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Original Article

# Surgical outcomes of a modified Marmot operation with transverse cutting of the spinal process in patients with degenerative lumbar spinal stenosis

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ABSTRACT

*Objective:* The authors developed a minimally invasive spinal surgery technique—a microscope-assisted modified Marmot operation combined with transverse cutting of the spinal process—to increase surgical field exposure and improve surgical outcomes in patients with degenerative lumbar spinal stenosis.
*Materials and methods:* We retrospectively analyzed 45 patients with degenerative lumbar spinal stenosis who underwent a microscope-assisted modified Marmot operation combined with spinal process transverse cutting laminectomy from February 2009 to June 2011. Pre- and postoperative evaluations of the patients were conducted using the Oswestry Disability Index (ODI) questionnaire and visual analog scale (VAS) scores for back pain. Operation time, blood loss, and postoperative time until ambulation were also measured.
*Results:* The age of the patients was 68.2 ± 7.2 years. The follow-up period was 15.3 ± 4.5 months. The postoperative hospital stay was 3.5 ± 2.2 days. The VAS scores of low back pain and leg pain were 72.1 ± 18.3 mm and 75.6 ± 20.1 mm preoperative, and 18.6 ± 17.3 and 23.8 ± 14.6 postoperative, respectively. The ODI questionnaire scores before and after the operation were 63.1 ± 6.8 and 26.5 ± 5.0, respectively. Patients had significant improvement in both VAS and ODI questionnaire scores after surgical decompression ($p < 0.05$). Operation time was 134.2 ± 19.6 minutes. Intraoperative blood loss was 66.5 ± 35.3 mL. No perioperative complication such as dural tear, hematoma, surgical site infection, or neurological deterioration was noted. All patients were able to walk within 2.4 ± 1.5 days.
*Conclusions:* A microscope-assisted modified Marmot operation combined with spinal process transverse cutting laminectomy was an effective procedure for spinal decompression. As the procedure produces only unilateral muscular trauma, patients can ambulate early. Overall, the procedure is safe and effective. It provides good surgical field exposure and satisfactory neurological and functional outcomes.


## 1. Introduction

Degenerative lumbar spinal stenosis is the most common lumbar disease in elderly people [1–6]. Decompression surgery is a treatment of choice for degenerative stenosis, but patients can still have symptoms even after a course of medication and rehabilitation [7,8]. Although current reports suggest that up to 80% of patients are satisfied with the results of surgical decompression [6,9,10], it is controversial, and further investigation is required to determine which surgical technique is most suitable [1,11]. In conventional lumbar decompression surgery, it is necessary to expose the paravertebral muscles, which can cause further significant muscle denervation [12–15]. Traditional open laminectomy and foraminotomy typically entail a wide range of muscle distraction with extensive destruction of posterior spinal elements and have the disadvantage of delayed functional recovery [1–3,16,17].

As a consequence of these related issues, many surgeons have developed various modified surgical techniques to minimize the invasiveness of the surgical procedures [1,2,18,19]. However, one of the major limitation of these surgeries is reduced surgical

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exposure; a good surgical field exposure is regarded as the hallmark of effectiveness and safety. Cho et al. reported on a split-spinous process laminotomy and discectomy, which digs out the spinous process and lamina. They used a high-speed burr to assist in the drilling of the bony part of the lamina as the essential part of the laminectomy, and called this the Marmot operation. However, it is difficult to decompress the lateral part of the spinal canal using the Marmot operation. To increase the surgical visual field and preserve the posterior spinal element, we modified this technique by adding transverse cutting of the spinal process with the assistance of a microscope.

The purpose of this study was to demonstrate the clinical outcomes in patients with degenerative lumbar spinal stenosis who were treated with a modified Marmot operation via a microscope-assisted unilateral approach.

## 2. Materials and methods

### 2.1. Patient population

The study design was reviewed and approved by the institutional review board at Taipei Tzu Chi Hospital of the Buddhist Tzu Chi Medical Foundation (registration code 01-XD11-032). We retrospectively reviewed the medical records of patients who met the inclusion criteria for this study from February 2009 to June 2011. The inclusion criteria were as follows: (1) presence of typical neurogenic intermittent claudication with radiculopathy and lower back pain; (2) radiographic evidence (magnetic resonance imaging) of compression of the cauda equina and nerve roots; (3) ineffective response to conservative treatment for more than 6 months; (4) complete clinical and radiological evaluations indicating degenerative lumbar spinal stenosis requiring surgical intervention; and (5) consent for decompression surgery with a signed form.

The exclusion criteria were as follows: (1) previous spine operations at the same level; (2) severe osteoporosis; (3) trauma-related conditions; (4) degenerative scoliosis and spondylolisthesis; and (5) concomitant systemic diseases, such as cardiopulmonary compromise and impaired cognition, which would compromise outcome assessment.

### 2.2. Operative procedures

The patients were placed in a prone position and general anesthesia was induced. The surgical spine levels were located and confirmed using a portable C-arm fluoroscope. After skin incision, unilateral distraction of the paravertebral muscle was performed and limited within the medical side of the facet joint. A small blade and the hook of a self-retained Aesculap retractor (B. Braun, Inc., New York, NY, USA) were used to push the soft tissue away to widen the surgical field (Figs. 1A and 2A). With the assistance of a microscope and using a high-speed burr (Midex-Rex; Medtronic, Fridley, Minnesota, United State), the cortex and cancellous bone of the ipsilateral spinal process and lamina were drilled, and transverse cutting of the spinal process was performed at the junction of the contralateral cortex of the spinal process and lamina (Figs. 1B and 2B). The thin layer of the contralateral cortex of the spinal process was preserved, and the contralateral paravertebral muscles remained attached to the cortex. We then pushed the thin layer of the spinal process away to increase the surgical field (Figs. 1C and 2C). The thick ligamentum flavum was exposed after drilling out the cortex of the ipsilateral spinal process and lamina. The bilateral inner parts of the facets were undercut using punches or a high-speed burr, and the thick ligamentum flavum was removed by 2 mm and 3 mm Kerrison punches at 45° for decompression and widening of the neuroforamen (Figs. 1D and 2D). The interspinous process ligament was distracted contralaterally but not removed. We also rotated the operating table by 15° to improve the view for the contralateral procedure. Finally, a Penfield #4 dissector was used along the foramen to confirm that the foraminotomy was adequate. Careful hemostasis was performed, and the wound was closed layer by layer.

### 2.3. Postoperative care

The urine catheter was removed on postoperative Day 1, and patients were encouraged to walk with a soft lumbar brace support. Only light analgesics (with nonsteroidal anti-inflammatory drugs) were administered for 2–3 days for pain.

### 2.4. Statistical analysis

All parameters were analyzed and Student *t* test was used to compare pre- and postoperative visual analog scale (VAS) scores for back pain and Oswestry Disability Index (ODI) questionnaire scores. A $p$ value of $<0.05$ was considered significant. Mean values are presented with the standard deviations.

## 3. Results

Table 1 shows patient characteristics and clinical functional outcomes. A total of 45 patients were analyzed, and no one was lost to follow-up. Twenty-seven men and 18 women with a mean age of 68 ± 7.2 years underwent surgery. The mean number of decompression segments was 3.5 ± 0.8 (range 2–5). Prior to surgery, the mean VAS score was 72.1 ± 18.3 mm (range 61–100 mm) for lower back pain and 75.6 ± 20.1 mm (range 58–100 mm) for leg pain. After surgery, the VAS score was 18.6 ± 17.3 mm (range 10–30 mm) for lower back pain and 23.8 ± 14.6 mm (range 10–40 mm) for leg pain. The ODI questionnaire scores were 63.1 ± 6.8 mm (range 51–78 mm) prior to surgery and 26.5 ± 5.0 mm (range 18–35 mm) after surgery. Patients had significant functional improvement in both VAS and ODI questionnaire scores after surgical decompression ($p < 0.05$). The mean operation time was 134.2 ± 19.6 minutes (range 110–182 minutes). The mean blood loss during surgery was 66.5 ± 35.3 mL (range 30–151 mL). The mean postoperative hospital stay was 3.5 ± 2.2 days (range 1–6 days). There were no perioperative complications such as dural tears, hematomas, surgical site infections, or neurological deterioration in this series. All patients were able to walk within 2.4 ± 1.5 days.

## 4. Discussion

In the present study, patients with degenerative lumbar spinal stenosis underwent a microscope-assisted modified Marmot operation with transverse cutting of the spinal process for bilateral decompression. They showed significant improvement in functional outcomes, as shown by both VAS and ODI questionnaire scores. Operation times were not long, and blood loss during surgery was limited. The postoperative hospital stay was also short. No perioperative complications such as dural tears, hematomas, surgical site infections, or neurological were observed deterioration in this series. The surgical decompression procedure was found to be effective and safe.

Decompression surgery is the “gold standard” treatment for degenerative lumbar spinal stenosis without instability, and it is effective in about 80% of patients with severe symptoms. However, the conventional approach for lumbar laminectomy and foraminotomy requires bilateral wide distraction of the paravertebral muscle to reach the lamina for decompression of the spinal canal. Damage to the bilateral muscles during decompression is thus

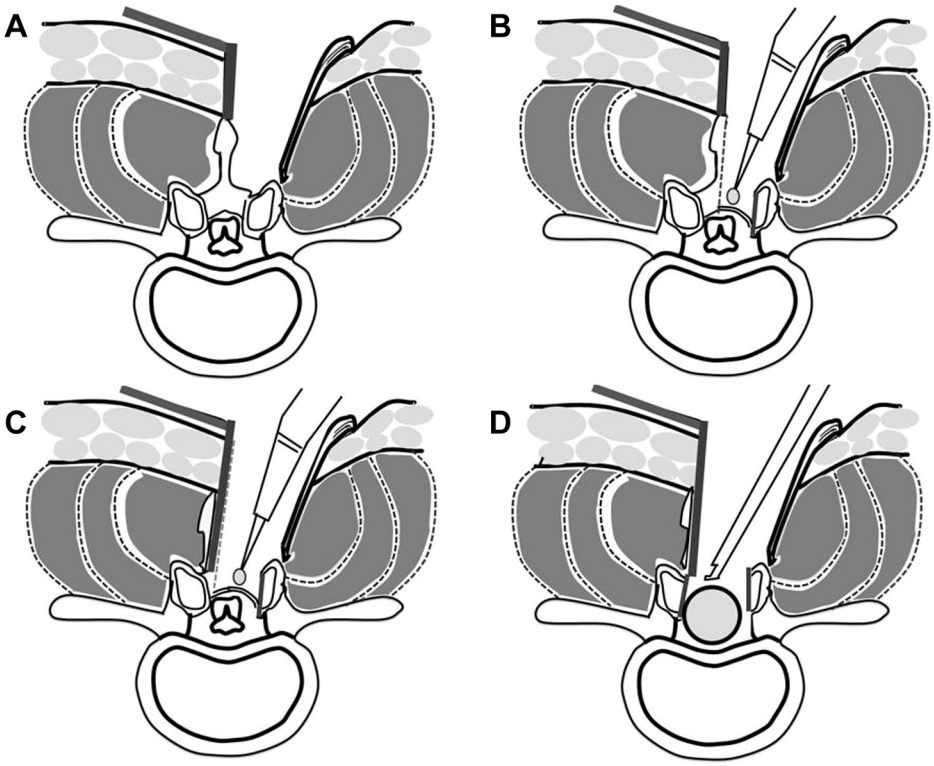


**Fig. 1.** Illustrations showing a microscope-assisted modified Marmot operation with transverse cutting of the spinal process for bilateral decompression. (A) The retractor is used on the unilateral side to the inner aspect of the facet joint. (B) The bony part of the unilateral spinal process and lamina is drilled out using a high-speed drill. (C) Transverse cutting is performed at the base of the spinal process, and the thin contralateral cortex is pushed further away to increase surgical exposure bilaterally. (D) Kerrison rongeurs are used for further removal of the lamina and ligmentum flavum, and further foraminotomy after sufficient drilling.

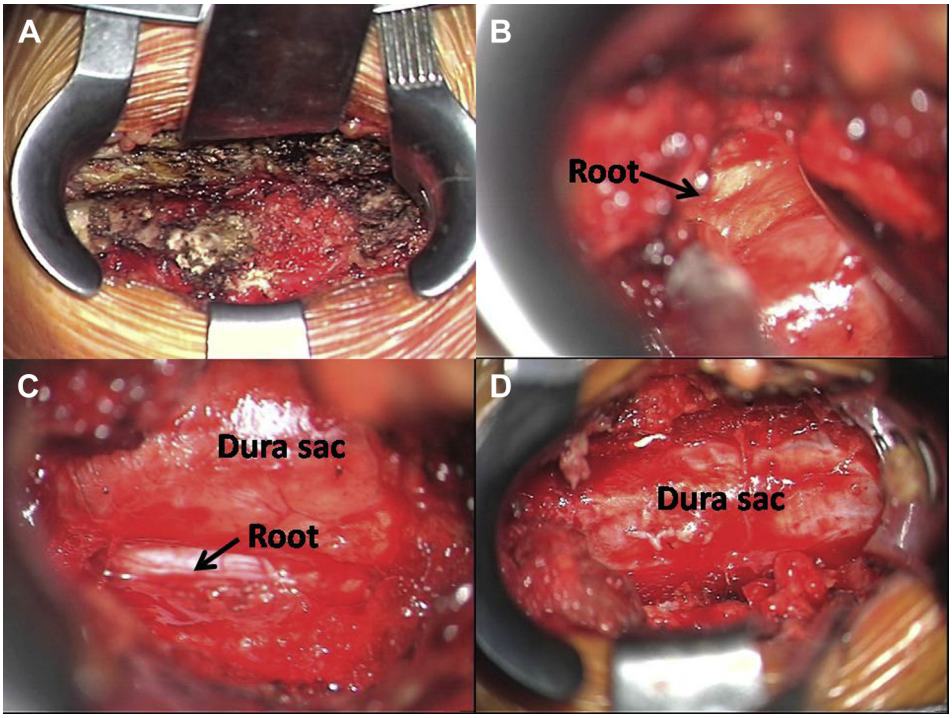


**Fig. 2.** Intraoperative photographs obtained during a microscope-assisted modified Marmot operation with transverse cutting of the spinal process for bilateral decompression. (A) Microscope assistance and use of a self-retained Aesculap retractor. (B) High-speed burr for drilling out the unilateral cortex and cancellous bone of the ipsilateral spinal process and lamina. (C) Transverse cutting is performed at the base of the spinal process, which is pushed away to the contralateral side for enhanced exposure of the operative field. (D) The bilateral inner part of the facets is also undercut using punches or a high-speed burr for decompression and widening of the neuroforamen. In all panels, the right side represents the cranial part and the left side represents the caudal part.

**Table 1**
Demographics of 45 patients who underwent microscope-assisted modified Marmot operation.

| | |
|---|---|
| No. of patients | 45 |
| Sex (male:female) | 27:18 |
| Age, mean range (range) (y) | 68 ± 7.2 (max 83, min 51) |
| Symptom duration, mean (range) (mo) | 16.3 ± 4.2 |
| Follow-up after surgery (mo) | 15.3 ± 4.5 |
| VAS (mm) prior to surgery | |
| Low back pain | 72.1 ± 18.3 |
| Leg pain | 75.6 ± 20.1 |
| VAS (mm) after surgery | |
| Low back pain | 18.6 ± 17.3 |
| Leg pain | 23.8 ± 24.6 |
| ODI prior to surgery | 63.1 ± 6.8 |
| ODI after surgery | 26.5 ± 5.0 |
| Postoperative time until walk (d) | 2.4 ± 1.5 |

Data expressed as mean ± SD.
ODI = Oswestry Disability Index; SD = standard deviation; VAS = Visual Analogue Scale.

substantial, and should be lessened to reduce postoperative pain and prevent further complications. Thus, minimal or less invasive surgical techniques have been developed, but with varying results. We developed a microscope-assisted unilateral approach, a modified Marmot operation combined with transverse cutting of the spinal process for bilateral decompression. In this surgery, both the central canal and the nerve root are decompressed with a need for only limited unilateral exposure of the paravertebral muscles and the inner side of the unilateral facet joints. To increase the surgical viewing field, we used a microscope, and cut the spinous process and pushed it to the contralateral side. In comparison with reported results of other minimally invasive surgical procedures, our procedure has the following benefits: (1) increased surgical visual field; (2) approach to only a unilateral site, which requires less muscle retraction; (3) a short learning curve; and (4) similar functional recovery as that for other minimally invasive procedures.

Our procedure preserves the supraspinous/interspinous ligament complex, which is probably the reason why our patients had good immediate postoperative VAS and ODI questionnaire scores with a short postoperative hospital stay. This modified Marmot technique was designed to avoid the steep learning curve of the original Marmot operation. The technique demonstrates a surgical outcome and length of hospital stay similar to those of the classic Marmot operation. Although the modified technique requires stripping of the unilateral side or paraspinal muscles, it is still as minimally invasive as feasible, which means both a shorter operation time and lower blood loss than when using the classic Marmot technique.

This study has the inherent limitations typical of a retrospective method, and the number of patients was small. The authors did not examine confounding factors that could affect patient satisfaction. A long-term follow-up study is needed.

## 5. Conclusion

Clinical outcomes as evaluated by the VAS and ODI questionnaire scores in patients with degenerative lumbar spinal stenosis were good. This modified Marmot technique appears to result in effective spinal decompression. Other advantages of this method were early ambulation and a short hospital stay.

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## References

[1] Usman M, Ali M, Khanzada K, Ishaq M, Naeem-ul-H, Aman R, et al. Unilateral approach for bilateral decompression of lumbar spinal stenosis: a minimal invasive surgery. J Coll Physicians Surg Pak 2013;23:852–6.
[2] Komp M, Hahn P, Merk H, Godolias G, Ruetten S. Bilateral operation of lumbar degenerative central spinal stenosis in full-endoscopic interlaminar technique with unilateral approach: prospective 2-year results of 74 patients. J Spinal Disord Tech 2011;24:281–7.
[3] El-Abed K, Barakat M, Ainscow D. Multilevel lumbar spinal stenosis decompression: midterm outcome using a modified hinge osteotomy technique. J Spinal Disord Tech 2011;24:376–80.
[4] Matsumura A, Namikawa T, Terai H, Tsujio T, Suzuki A, Dozono S, et al. The influence of approach side on facet preservation in microscopic bilateral decompression via a unilateral approach for degenerative lumbar scoliosis. Clinical article. J Neurosurg Spine 2010;13:758–65.
[5] Hatta Y, Shiraishi T, Sakamoto A, Yato Y, Harada T, Mikami Y, et al. Muscle-preserving interlaminar decompression for the lumbar spine: a minimally invasive new procedure for lumbar spinal canal stenosis. Spine 2009;34:E276–80.
[6] Haro H, Maekawa S, Hamada Y. Prospective analysis of clinical evaluation and self-assessment by patients after decompression surgery for degenerative lumbar canal stenosis. Spine J 2008;8:380–4.
[7] Katz JN, Stucki G, Lipson SJ, Fossel AH, Grobler LJ, Weinstein JN. Predictors of surgical outcome in degenerative lumbar spinal stenosis. Spine 1999;24:2229–33.
[8] Turner JA, Ersek M, Herron L, Deyo R. Surgery for lumbar spinal stenosis. Attempted meta-analysis of the literature. Spine 1992;17:1–8.
[9] Castro-Menendez M, Bravo-Ricoy JA, Casal-Moro R, Hernandez-Blanco M, Jorge-Barreiro FJ. Midterm outcome after microendoscopic decompressive laminotomy for lumbar spinal stenosis: 4-year prospective study. Neurosurgery 2009;65:100–10.
[10] Cho DY, Lin HL, Lee WY, Lee HC. Split-spinous process laminotomy and discectomy for degenerative lumbar spinal stenosis: a preliminary report. J Neurosurg Spine 2007;6:229–39.
[11] Cavusoglu H, Turkmenoglu O, Kaya RA, Tuncer C, Colak I, Sahin Y, et al. Efficacy of unilateral laminectomy for bilateral decompression in lumbar spinal stenosis. Turk Neurosurg 2007;17:100–8.
[12] Sihvonen T, Herno A, Paljarvi L, Airaksinen O, Partanen J, Tapaninaho A. Local denervation atrophy of paraspinal muscles in postoperative failed back syndrome. Spine 1993;18:575–81.
[13] Kawaguchi Y, Matsui H, Tsuji H. Back muscle injury after posterior lumbar spine surgery. A histologic and enzymatic analysis. Spine 1996;21:941–4.
[14] Kawaguchi Y, Matsui H, Tsuji H. Changes in serum creatine phosphokinase MM isoenzyme after lumbar spine surgery. Spine 1997;22:1018–23.
[15] Kawaguchi Y, Matsui H, Gejo R, Tsuji H. Preventive measures of back muscle injury after posterior lumbar spine surgery in rats. Spine 1998;23:2282–7. discussion 8.
[16] Bouras T, Stranjalis G, Loufardaki M, Sourtzis I, Stavrinou LC, Sakas DE. Predictors of long-term outcome in an elderly group after laminectomy for lumbar stenosis. J Neurosurg Spine 2010;13:329–34.
[17] Hong SW, Choi KY, Ahn Y, Baek OK, Wang JC, Lee SH, et al. A comparison of unilateral and bilateral laminotomies for decompression of L4–L5 spinal stenosis. Spine 2011;36:E172–8.
[18] Lin SM, Tseng SH, Yang JC, Tu CC. Chimney sublaminar decompression for degenerative lumbar spinal stenosis. J Neurosurg Spine 2006;4:359–64.
[19] Kawakami M, Nakao S, Fukui D, Kadosaka Y, Matsuoka T, Yamada H. Modified Marmot operation versus spinous process transverse cutting laminectomy for lumbar spinal stenosis. Spine 2013;38:E1461–8.