the mean surgery duration was longer in MD may be caused by technical issues such as frequent use of fluoroscopy after pre-operative level check, hemorrhage control, and difficulties in instrument handling and visualization, which share the same portal. MD also had a steep learning curve which can prolong surgery duration in initial 20 to 30 patients. Moreover, the MD operation field was dry even in the use of endoscopic and the magnification of the microscope was only 2-10x magnification [3], [11], [17], [24].

We reached around 30 minutes of BESS surgery after passing through the 25-30 consecutive cases in the early learning curve. At the early learning curve, we done it within 45 minutes to one hour. We found that BESS can overcome the technical difficulties of MD by allowing free instrument movement and handling as well as angulation of surgical instruments. Endoscopes can freely move, as they act on different portals. We achieved clear visualization under ×30 by continuous saline irrigation, which reduced blood loss and widened epidural space while preserving epidural fat and vessels from unnecessary damages. Fluid pressure also helps to loosen perineural fibrosis. Moreover, hemorrhage control with a bipolar system under continuous saline irrigation prevents thermal injury [11], [17], [25].

Length of stay (LOS) can be influenced by many variables: preoperative, perioperative, and postoperative. Preoperative variables are usually associated with comorbid and other non-modifiable factors such as elderly, morbid obesity, metabolic diseases, and opioid use. Perioperative variables include use of fibrin sealant, surgical invasiveness (open vs. MISS), intraoperative complications, fluids administered, and drain use. Finally, postoperative variables, including blood transfusion and complications, also have been associated with increased LOS. Elective open posterior spine surgery has a variable reported LOS but usually ranges from 3 to 7 days. MISS had a significantly reduced postoperative period compared to open surgery [26]. Wong *et al*.'s [21] study showed that MISS significantly decreases morbidity in the elderly, primarily due to decreases in blood loss, soft-tissue injury, and physiological stress, which further reduce the length of stay despite patient age.

In the MD group, LOS is longer than in the BESS group (mean 1.16 vs. 0.74, P=0.0). This result may be explained by Choi *et al*.'s [27] study on surgical invasiveness between various MISS techniques, which showed that microscopic procedure causes more muscle injury (more serum C-protein kinase elevation) than full endoscopic procedure, thus increasing postoperative back pain and hospitalization. This result also similar to Heo *et al*.'s [13] study, which showed that BESS had a lower approach-related soft-tissue injury than in the microsurgical procedure and allowed early recovery, lower post-operative pain and pain killer consumption, shorter LOS, and earlier reincorporation to active daily living. Moreover, postoperative drainage represents the effectiveness of intraoperative hemorrhage control. In our study, the BESS group had a significantly smaller amount of vacuumed drainage fluid and a shorter period of drainage utilization than the MD group. This result was similar to Kang *et al*. [17] study, which showed that the drain output amount of the BESS group was significantly less than the MD group (25.5±15.8 vs. 53.2±32.1ml, P=0.043). Thus, the time of drain removal was also significantly shorter, which further contributed to a lesser LOS in the BESS group.

Functional outcomes and complications associated with the MISS technique

Contrary to the recent meta-analysis by Chen *et al*., [12] Heo *et al*., [13], and Park *et al*. [19] that compared these two procedures for LCS, we found that BESS has some superiority in the immediate-term follow-up and lesser post-operative complications. We took all the advantage from BESS technology that enable us to see the operation field thoroughly and decompress the nerve adequately not only for LCS but also HNP patients.

Post-operative observations in one-year follow-up showed a significant reduction in the pain scale for both groups compared to the pre-operative state. However, BESS patients experienced a significantly higher reduction in the pain scale compared to the MD group. There was also a significant post-operative difference in VAS and ODI scores for BESS compared to MD, 0 versus 2 ($p < 0.001$) and 2 versus 16 ($p < 0.001$), respectively. This result is similar to Kang *et al*.'s [17] study, which showed that BESS had shorter surgery duration and LOS, lesser post-operative pain, and favorable long term clinical outcomes in contrast to Heo *et al*. [13] and Park *et al*. [19] studies which showed a similar final (12 months) clinical outcome between the microscopic group and the endoscopic group.

Chen *et al*. [12] showed a similar complication rate between biportal and microscopic techniques. In general, complication rates may be higher in the learning phase of all minimally invasive procedures. Furthermore, complications are higher when the surgical field is unclear because of bleeding [12]. In our study, no complications were observed in the BESS group, even in the learning phase of this technique. A clear vision due to the high magnification of the surgical field along with continuous saline irrigation in BESS techniques might minimize the risk of complication which arises from the unclear surgical field.

In our study, 10 patients of the MD group had postoperative complications, including residual pain, recurrence, and segment instability. Residual leg pain was observed in three patients and disappeared after additional decompression surgery at 3, 6, and 7 months following the first surgery. Recurrent leg pain is a serious problem following symptom improvement after initial decompression surgery. In the MD group, the recurrence rate was 13.04%. This recurrence rate was smaller than Chang *et al*. [28] study, which reported a 21.7% recurrence rate following MD surgery despite different study populations. The leg pain was significantly reduced after revision surgery. The patient with segmental instability, which was the patient with LCS, was also complaining about recurrent leg pain but on a different side from the pre-operative symptomatic side. Hypermobility of the affected level along with scar tissue may irritate the nerve root and cause radicular pain. To prevent recurrent leg pain, sufficient decompression with or without fusion should be performed, especially in patients with LCS considering the dynamic instability.

Revision surgery is recommended for new pathology, inadequate initial decompression, or in case of iatrogenic instability. It is one of the important keys in evaluating any surgical procedure, which is crucial to patient safety and well-being as well as having significant cost implications. In our study, 8 out of 10 complicated cases underwent revision surgery including fusion surgery in one patient with LCS and dynamic instability. One patient refused surgery and another one had improvement after non-operative treatment.

In Senker *et al*. [29] study, obese patients may have increased comorbidities and perioperative complications from an open surgical approach and may have improved outcomes with MISS because it creates smaller potential space for infection and smaller tissue dissection [21]. In our study, patients with complications were 10% overweight, 60% obese I, 30% obese II. However, there was no association between complication and BMI in our study (P=0.234).

Although no complications are observed in the BESS group of our study, BESS can have unsuccessful outcomes that are mostly associated with hematomas, incomplete decompression, and dural injury. Persistent or recurrent leg pain can occur due to inadequate decompression, battered nerve root, or new pathology. However, it is less likely to have an inadequate decompression as BESS provides a much better view of the operating field, even better than open surgery as the scope can enter deep inside the disc space to evaluate the adequacy of decompression.

Age more than 70 years, female gender, pre-operative anticoagulant medication, intraoperative water infusion pump, and bony procedures such as laminectomy or interbody fusion are increasing the risk of epidural hematoma after BESS [30]. Eum *et al*. [31] in their early trial of BESS in 2016, showed complications that were developed in eight cases; 3 post-operative headaches, 2 dural tears, 2 post-operative numbness, and 1 post-operative epidural hematoma. However, recent studies have shown successful results without serious complications [32].

We believe that every procedure that follows the standard operating procedure will have a risk reduction toward complications. In MD, complications are more likely to happen due to technical drawbacks. BESS is more instrument dependent, in which any surgeon could face the same difficulty when using problematic tools.

Conclusion

MISS aims to improve patients' quality of life while reducing the complications related to extensive soft-tissue violation. However, it cannot fully replace open surgery, which may be needed in certain scenarios. This preliminary study compared two MISS techniques and has demonstrated non-inferiority of the newer technique (BESS) toward the former (MD). A similar long-term clinical outcome suggests that both procedures were comparably effective to achieve decompression in lumbar stenosis. BESS is potentially safe and effective as an alternative to MD, as shown in better immediate outcome results: lesser drain output, faster drain removal, shorter surgical duration, and lesser postoperative hospitalization (LOS). However, the final choice of operative procedure may depend on the surgeon's experience and preference. Randomized controlled studies with larger sample sizes and longer follow-up times are needed for further research.

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