Microendoscopic decompression for lumbar spinal stenosis caused by facet-joint cysts: a novel technique with a cyst-dyeing protocol and cohort comparison study

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OBJECTIVE Facet cysts may represent a sign of intrinsic facet disease and instability, increasing the importance of less-invasive approaches that limit tissue dissection and improve visualization. The authors developed an intraoperative cyst-dyeing technique, involving the injection of indigo carmine from the facet joint into the cyst, as an adjunct during decompression. This study aimed to evaluate the clinical outcomes and perioperative complication rates of microendoscopic spinal decompression for lumbar spinal stenosis (LSS) and lumbar foraminal stenosis (LFS), caused by facet cysts and to elucidate the efficacy of the cyst-dyeing method in microendoscopic surgery for facet cysts.

METHODS Forty-eight consecutive patients who underwent surgical treatment with microendoscopic decompression for symptomatic LSS or LFS caused by facet cysts from 2011 to 2018 were reviewed. These patients were divided into two groups: a group that did not receive dye (N), with the patients undergoing surgery from April 2011 to May 2015; and a group that received dye (D), with patients undergoing surgery from June 2015 to March 2018. The authors evaluated the operative time, blood loss, perioperative complications, visual analog scale scores for low-back and leg pain, and Japanese Orthopaedic Association scores. Surgical outcome was evaluated 2 years postoperatively and was compared between groups D and N.

RESULTS The clinical outcomes were generally excellent or good. Group N consisted of 36 patients and group D of 12 patients. Comparing the clinical results, it was found that the cyst-dyeing method reduced the perioperative complication rate, including reduction in dural tears to 0%, and shortened the average operative time by approximately 40 minutes.

CONCLUSIONS In this study, the authors demonstrated that the clinical outcomes of microendoscopic spinal decompression in patients with LSS or LFS caused by facet-joint cysts are generally favorable. Additionally, the adjunctive cyst-dyeing method effectively delineated the cystic and dural boundaries, facilitating safer and more effective cyst separation and neural decompression. Microendoscopic surgery combined with this novel facet cyst-dyeing method is a safe and effective minimally invasive technique for facet-joint cysts.

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KEYWORDS endoscopic spinal surgery; facet-joint cyst; indigo carmine; lumbar spinal stenosis; lumbar foraminal stenosis; surgical technique

L umbar spine facet-joint cysts are a common cause of symptomatic lumbar spinal stenosis (LSS) and lumbar foraminal stenosis (LFS).1–5 The gold-standard treatment for symptomatic facet-joint cysts is surgical excision, with or without segmental fusion.1,4,6 Depending on the anatomical position of the facet-joint cysts, surgical procedures include hemilaminectomy, laminectomy, medial facetectomy, and total facetectomy, with or without fusion.4 Facet cysts are thought to result from intrinsic facet disease and inflammation, so the potential for cyst recurrence or symptomatic instability after decompression and the role of fusion for preventing these complications...
contribute to continued controversy regarding the ideal surgical management.7 Given the concern for postdecompression instability, there is a theoretical advantage to less-invasive approaches that maintain soft-tissue integrity during decompression.

There has been tremendous growth in the last decade of minimally invasive spinal decompression techniques using microscopic or endoscopic approaches to treat a multitude of spinal conditions.8-11 Microendoscopic spinal decompression techniques are advantageous over traditional open techniques, allowing for smaller skin incisions, limited tissue dissection, and improved visualization.9 Nonetheless, facet-joint cysts offer unique challenges resulting from adhesions between the cyst and dural sac. These adhesions present challenges both in terms of identification of a clear anatomical boundary and mechanical separation of the cyst and dura. These features result in a higher incidence of durotomy during decompression for facet cysts, and dural defects can be particularly challenging to repair in constrained surgical fields with minimally invasive approaches.

In 2015, our department (Department of Orthopaedic Surgery, Wakayama Medical University) developed a microendoscopic decompression protocol with an adjunctive cyst-dyeing technique, involving the injection of indigo carmine from the facet joint into the cyst, to characterize the cyst and anatomical boundaries (Fig. 1). This protocol’s impact and the efficacy of microendoscopic decompression for lumbar facet-joint cysts had not yet been evaluated.

This study aimed to evaluate the clinical outcome and perioperative complication rates of microendoscopic spinal decomposition for LSS or LFS caused by facet-joint cysts and to elucidate the efficacy of our adjunctive cyst-dyeing method in microendoscopic surgery for facet-joint cysts.

Methods

Study Design and Population

We retrospectively reviewed the medical records of all consecutive patients who underwent surgery for symptomatic LSS or LFS caused by facet-joint cysts at our institution between April 2011 and March 2018. All patients underwent posterior spinal endoscopic decompression surgery. The inclusion criteria were as follows: 1) neurogenic claudication or radicular leg pain with associated neurological signs, 2) LSS or LFS caused by facet-joint cysts on cross-sectional MRI, and 3) failure of conservative treatment for at least 3 months. Exclusion criteria were tumor, rheumatoid arthritis, arterial insufficiency of the leg, polyneuropathy, pyogenic spondylitis, destructive spondyloarthropathy, other combined spinal lesions, or previous back surgery.

Fifty-one patients met the initial criteria for inclusion. One patient who had rheumatoid arthritis and 2 patients who had arterial insufficiency of the leg were excluded. Thus, 48 patients were included in the final analysis (Fig. 2). These patients were divided into two groups: a group that did not receive a dye injection (N), with the patients undergoing surgery from April 2011 to May 2015; and a group that did receive a dye injection (D), with the patients undergoing surgery from June 2015 to March 2018.


Ethics Statement

All procedures performed in this study, as pertaining to human participants, were in accordance with the ethics standards of the relevant institutional research committee (the Research Ethics Committee of Wakayama Medical University) and with the 1964 Declaration of Helsinki and its later amendments. Informed consent was obtained from all participants.

Cyst-Dyeing Method

Before microendoscopic spinal decompression surgery, the facet cyst was dyed. For cyst dyeing, the patient was placed prone under general anesthesia. First, facet-joint arthrography (using 1 mL of contrast medium; IOVERIN 20 mg/5 mL, Daiichi Sankyo) was performed with fluoroscopic monitoring for any leakage outside the joint capsule. To avoid intrathecal injection of indigo carmine, it was also confirmed that there was no inflow of contrast agent into the medullary cavity. Then, 1 mL of indigo carmine (INDIGOCARMINE 180 mg/10 mL, Teva Takeda Pharma Ltd.) was injected into the cyst, without changing the needle (Fig. 1D). Thereafter, microendoscopic surgery commenced.

Surgical Procedures

Microendoscopic laminotomy (MEL)8,12 was performed in 45 patients with intraspinal canal stenosis, and microendoscopic decompression (MED) of the spine11 was performed in 3 patients with foraminal stenosis. The surgeries were performed by 3 endoscopic spine surgeons, who were certified by the Japanese Orthopaedic Association (JOA).

For the MEL, a skin incision of approximately 16 mm in length was made to target the interlaminar space. Sequential tubal dilators of the METRx endoscopic system (Medtronic Sofamor Danek) were inserted through the
incision. The microendoscopic procedure allows bilateral decompression of the central canal and bilateral lateral recesses via a unilateral approach. To preserve the facet joint's integrity, we developed custom-designed instruments, including a high-speed drill with a long, curved endoscopic bit (Midas Rex, Medtronic), and curved Kerrison rongeurs, to undercut the facet joint. Laminotomy was performed using the long, curved-bit high-speed drill. Decompression of the bilateral lateral recess was achieved via a medial trumpet facetectomy. The integrity of the facet joint was preserved using the curved Kerrison rongeurs.

For MED at L5–S1, under fluoroscopic guidance, the transverse process, lateral aspect of the L5–S1 facet, and sacral ala (thoracolumbar spine triangle) were drawn on the skin surface. A 16-mm skin incision was made, triangulated by the 3 bony structures of the thoracolumbar spine triangle, and a tubular retractor was introduced into the extraforaminal zone. After clear demonstration of the posterior surface of these bony structures, the lumbosacral ligament was first identified as a landmark for bony decompression. The lower border of the L5 transverse process, the upper border of the sacral ala, and the lateral osteophyte of the S1 superior articular process were drilled out until the lumbosacral ligament was released from the surrounding bony structures. After resection of this ligament, the L5 spinal nerve could be identified as a flattened nerve constricted by thick, dense fibrous tissue. After releasing the constricted fibrous band, further decompression was performed along the nerve laterally and caudally by additional resection of the sacral ala, if necessary. When the nerve was not completely released through this procedure and/or if concomitant foraminal stenosis was present, we attempted to remove the inferior half of the pedicle to enlarge the foramen, instead of removing the osteophyte and bulging disc at the L5–S1 segment. Violation of these structures and further resection of the facet joint and the pars interarticularis were avoided, mitigating the risk of inducing lumbar segmental instability after the operation.

Clinical Outcome Measurements

Outcomes were evaluated using the JOA scoring system for low-back pain before and 2 years after surgery. The JOA scoring system (full score = 29 points), visual analog scale (VAS) for low-back pain and leg pain (full score = 100 mm), and perioperative complications were used to measure neurological and axial pain outcomes. The JOA score is calculated as follows: JOA score recovery rate: = \frac{100 \times (postoperative JOA score - preoperative JOA score)}{(29 - preoperative JOA score)}. At the 2-year postoperative visit (a routine planned visit for all patients who underwent microendoscopic spinal surgery at our institution), the JOA and VAS scores were reevaluated. Successful treatment was defined as a recovery rate > 25%. Furthermore, the achievement of a minimal clinically important difference (MCID) (low-back pain VAS: decrease by ≥ 22 mm; leg pain VAS: decrease by ≥ 50 mm) was investigated.

We evaluated lumbar VAS scores (low-back pain and leg pain) as patient-reported items and JOA scores as medical staff–reported items. All other parameters were evaluated before and 2 years after surgery. All results were collated and analyzed independently from the operating surgeon.

Spinal instability was defined as follows: anterolisthesis or retrolisthesis > 2 mm or changes in disc angle > 10° on dynamic radiographs obtained before and 2 years after surgery. We also investigated the recurrence of facet-joint cysts and additional surgery.

Statistical Analysis

The Wilcoxon rank-sum test was used to compare preoperative JOA and lumbar VAS scores with the same scores assessed at the 2-year postoperative visit. The operation time, blood loss, perioperative complication rate, JOA recovery rate, success rate, and MCID achievement were also compared.
rate by lumbar VAS scores (low-back pain and leg pain) were compared between the group that received dye (D) and the group that did not (N). All statistical analyses were performed using JMP version 14 (SAS Institute), with the level of significance set at p < 0.05.

Results

Forty-eight patients (30 men and 18 women, mean age 69.1 ± 9.1 years) were included in the study (Table 1). Among the 48 patients, 21 (44%) had facet-joint cysts at L5–S1, 20 (42%) had cysts at L4–5, 6 (12%) had cysts at L3–4, and 1 (2%) had a cyst at L2–3. MEL was performed in 45 patients with intraspinal canal stenosis, and MED was performed in 3 patients with foraminal stenosis. Group N consisted of 36 patients and group D of 12 patients. The mean overall follow-up period after surgery was 4.8 years (57 months). Three patients (6.2%) who met the definition of having spinal instability were included in this series. Two of these patients were in group N and 1 was in group D. These patients had no significant difference in clinical outcome compared with patients without instability. All patients were surveyed 2 years after the surgery.

Overall, the mean operation time was 137 minutes. The mean blood loss was 17 mL (Table 1). Regarding perioperative complications, a dural tear was observed in 4 patients (all in group N); these tears did not affect the postoperative course in any of the patients. The VAS scores for low-back pain and leg pain at 2 years after surgery were significantly improved (p < 0.001). The achievement rates of an MCID for low-back pain and leg pain were 79.2% (38/48 patients) and 77.1% (37/48 patients), respectively. The average JOA score was 15.4 points preoperatively and 25.4 at the 2-year follow-up. The mean JOA recovery rate was 74.5%. The success rate of microendoscopic surgery was 93.8% (45/48 patients) (Table 2).

Comparing between groups D and N, the perioperative complication rate, JOA recovery rate, success rate, and MCID achievement rate for both low-back pain and leg pain were not significantly different between the groups (Table 3). Blood loss and the JOA recovery, success rate, and achievement rates of low-back pain MCID and leg pain MCID were good in both groups. The operative time was significantly longer in group N than in group D (p < 0.01). Furthermore, in group N, dural damage occurred in 12% of patients but in no patients in group D.

Representative Case

A 73-year-old man presented with left leg-pain and claudication symptoms. Lumbar MRI demonstrated extraradicular stenosis with facet-joint cysts on the left side at L5–S1 (Fig. 3A–C), and radiographs demonstrated no instability on flexion-extension images. Under general anesthesia, left L5–S1 facet arthrography with contrast and indigo carmine staining was performed fluoroscopically with the patient in the prone position. There was continuity between the cyst and the left L5–S1 facet joint. We performed MED surgery for left L5 radiculopathy. Using the cyst-dyeing method, the boundary between the cyst and dura was clear, and the operation could be performed easily and safely (Fig. 1C and D). The total blood loss and operative time were 10 mL and 70 minutes, respectively (Fig. 3E and F). The patient was able to mobilize and ambulate immediately postoperatively. His leg pain improved, and this improvement was sustained at the 2-year follow-up.

Discussion

In this study, we evaluated the clinical outcomes and perioperative complication rates of microendoscopic spinal decompression for LSS or LFS caused by facet-joint cysts and clarified the efficacy of an adjunctive cyst-dyeing method. The results showed that microendoscopic surgery is a safe and effective treatment for facet-joint cysts, with excellent outcomes in terms of pain relief and functional improvement.
ing method. The clinical outcomes were generally excellent or good. In comparing the clinical results of the group that underwent cyst dyeing (D) and the group that did not undergo cyst dyeing (N), we found that the cyst-dyeing method reduced the perioperative complication rate, including a reduction in the dural tear rate to 0%, and shortened the average operative time by about 40 minutes (Table 3). By dyeing the facet-joint cysts with indigo carmine, the anatomical boundary between the cyst and dura mater became very clear, facilitating safer and expedited cyst separation and neural decompression. While spinal endoscope-assisted surgery provides excellent visualization and perspective, the smaller surgical field creates constraints in terms of tissue separation and repair of dural defects. Therefore, the cyst-dyeing method was valuable and helped prevent common complications of endoscopic spinal surgery.

Facet-joint cysts are generally treated surgically with cyst removal and neural decompression with or without fusion. Facet cysts are thought to result from intrinsic facet disease and inflammation, so decompression alone carries a theoretical risk of symptomatic instability in the future. Fusion is considered as an adjunct to decompression, not only in instances of spondylolysis or when more extensive decompression results in facet compromise but also in avoiding postdecompression instability. Fusion procedures, however, carry the risk of adjacent-segment pathology and pseudarthrosis, as well as an increased incidence of a multitude of other complications, including deep vein thrombosis, wound complications, and infections, compared with decompression alone. Given the higher complication rate with fusion procedures and the concern for postdecompression instability after decompression alone, microendoscopic decompression procedures offer an attractive alternative strategy, by allowing for thorough decompression while maintaining soft-tissue integrity and mitigating the risk of postdecompression instability.

At our institution, we have performed microendoscopic decompression surgery for decades and have demonstrated in large case series that it does not result in spinal instability, due to maintenance of posterior supporting tissue, as compared with conventional decompression surgery. The results of the present study indicate that microendoscopic decompression surgery could provide good surgical outcomes for LSS or LFS resulting from facet-joint cysts.

### Table 3. Surgical results according to group

<table>
<thead>
<tr>
<th>Group</th>
<th>No. of patients</th>
<th>Mean op time, mins</th>
<th>Mean blood loss, mL</th>
<th>Periop complications, n (%)</th>
<th>Dural tear rate, %</th>
<th>Mean JOA recovery rate, %</th>
<th>Success rate, n (%)</th>
<th>Achievement of MCID, n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>12</td>
<td>107.5 ± 14.2</td>
<td>14.2 ± 3.6</td>
<td>0 (0)</td>
<td>0</td>
<td>79.5 ± 18.0</td>
<td>12 (100)</td>
<td>Low-back pain: 11 (91.7)</td>
</tr>
<tr>
<td>N</td>
<td>36</td>
<td>146.9 ± 40.2</td>
<td>17.8 ± 6.4</td>
<td>4 (11.1)</td>
<td>11.1</td>
<td>72.8 ± 28.7</td>
<td>33 (91.7)</td>
<td>Leg pain: 10 (83.3)</td>
</tr>
<tr>
<td>p Value</td>
<td></td>
<td>0.002*</td>
<td>0.069</td>
<td>0.228</td>
<td>0.228</td>
<td>0.453</td>
<td>0.301</td>
<td></td>
</tr>
</tbody>
</table>

Mean values are presented as the mean ± SD.
* Statistically significant.
† MCID for low-back pain: VAS score 22; for leg pain: VAS score 50.

![FIG. 3. Representative case. A: Parasagittal MR image showing that the left L5 nerve root is compressed from the rear (arrow). B: Axial MR image of the L5–S1 vertebrae showing a massive lesion compressing the left L5 nerve root (arrow). C: Coronal MR image showing the massive lesion compressing the left L5 nerve root (arrow). D: For cyst dyeing, the patient was placed prone under general anesthesia. First, facet-joint arthrography was performed with fluoroscopic monitoring for any leakage outside the joint capsule. Then, 1 mL of indigo carmine was injected into the cyst, without changing the needle. E: Intraoperative image showing removal of the dyed facet-joint cyst. F: Intraoperative image of the left L5 nerve root after removal of facet-joint cyst.](image-url)
cysts. In our follow-up, lasting over 2 years (average 57 months), there was no recurrence of facet-joint cysts, and there were no cases requiring additional fusion surgery due to spinal instability. Moreover, to carry out minimally invasive surgery more safely and expeditiously, this study introduced an adjunctive cyst-dyeing protocol and clarified its efficacy. The findings of this study indicate that microendoscopic surgery combined with the cyst-dyeing method is a safe and effective, minimally invasive treatment for facet-joint cysts.

This study has several limitations. First, facet-joint cysts are far less common than more typical causes of lumbar stenosis, making it difficult to amass larger cohort sizes for comparison. To gather enough data, this study required a retrospective design, which allows for some types of inherent bias. The second limitation of this study is that the two groups did not comprise cases from the same period, so there is a confounding factor of improving the operator’s knowledge and surgical technique. Therefore, it is difficult to attribute the decreased operative time and decreased incidence of dural tearing entirely to dyeing the cyst. The dural tear in the N group occurred in cases performed in 2014 and 2015 when the knowledge and skills had improved rather than when microendoscopic surgery was introduced for facet-joint cysts. Under such circumstances, we developed the cyst-dyeing technique as a method to avoid dural tearing. In the clinical setting, cyst staining has been found to help reduce surgery time and avoid dural tears, rather than improving knowledge and skills. Therefore, randomized controlled trials are needed to assess the usefulness of the cyst-dyeing technique, excluding confounders. This study also carries the limitation of a single-institutional outlook, where there is a high volume of microendoscopic procedures and high relative degree of technical expertise. The results, therefore, may not be reproducible in other clinical contexts. We would recommend prospective evaluation and multicenter involvement in the future, as a next step to further evaluate the role of microendoscopic decompression for lumbar facet cysts.

Conclusions

This study demonstrated that clinical outcomes for microendoscopic spinal decompression in patients with lumbar stenosis caused by facet-joint cysts were generally excellent. In addition, utilizing an intraoperative cyst-dyeing protocol during minimally invasive surgery for facet-joint cysts led to decreased complication rates and expedited operative times, due to improved identification of the boundary between the facet cyst and dura. Microendoscopic surgery combined with an adjunctive cyst-dyeing technique is a safe and effective minimally invasive treatment for facet-joint cysts causing lumbar stenosis.

References


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Author Contributions
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