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*Title Page

Endoscopic Discectomy of L5-S1 Disc Herniation via an Interlaminar Approach: Prospective Controlled Study Under Local and General Anesthesia

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Abstract

Study Design. Prospective, controlled study.

Objective. To evaluate the clinical results of endoscopic interlaminar lumbar discectomy at the L5-S1 level and compare the technique feasibility, safety, and efficacy under local and general anesthesia.

Summary of Background Data. Open discectomy remains the standard method for treatment of lumbar disc herniation, but can traumatize spinal structure and leaves symptomatic epidural scarring in more than 10% of cases. The usual transforaminal approach may be associated with difficulty reaching the epidural space due to anatomical peculiarities at the L5-S1 level. The endoscopic interlaminar approach may provide a direct pathway for decompression of disc herniation at the L5-S1 level.

Methods. Seventy-four patients with L5-S1 disc herniation underwent endoscopic interlaminar lumbar discectomy from October 2006 to January 2008 by two spinal surgeons using different anesthesia in two medical centers. Visual analog scale (VAS) scores for back pain and leg pain and Oswestry Disability Index (ODI) sores were recorded preoperatively, and at 3,6, and 12 months postoperatively. Results were compared to evaluate the technique feasibility, safety, and efficacy under local and general anesthesia.

Results. VAS scores for back pain and leg pain and ODI revealed statistically significant improvement when we compared with preoperative values. Mean hospital stay was statistically shorter in local anesthesia group. Complications included one case of dural tear with rootlet injury and two cases of recurrence within one month who subsequently required open surgery. There were no medical or infectious complications in either group.

Conclusion. Disc herniation at the L5-S1 level can be adequately treated endoscopically with an interlaminar approach. General and local anesthesia are both effective for this procedure.

Key words: lumbar disc herniation; percutaneous endoscopic discectomy; interlaminar approach; local anesthesia; general anesthesia.

***Key Points (3-5 main points of the article)**

Key points

1. This is the first report to compare clinical results, technique feasibility, safety, and efficacy of endoscopic interlaminar discectomy at L5-S1 under local and general anesthesia.
2. The endoscopic interlaminar operation provides an alternative route to overcome the anatomical peculiarities of the L5-S1 level that hinder the transforaminal operation.
3. The endoscopic interlaminar approach to L5-S1 disc herniation can achieve satisfactory clinical results with local or general anesthesia.
4. Under general anesthesia the joystick principle, medial and lateral as well as cranial and caudal mobility within the spinal canal, could be easily applied to search and remove the extruding disc by controlling optics and the bipolar system.
5. The most important contribution of local anesthesia to the endoscopic interlaminar operation is the surgeon can continuously receive feedback from patient to prevent neural damage and help to monitor clinical improvement during surgery.

***Mini Abstract (50 words)**

Mini-abstract

The interlaminar endoscopic discectomy can overcome the osseous limitations of the transforaminal approach at the L5-S1 level and it can be performed under local or general anesthesia.

Introduction

Open discectomy is still a standard procedure for treating lumbar disc herniation, and has provided good results. Nonetheless, one operative consequence is epidural scaring, which may not be apparent on MRI but becomes clinically symptomatic in more than 10% of cases.[1-3] Additionally, the occurrence of operation induced destabilization due to the necessary resection of spinal canal structures may result in post-discotomy syndrome.[3-5] In the past decades many new surgical techniques have been developed to reduce tissue damage and its consequences. Endoscopes have been used since the early 1980s to inspect the intervertebral space after completion of open discectomy. The endoscopic transforaminal procedure with posterolateral access evolved from this technique. Endoscopic assisted interlaminar procedures were reported in the literature in the late 1990s.[6-8] Lateral access of transforaminal endoscopic surgery to optimize the route to the spinal canal under continuous visualization has been performed since the late 1990s.[9] Currently, the most widely used endoscopic procedure in patients with lumbar disease is transforaminal surgery via the posterolateral approach; however, difficulty in achieving adequate resection of herniated discs within the spinal canal can occur.[10-15] The lateral approach can provide better access to the spinal canal under direct and continuous visualization. The transforaminal approach to L5-S1 is difficult in some cases because of anatomical constraints. A large L5 transverse process, large facets joint, a narrowed disc space, and neuroforamen with a high iliac crest all limit operative access to the L5-S1 disc space.[16,17]

In such situations, an interlaminar endoscopic discectomy has been used to overcome the anatomic limitations at the L5-S1 level, and it can be performed under local or general anesthesia. We present the technique and evaluate its feasibility, safety, and efficacy in patients undergoing general or local anesthesia.

■ Materials and Methods

There were seventy-four patients enrolled in this prospective study who had received endoscopic excision of lumbar disc herniation at the L5-S1 level via an interlaminar approach between October 2006 and January 2008 in two medical centers in middle Taiwan. All patients at least were followed up more than 12 months. Fifty were men, and twenty-four were women. The average patient age was 39 years (range, 18 to 61 years). All patients suffered from symptomatic leg pain, and underwent plain x-ray and magnetic resonance imaging (MRI) examinations. The duration of leg pain ranged from 1 day to 13 months (mean, 61 days). Eighteen patients with severe pain symptoms were operated on immediately, and 56 had received conservative treatment for at least for 6 weeks. All disc herniations occurred at the L5-S1 level with unilateral symptoms and correlated with image findings. General anesthesia (GA) was administrated by an anesthesiologist to 34 patients in one medical center when the operation performed by an orthopaedic surgeon and local anesthesia (LA) was used for the other 40 patients in another medical center when the operation was done by a neurosurgeon.

Follow up examinations were performed at 3, 6, and 12 months postoperatively. In addition to general parameters, visual analog scale (VAS) scores for back pain and leg pain and the Oswestry Disability Index (ODI) scores were recorded preoperatively and at follow-up visits. The descriptive analysis of group characteristics was performed with SPSS version 15.0 for Windows (SPSS, Chicago, Illinois, USA). The ANOVA test was applied to compare the clinical results of interlaminar endoscopic lumbar discectomy employed between local and general anesthesia. Statistical significance was assumed when $P < 0.05$.

Inclusion Criteria

Patients were included if they met the following criteria: 1) unilateral radiating leg pain that was more predominant than back pain; 2) MRI investigation revealed a single level posterolateral disc herniation at L5-S1 and correlated with the clinical findings; and 3) no previous surgery at the same level of the lumbar spine.

Exclusion Criteria

Patients with the following criteria were excluded: 1) recurrent disc herniation at the same level; 2) severe narrowing of the interlaminar distance < than 6 mm; 3) central or lateral stenosis of the lumbar spine; and 4) sequestering disc craniocaudal beyond half the adjacent vertebral body.

Operative technique

Surgery was performed with the patient prone on a radiolucent table under local or general anesthesia. The choice of anesthesia depended on the operation performed by the neurosurgeon or orthopaedic surgeon. The skin incision was made as close to medial in the craniocaudal middle of the interlaminar window as possible. A dilator, 7.0 mm in outer diameter, was bluntly inserted to the lateral edge of the interlaminar window, then an operative sheath with an 8.0 mm outer diameter and beveled opening was directed toward the ligamentum flavum (Figure 1). The rest of the procedure was performed under direct visual control and constant irrigation. A lateral incision window of approximately 4-6 mm was made in the ligamentum favum. The neural structures and epidural fat tissue were exposed (Figure 2). The operating sheath with beveled opening can be turned and used as a nerve hook. The joystick principle, medial and lateral as well as cranial and caudal mobility within the spinal canal, could be used to search for and remove the extruding disc by the controlling optics and bipolar system.

All the operating instruments and endoscopic system were supplied by Richard and Wolf (Knittlingen, Germany). The high-resolution endoscope has a diameter of 7 mm with a 4.2 mm intra-endoscopic working channel. The angle of vision is 25°. The working sheath has an

8.0 mm outer diameter and a beveled opening, both of which enable the creation of visual and working fields in an area without a clear, anatomically preformed cavity. In addition, a high-voltage bipolar probe (Ellman Innovations, New York, USA) was used.

■ Results

Clinical Outcome

A total of 74 patients were operated on between October 2006 and January 2008 for lumbar disc herniation at the L5-S1 level via the interlaminar approach. Forty patients at one medical center received LA and were operated on by a single neurosurgeon and 34 patients another medical center received GA and were operated on by a single orthopaedic surgeon. There were no statistically significant differences in patient demographics between the LA and GA group (Table 1). All patients were follow-up for more than 12 months. One patient in the LA group and one in the GA group had recurrent disc herniation (recurrent rate, 2.7%) within 1 month after surgery. Both were treated with an open procedure. One patient in the GA group was converted to open discectomy due to tear of the dural sac and rootlet injury. All patients in the LA group tolerated the procedure well, though some patients felt varying degrees of discomfort during the procedure.

The mean preoperative VAS score for back pain was 57.65 (range, 0-100), and for leg pain was 75.88 (range, 10-100), and the mean preoperative ODI was 48.49 (range, 14-84). At the 12 months after surgery, the mean VAS for back pain was 10.54 (range, 0-20), the mean

VAS for leg pain was 11.11 (range, 0-30), and mean ODI was 9.13 (range, 0-22) (Figures 3, 4, and 5). There was constant and significant improvement in back pain, leg pain, and daily activities in both groups after surgery ($P < 0.05$). There were no statistically significant differences in VAS or ODI scores between the LA and GA group. The mean operative time in the LA group was 72.07 minutes (range, 25-140), and in the GA group was 79.78 minutes (range, 50-130), but this difference was not statistically significant. The mean hospital stay in the LA group was 2.96 days (range, 2-5), and significantly shorter ($P < 0.05$) than 3.83 days (range, 3-5) in the GA group.

Perioperative Complications

No resection of spinal bony structure was required in either group. In the GA group, a case of dural injury and damage to the nerve rootlet occurred when we were removing the disc with a disc forceps. Only mild numbness and hypoesthesia in the distal leg and lateral foot were noted. There was no need to repair the dura and the patient's leg pain improved. Transient postoperative dysesthesia occurred in 13 patients (7 in the GA group, 6 in the LA group). There was no uncontrolled epidural bleeding, wound infections, or associated medical complications in either group.

■ Discussion

Success rates for conventional open discectomy for lumbar disc herniation from 75% to 100%.[18-21] The outcomes of lumbar discectomy do not seem to be affected by the introduction of the microscope and depend on patient selection rather than surgical technique.[22] From the point of avoidance or reduction of traumatic injury to spinal canal structures, endoscopic surgery may be an option for treating lumbar disc herniation. A patients preoperative functioning is attained to a high extent and rehabilitative programs are not needed after surgery.[23] Additionally there is no surgery related deterioration of existing symptoms in the epidural and intra-disc procedure.[24] Associated medical diseases do not increase the morbidity.

Yeung and Tsou[25] have improved the percutaneous transforaminal endoscopic technique by using the principles of targeted fragmentectomy under LA with the introduction of high resolution working channel endoscopes, lasers, and RF bipolar flexible probes. The technique is now more versatile after improvements in the endoscopic system and surgical technique. There are several anatomical peculiarities at the L5-S1 level that hinder the transforaminal approach to the L5-S1 disc space, including facets joint overlapping the disc space cephalocaudally and laterally. The transverse process at the L5 level is larger than in the upper lumbar spine. Ebraheim *et al*[26] have found the intertransverse space was the narrowest at the L5-S1 level (average, 13.4 mm ± 4.1 mm), compared with an average of 24 mm ± 3 mm at all the other lumbar intertransverse spaces in cadaveric dissection. All the above described anatomical peculiarities with high iliac wing hinder transforaminal access to the L5-S1 disc space. Although many different techniques have evolved to overcome these problems,[27-29] it is still difficult to access the migrated disc and centrally located disc herniation.

Ebraheim *et al*[30] found the interlaminar distance was greatest at L5-S1 level and the width of the interlaminar space was also a maximum of 31 mm (range, 21-40 mm). In the coronal plane, the L5 lamina is not directed vertically as the upper lumbar lamina, and it has a backward and downward angulation. This anatomical peculiarity helps to access the interlaminar space of the spinal canal at the L5-S1 level if the trajectory of the endoscope is 5 to 10 degrees in the caudal-cephalo direction. The spinal canal at the L5-S1 level contains the thecal sac with only the sacral roots and the proportion of free space at the L5-S1 level is also greater. The S1 root exits at the L5-S1 disc space with an average 22 degrees (range, 18-26 degrees) of take-off angle, and it is possible to access the herniation in the axilla of the S1 root within this angle.[31,32] In cases of a posterolateral herniated L5-S1 disc, the nerve root is displaced and this creates more space for entry because of the mass effect. Irrespective of the location in the shoulder or axilla areas, the mass effect of a herniated disc always has the same displaced vector to the nerve root.

The ligamentum flavum forms a tented recess with the apex in the midline and just inferior to the inferior edge of the cephalic lamina. The depth of this recess up to the dura measures 3 to 4 mm, and is usually occupied by epidural fat.[33] This depth may be partly obliterated in cases of a disc prolapsed in the canal. This recess forms the working space for the entry of the endoscopic in an interlaminar lumbar discectomy. The ligamentum flavum also has an essential biomechanical role, and any injury to it is likely to have negative consequences. Peridural fibrosis is the direct consequence of intrusion into the spinal canal with a break of this effective barrier.[34] The epidural fat, which acts as a lubricant, is largely preserved. Postoperative MRI revealed no scar in the access area and only slight scaring in the spinal canal. The revision procedures, unlike those following conventional procedures, were no more difficult and did not require a longer operative time.[34-35]

In cases with a large annular defect, the posterior third of the intra-disc nucleus should be cleaned to prevent recurrence. Because of the difference in level between the interlaminar window and the intervetebral disc space, resection of the intradiscal nucleus is frequently limited.[36,37] This might explain the shorter time period of recurrent disc herniation. The new endoscope with its 4.2 mm working channel and corresponding instruments has largely overcome the technical problems associated with previous devices.[38-40] The following advantages are gained from this surgical technique and endoscopic system: 1) good illumination and expanded field of vision with 25° optics; 2) cost effectiveness due to shorter hospital stay and reduced anatomical trauma; 3) reduced bleeding; 4) facilitation of revision surgery, 5) no need for postoperative rehabilitation, and 6) a high degree of patient satisfaction. The disadvantages of this technique are the steep learning curve and the expense of the equipment.

The clinical results of this prospective study are comparable to that with conventional procedures. Although a case of injury to the dura and rootlet occurred in GA group, we have not shown a definite difference in outcomes for VAS and ODI scores between local and general anesthesia. Both anesthetic techniques applied in endoscopic interlaminar lumbar discectomy at L5-S1 level achieved good outcomes and high patient satisfaction, but LA was associated with significantly shorter hospital stay. The patients in the LA group usually felt discomfort in the low back and leg during intraoperative manipulation of the dural sac and nerve root, but they tolerated the procedure well under mild conscious sedation with pethidine (25-50 mg intramuscularly) and fentanyl (1-2 ml intravenously). To prevent over irritation of dural sac and nerve root, we sometimes kept the working sheath out of the incision window of ligamentum flavum and extracted the extruded disc with other smaller instruments. The most important contribution of LA is that we can continuously get feedback from the patient to prevent neural damage and help to monitor clinical improvement during the operation.

We compared performing the surgery with local and general anesthesia because of the different problems that would potentially be encountered during surgery. The avoidance of intraoperative nerve injury might be easier due to intraoperative feedback from patients under

LA, but it is more difficult to use the working sheath as a nerve hook and to use the joystick principle to search for and remove the extruding disc. In contrast, GA affords freedom from discomfort, and allows manipulation of the instruments and retraction of the dural sac and nerve root in the spinal canal, but does not allow patient feedback. Most removal of the extruded disc was through the axillary area in the LA group and it was usually approached via the shoulder area in the GA group.

We conclude that endoscopic interlaminar discectomy at the L5-S1 level is a safe, effective operation, regardless of which method of anesthesia is used. Both anesthetic methods achieved good outcomes and high patient satisfaction. LA is associated with significantly shorter hospital stay and it affords continuous patient feedback to prevent neural damage and monitor the improvement of results during surgery.

Figure Legends

Figure 1. Intraoperative image showing the placement of the guide pin in the interlaminar window in anterior-posterior view (a, b) and blunt insertion of the dilator with the beveled working sheath to the ligamentum flavum (c, d).

Figure 2. Intraoperative endoscopic view showing, (a) incision of ligamentum flavum, (b) opening the ligamentum flavum and exposure of the axilla with dural sac, (c) extruded disc material in the axilla, and (d) dural sac with S1 root and axilla after decompression.

Figure 3. Mean values of VAS scores for back pain, leg pain, and ODI results in the local anesthesia (LA) group.

Figure 4. Mean values of VAS scores for back pain, leg pain, and ODI results in the general anesthesia (GA) group.

Figure 5. Mean values of VAS scores for back pain, leg pain, ODI in all patients.

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tables

Table. Demographic and preoperative clinical features of 74 patients

	Local Anesthesia	General Anesthesia	All patients
Patient number	40	34	74
Male	30	20	50
Female	10	14	24
Age	37.96 (8-55)	40.52 (20-61)	39.11 (18-61)
Hospital stay (days)	2.96 (2-5)	3.83 (3-5)	3.35 (2-5)
Operative time	72.07 (25-140)	79.7 (50-130)	75.54 (25-140)
ODI	47.87 (14-84)	49.25 (18-70)	48.49 (14-84)
VAS, back pain	55.36 (0-90)	60.43 (10-100)	57.65 (0-100)
VAS, leg pain	77.14 (10-100)	74.35 (10-100)	75.88 (10-100)

ODI, Oswestry Disability Index; VAS, visual analog scale.

Figure 1
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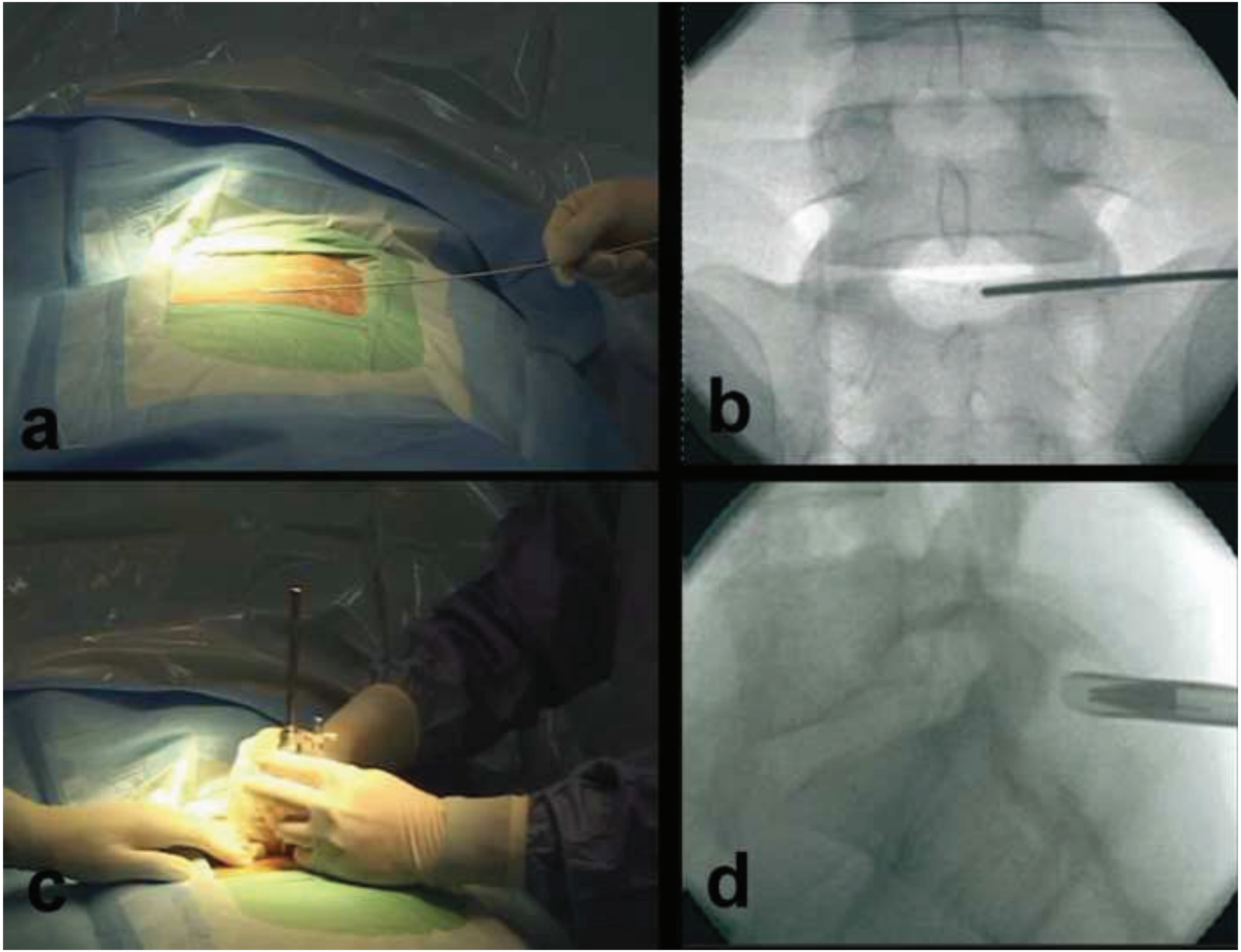

Figure 2
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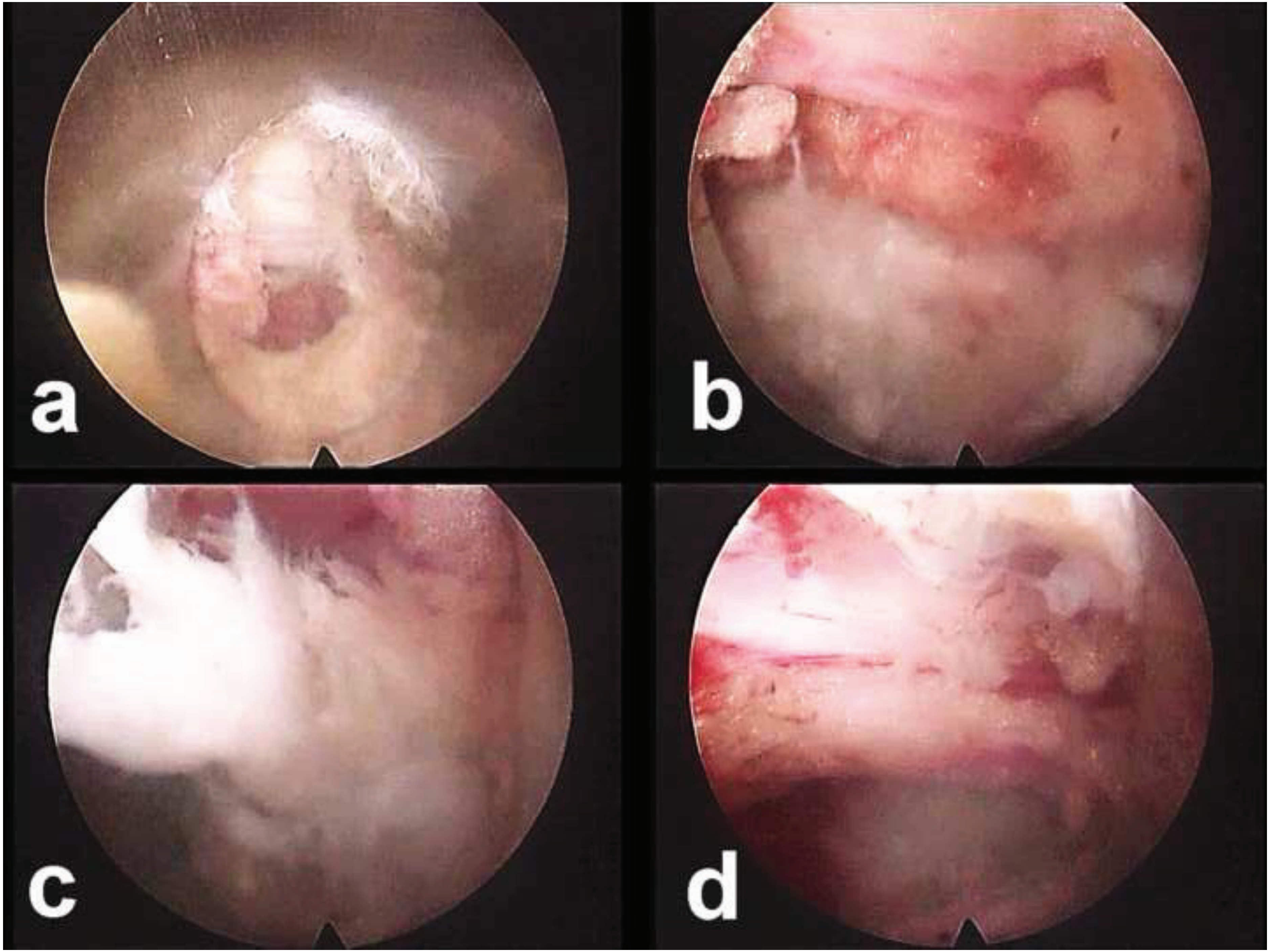

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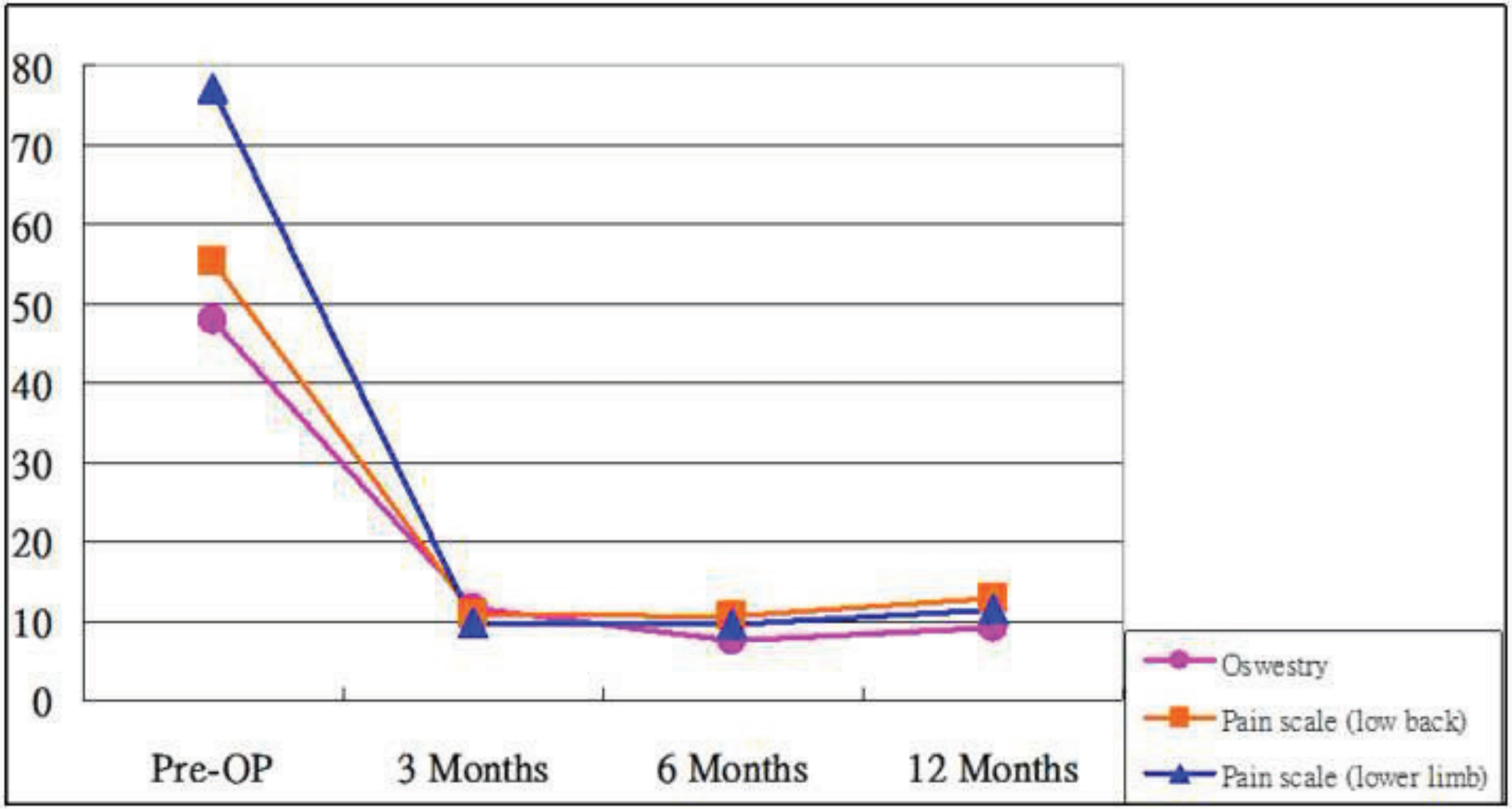

Figure 4

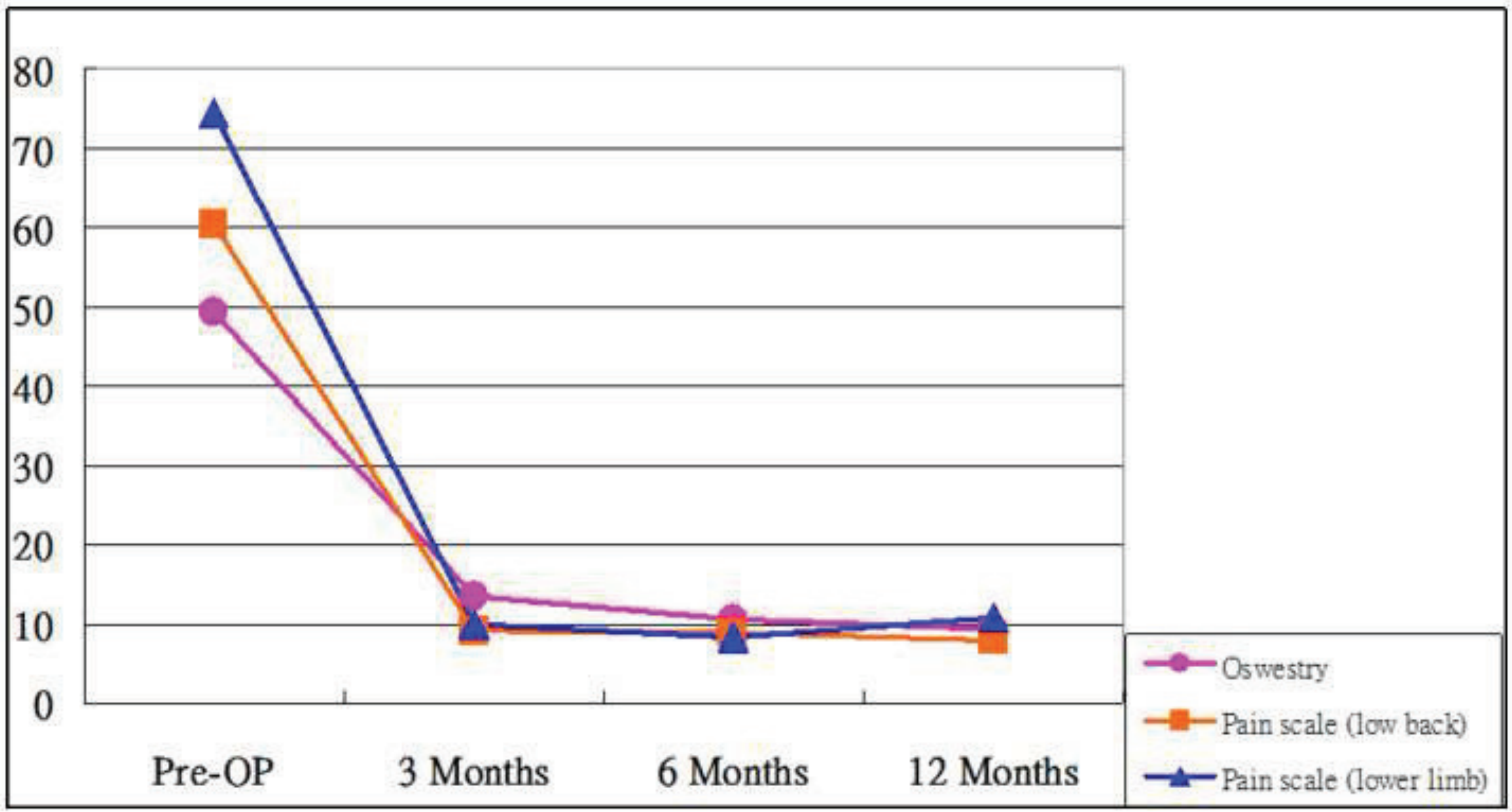
80
70
60
50
40
30
20
10
0
Pre-OP
3 Months
6 Months
12 Months
Oswestry
Pain scale (low back)
Pain scale (lower limb)

Figure 5
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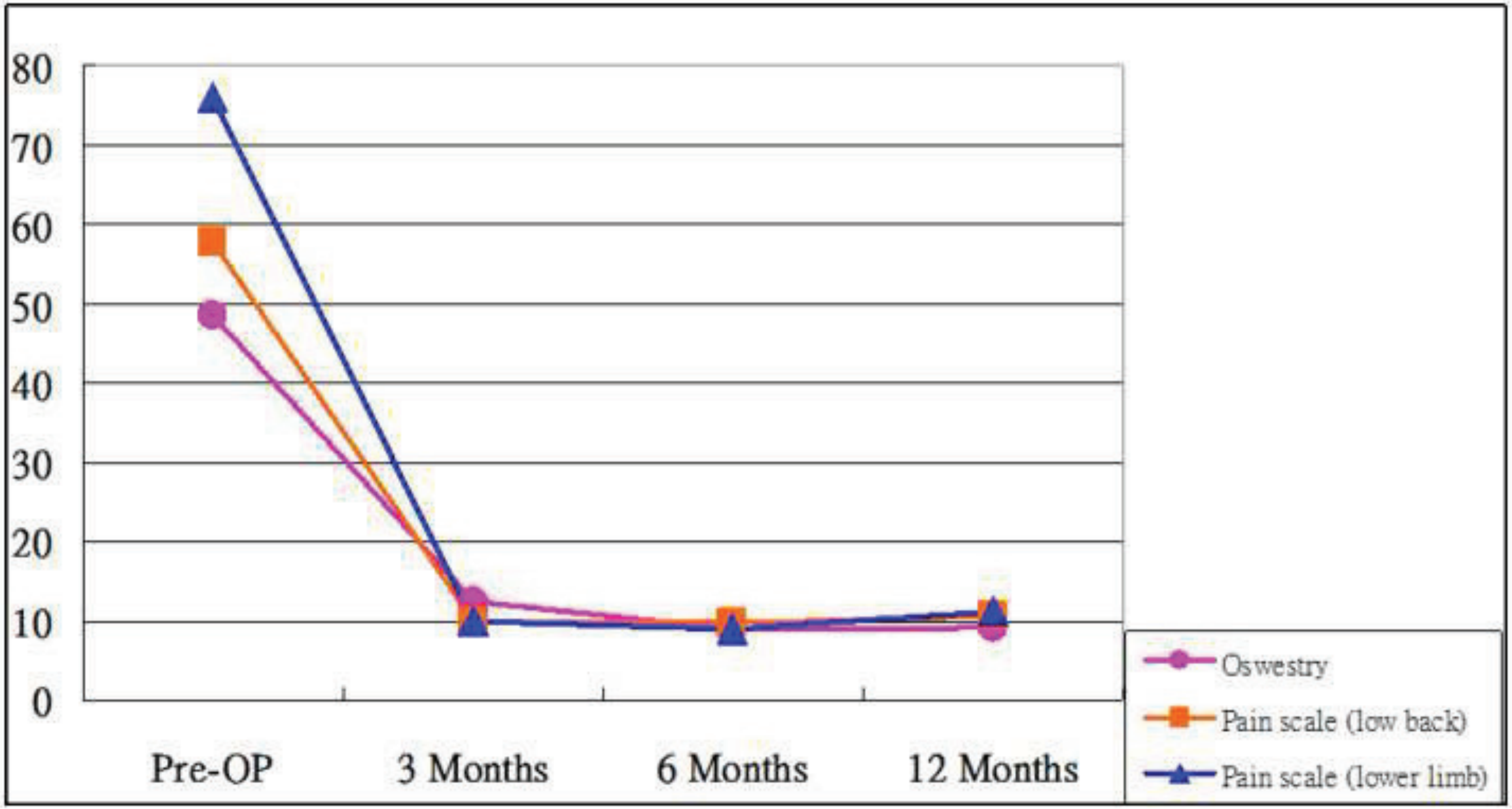

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