A comparison of the bilateral decompression via unilateral approach versus conventional approach transforaminal lumbar interbody fusion for the treatment of lumbar degenerative disc disease in the elderly

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Abstract

Background:

To investigate the early efficacy of the bilateral decompression via unilateral approach versus conventional approach transforaminal lumbar interbody fusion (TLIF) for the treatment of lumbar degenerative disc disease in the patients over 65 years of age, especially in the perioperative factors and the recovery of the soft tissue.

Methods:

The clinical data from 61 aging patients with lumbar degenerative disease who received surgical treatment were retrospectively analyzed. 31 cases who received the lumbar interbody fusion surgery with bilateral decompression via unilateral approach (BDUA) were compared with 30 cases who received conventional approach transforaminal lumbar interbody fusion. The radiographic parameters were measured using X-ray including lumbar lordosis angle and fusion rate. Japanese Orthopedic Association (JOA), Visual Analogue Scale (VAS) and Oswestry Disability Index (ODI) scores were used to evaluate the clinical outcomes at different time points. Fatty degeneration ratio and area of muscle/vertebral body were used to detect recovery of soft tissue.

Results:

All 61 patients received the BDUA approach and conventional approach transforaminal lumbar interbody fusion under general anesthesia. The BDUA approach group was found to have significantly less intraoperative blood loss and postoperative drainage compared to conventional approach transforaminal lumbar interbody fusion group. Symptoms of spinal cord and nerve compression were significantly relieved postoperatively, as compared with the preoperative state. However, the opposite side had a lower rate of fatty degeneration comparing to decompression side (P<0.05) six months after surgery in the BDUA group. While there were no significant differences (P>0.05) in two sides of conventional transforaminal lumbar interbody fusion approach group six months after surgery.

Conclusions:

Bilateral decompression via unilateral approach (BDUA) is able to reduce the intraoperative and postoperative body fluid loss in the elderly. The opposite side of depression in BDUA shows less fatty degeneration, which indicates better recovery of the soft tissue of the aging patients.

Background

Lumbar degenerative diseases are the most common spinal diseases in the aging population and are increasing in worldwide; among these diseases, lumbar degenerative disc disease is especially common. Between 2000 and 2009, 380,305 patients were diagnosed and underwent surgery, and the number of cases increased 2.4-fold in the United States[1]. The multifidus muscles, located on either side of the spinous processes, play an important role in stabilizing the joints within the spine[2]. Recent research has shown that among the paraspinal muscles, the multifidus muscle is associated with facet joint osteoarthritis, spondylolisthesis, and disc narrowing[3]. Imaging indicates that these diseases cause a decrease in muscle size and radiographic density, and an increase in fat deposits[4]. Recent research has shown that degeneration of the paraspinal muscles, especially the left muscle, are correlated with age[5]. The paraspinal muscles may also be replaced with fat in people with lumbar degenerative disease[6], and this replacement may be aggravated postoperatively[7]. In patients undergoing posterior lumbar interbody fusions, smaller area of the paraspinal muscles were associated with poorer fusion rates .8 In lumbar intervertebral disc surgery, bilateral decompression via a unilateral approach[9] (BDUA) has better results in terms of reducing the operation time, blood loss and other complications. However, no studies of prognosis, especially the recovery of the soft tissue, have reported using BDUA in an elderly population, such as in those over the age of 65. In addition, few studies have investigated postoperative multifidus muscle changes, particularly fatty degeneration. This study
retrospectively analyzed 61 patients who received lumbar fusion between January 2016 and April 2018, and compared BDUA and conventional approach transforaminal lumbar interbody fusion.

Methods

Patient data

The inclusion criteria were as follows: 1. Single-segment degenerative disc herniation and spinal canal stenosis with neurological symptoms. 2. Age over 65 years. 3. More than one radiographic examination: X-ray, computed tomography (CT), MRI or DTI confirming nerve root compression. 4. Good general condition

The exclusion criteria were as follows: 1. More than one segmental disc herniation. 2. Lumbago and no clear nerve root symptoms. 3. Advanced age (over 95 years). 4. Tumors. 5. Serious postoperative complications.

Lumbar disc herniation was combined with stenosis in L4/5 in 53 patients, L3/4 in 2 patients and L5/S1 in 5 patients. Group A received bilateral decompression via a unilateral approach surgery, and group B received conventional transforaminal lumbar interbody fusion approach. All patients underwent lumbar X-ray, three-dimensional CT, and magnetic resonance imaging (MRI) before surgery. After surgery, all patients were followed up for 26.2 months, with a range of 20–36 months.

Surgical methods

Bilateral decompression via unilateral approach (BDUA) group

Each patient was placed in prone position and intubated under general anesthesia. A paravertebral incision was made in the lesion intervertebral space. The paravertebral muscle space was obtusely separated. With the help of mini-retractor designed by ourselves[10], multifidus and the longissimus muscles were separated and the pedicle entry point was exposed clearly(Figure 1 A,B,C). The pedicle screw was inserted into the target vertebra, and the articular process was removed with bone biting forceps. The vertebral plate after c-arm X-ray fluoroscopy confirmed that the reduction was satisfactory. During this process, the nerve root and dural sac were protected. Then the inferior facet and approximately 1/3 of the superior facet were removed, the spinal canal was exposed, and the upper and lower laminar margins were removed depending on the specific conditions of spinal stenosis. Meanwhile, the protruded nucleus was removed, the intervertebral space was opened, and the cartilage of the vertebral endplate was removed for use in the bone graft fusion. The extracted articular process and lamina were used for granular packing in the intervertebral space, and the cancellous bone was compressed and placed into the intervertebral fusion cage. Wiltse’s approach was used to implant a contralateral pedicle screw. Finally, the incision was sutured after a negative pressure flow tube was placed. Figure 2A,C shows an intraoperative photographs and schematic diagram of this surgical approach.

Control group: conventional approach transforaminal lumbar interbody fusion.

Each patient was placed in prone position and intubated under general anesthesia. The pedicle screws were placed into the upper and lower vertebral bodies. The spinous process and bilateral lamina and ligaments were removed with bone biting forceps, whereas the ligamentum flavum and the medial edge of the articular process were removed according to the specific conditions of the disease. The nerve root canal and lateral crypt were expanded, and the dural sac and nerve root were protected intraoperatively. Then the annulus fibrosus was cut open, the nucleus pulposus was removed, upper and lower cartilage endplates were removed, and autologous bone particles were implanted between the vertebral bodies. The dural sac and nerve roots were then explored. Finally, the incision was sutured after a negative pressure flow tube was placed. Figure 2B, D shows a schematic diagram and intraoperative photographs of this surgical approach.

Postoperative management
All patients in the two groups had the drainage tube removed within 72 hours and rested in bed for 3 days. Then, they were allowed to ambulate with the assistance of a lumbar brace within at least the next six weeks. All patients were followed up every three months, and X-ray, CT and MRI scans were reviewed.

Clinical and radiological assessment

All patients were assessed with Japanese Orthopedic Association (JOA), Visual Analogue Scale (VAS) and Oswestry Disability Index (ODI) scores before and after surgery. In addition, all patients were followed up every 3 months after surgery with X-ray, CT and MRI of the lumbar spine. X-ray and CT were used to calculate the lumbar spine fusion rate, and X-ray was used to measure L1-S1 lumbar lordosis (Figure 3 A, B). As shown in Figure 4 A,B, MRI was used to detect the fatty degeneration and muscle/vertebral body ratio[11]. VB represents the vertebral body size, CSA represents the cross-sectional area, and SC indicates subcutaneous fat. The gray-scale range of the CSA and SC areas was analyzed in Image J software (National Institutes of Health, MD, USA), as shown in Figure 4C, D. The grayscale value of the CSA region overlap with the SC region in Figure 4E was used as an index of fatty degeneration of the multifidus muscle. In addition, the CSA/VB ratio indicated the degree of multifidus muscle atrophy. The surrounding layers of the lumbar fusion area were chosen to avoid metal interference.

Statistical analysis

All data were analyzed in SPSS 22.0 software (IBM Corporation, NY, USA) and are presented as mean ± standard deviation. A P-value of < 0.05 was considered statistically significant. The clinical and radiological assessments were analyzed with paired-sample t-tests to compare the changes.

Results

Perioperative conditions

All 61 patients received the BDUA approach or conventional approach transforaminal lumbar interbody fusion under general anesthesia. All operations were performed successfully without any injury to the nerve root. After the operation, no serious complications such as deep infection, nerve injury, cerebrospinal fluid leakage, deep venous thrombosis or pulmonary infection occurred. The vacuum drainage was removed within three days postoperatively and all patients were discharged three to four days after the operation. Symptoms of spinal cord and nerve compression were significantly relieved postoperatively, as compared with the preoperative state.

Clinical and radiological results

The general data are shown in Table 1, including sex, age, BMI, high blood pressure, diabetes and the segment of the herniated disc. These factors were not significantly different (P>0.05), thus excluding the influence of general factors on the results.

The average operation time for the BDUA group was 2.61 ± 0.78 hours, whereas that of the conventional approach group was 2.85 ± 0.68 hours. The operation times were not significantly different (P > 0.05). However, the BDUA group had the advantage of less Intraoperative blood loss and less drainage. The lengths of hospital stays between two groups has no significant difference. Clinical outcomes are shown in Table 3, including the VAS, ODI and JOA scores. Most of the scores between two groups were not significantly different. However, the VAS score of the BDUA group was 1.33±0.48, whereas that of the control group was 3.45±0.43. This result suggests that patients in the BDUA group had less pain in the early stages after surgery. However, at the last follow-up time, both groups showed significant pain relief. As shown Table 4, the fusion rate and lumbar lordosis between the groups were not significantly different (P>0.05). MRI was performed to detect recovery of soft tissue (Table 5). We chose the surrounding layers to avoid metal interference. Both the fatty degeneration ratio and area of muscle/vertebral body were not significantly different (P > 0.05) preoperatively. However, the affected side had a
higher rate of fatty degeneration six months after surgery in the BDUA group, thus indicating differences in postoperative recovery.

**Discussion**

Age is the most significant factor in lumbar degenerative disease, in both the osseous structures and soft tissues. In osseous structures, the vertebral height and disc height are influenced the most. However, the relationship between age and lumbar disc height remains controversial. Khan[5] has found that disc heights, especially those of the L3 segment and L2/L3 disc, are influenced by aging, whereas Bach, by using CT scans, has found no significant difference between middle-aged and elderly people. Variation in disc height is determined much more by sex than by age. However, recent research has clearly indicated that aging is related to the loss of lumbar curvature[12], fatty infiltration in the lumbar paravertebral muscles[13], and loss of extensor muscle strength[14]. With increasing age, the lumbar muscle fat content changes[15] and causes degeneration of the lumbar spine. Yanik also found a significantly higher fatty degeneration in the paravertebral muscle in patients with low back pain by using the chemical shift MRI.[16] In addition, the occurrence of low back pain after prolonged bed-rest can lead to the atrophy of the paravertebral muscle.[17] However, the paravertebral muscles, especially the multifidus muscles, are influenced the most during the operation.[18] Thus, protecting the paravertebral muscles may be a favorable option to improve the prognosis of aging patients.

TLIF, the most common approach in lumbar fusion surgery, was first proposed by Harms in 1982[19]. All degenerative diseases, including degenerative disc disease, disc herniation and spinal canal stenosis, are indications for the TLIF approach. However, TLIF may lead to significant paraspinal muscle injury because of the incision of the lumbar multifidus[20]. Therefore, we used the intermuscular space between the paraspinal muscles. BDUA, first proposed by Young[21], decreases pressure on the side with greater symptoms (including the joints, joint resection, and enlarged nerve root canal and vertebral canal) and involves fusion through intervertebral bone grafting. The treatment limits damage to the spinal rear structure and maximizes retention of structures and ligaments of the posterior components. In addition, the operation reduces the postoperative incidence of low back pain and maintains the stability of the spine. On the milder side, we used the Wiltse approach to avoid injury from muscle dissection. This approach, first reported by Wiltse[22], uses the clearance between the multifidus and latissimus muscles to access the vertebral lamina. Because of the clearance involves connective tissues and avoids vessels and nerves, this approach limits the possibility of vascular injury and neurological impairment[23]. After the operation, the lumen can close by itself without drainage; therefore, none of our patients had any drainage on that side. Patients receiving the Wiltse approach had less postoperative drainage. In addition, the multifidus muscles can assist in the patient’s lateral position, and the integrity of the multifidus muscles can reduce the postoperative recovery times of patients.

TILF and PLIF, the two common surgical approaches in lumbar fusion surgery, have been modified, and MIS-TLIF minimally invasive surgical methods have been proposed[24] [25]. MIS-TLIF may be efficient in the treatment of one-level lumbar stenosis[26], especially in obese patients[27]. However, MIS-TLIF is not suitable for degenerative disease affecting more than two segments, severe spinal stenosis, and grade II or higher spondylolisthesis, PLIF and TLIF cannot be substituted in some patients. BDUA has the advantages of reducing paraspinal muscle injury, operation time, operation expense, blood loss and postoperative bed time; therefore, it is preferred for elderly patients. This approach is also suitable for more than one segment. However, BDUA may not be suitable for patients with a herniated disc on both sides. Because it is beneficial to the slow postoperative recovery of elderly patients’ soft tissue, and because of the tendency for postoperative pneumonia, lower limb thrombosis, and other complications, BDUA is the preferred surgical method for most patients.

**Abbreviation**

CT: computed tomography; MRI: magnetic resonance imaging; VAS: visual analogue scale; ODI: Oswestry Disability Index; BDUA: bilateral decompression via unilateral approach; TILF: transforaminal lumbar interbody fusion; VB: vertebral body; CSA: cross-sectional areal; SC: subcutaneous fat
Declarations

Acknowledgments

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Conflict of interest

None of the authors have a conflict of interest to declare.

Author contributions

YH and JC carried out the acquisition and interpretation of data. PG and CG carried out the clinical data collection. JF, ZH and XC carried out the operation and radiological measurements. GY and WZ carried out the design of this study.

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Availability of data and materials

The data which analyzed during the study are stored in our hospital and are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

The study protocol was approved by the Ethics Committee of Jiangsu Provincial Hospital and written informed consent were obtained from all patients.

Consent for publication

Written informed consent for publication was obtained from all participants.

Competing interests

The authors declare that they have no competing interests.

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### Tables

**Table 1** Descriptive data and disease characteristics of patients

| Variable                      | BDUA     | Control  | P-Value   | Significance |
|-------------------------------|----------|----------|-----------|--------------|
| Sex                           |          |          | 0.3004*   | ns           |
| Male                          | 16       | 20       |           |              |
| Female                        | 15       | 10       |           |              |
| Age                           | 72.26±3.43 | 71.33±3.41 | 0.2956    | ns           |
| 65-70                         | 6        | 10       |           |              |
| 70-75                         | 14       | 14       |           |              |
| over 75                       | 11       | 6        |           |              |
| BMI                           | 24.85±2.93 | 24.87±2.10 | 0.9875    | ns           |
| High blood pressure           | 11       | 6        | 0.2546*   | ns           |
| diabetes                      | 4        | 5        | 0.7315*   | ns           |
| Segment of herniated disc     |          |          | 0.8068*   | ns           |
| L3/4                          | 1        | 2        |           |              |
| L4/5                          | 24       | 23       |           |              |
| L5/S1                         | 6        | 5        |           |              |

Note: Data shown as number or mean ± standard deviation. P < 0.05, significant difference.

*χ² test. Otherwise, independent samples t test.

BMI, Body Mass Index

**Table 2** Perioperative Factors and Postoperative Outcomes

| Variable                      | BDUA     | Control  | P-Value   | Significance |
|-------------------------------|----------|----------|-----------|--------------|
| Operation time                | 2.61±0.78 | 2.85±0.68 | 0.2132    | ns           |
| Intraoperative blood loss     | 153.9±102.9 | 251.7±156.1 | 0.0059    | **           |
| Drainage                      | 178.4±86.7 | 359.8±179.2 | <0.0001   | ****         |
| Days of hospital stay         | 10.35±3.49 | 12.07±3.59 | 0.0642    | ns           |
| Complications cases           | 3        | 2        | 0.94*     | ns           |
| Side of fusion                |          |          |           |              |
| Both                          | 0        | 30       |           |              |
| Left side                     | 13       | 0        |           |              |
| Right side                    | 18       | 0        |           |              |

Note: Data shown as number or mean ± standard deviation. P < 0.05, significant difference.

*χ² test. Otherwise, independent samples t test.

**Table 3** The VAS,ODI and JOA scores of patients at different time points
### Table 4 Radiologic assessments of patients at postoperation and follow-up

| Variable                  | BDUA      | Control    | P-Value   | Significance |
|---------------------------|-----------|------------|-----------|--------------|
| Fusion rate (% of patients) | 0.8814    | 0.8814     | 0.8814    | 0.8814       | ns           |
| 3 months                  | 93.8      | 93.3       | 0.8814    | 0.8814       | ns           |
| 6 months                  | 96.8      | 100        | 0.8814    | 0.8814       | ns           |
| last time                 | 100       | 100        | 0.8814    | 0.8814       | ns           |
| Lumbar lordosis           |           |            |           |              |              |
| 3 months                  | 44.79±8.15| 46.30±8.32 | 0.4797    | 0.4797       | ns           |
| Last time                 | 48.60±7.61| 51.50±3.35 | 0.0606    | 0.0606       | ns           |

Note: Data shown as number or mean ± standard deviation. P < 0.05, significant difference. Independent samples t test.

### Table 5 Fatty degeneration ratio and lumbar muscularity of the paraspinal muscles of two groups using MRI

| Variable                  | BDUA      | Control    | P-Value   | Significance |
|---------------------------|-----------|------------|-----------|--------------|
|                           |           |            |           |              |              |
| Fusion rate (% of patients) |           |            |           |              |              |
| 3 months                  | 93.8      | 93.3       | 0.8814    | 0.8814       | ns           |
| 6 months                  | 96.8      | 100        | 0.8814    | 0.8814       | ns           |
| last time                 | 100       | 100        | 0.8814    | 0.8814       | ns           |
| Lumbar lordosis           |           |            |           |              |              |
| 3 months                  | 44.79±8.15| 46.30±8.32 | 0.4797    | 0.4797       | ns           |
| Last time                 | 48.60±7.61| 51.50±3.35 | 0.0606    | 0.0606       | ns           |

Note: Data shown as number or mean ± standard deviation. P < 0.05, significant difference

Independent samples t test.
| Variable                              | BDUA                        | Control                      | p-value | Significance |
|--------------------------------------|-----------------------------|------------------------------|---------|--------------|
| Fatty degeneration ratio %           | preoperative 6-month Change (%) | preoperative 6-month Change (%) |         |              |
| Affected side                        | 7.96±2.86 11.68±3.08 2.69±2.24 | 8.59±3.77 11.38±4.60 2.79±4.57 | 0.9601  | ns           |
| Opposite side                        | 8.93±3.48 9.42±3.17 1.46±2.80  | 8.89±3.23 12.97±4.58 4.09±5.05 | 0.0143  | *            |
| p-value                              | 0.2893                      | 0.7472                       |         |              |
| Significance                         | ns                          | ns                           |         |              |
| Area of muscle/vertebral body %      |                             |                              |         |              |
| Affected side                        | 137.9±37.2 142.3±45.1 4.5±7.9  | 135.7±16.1 149.9±44.7 1.09±11.4 | 0.1781  | ns           |
| Opposite side                        | 149.4±36.0 150.9±39.9 1.5±16.1  | 136.8±37.3 145.7±36.8 -4.11±13.7 | 0.1039  | ns           |
| p-value                              | 0.1487                      | 0.1685                       |         |              |
| Significance                         | ns                          | ns                           |         |              |

Note: Data shown as number or mean ± standard deviation. P < 0.05, significant difference
Independent samples t test.

Figures
**Figure 1**

A, The self-designed mini-retractor B&C, Intraoperative usage of the self-designed mini-retractor and the exposure of pedicle entry point.
Figure 2

A&C, Intraoperative photographs (A) and schematic diagram (C) of bilateral decompression via unilateral approach; B&D, Intraoperative photographs (B) and schematic diagram (D) of bilateral decompression via unilateral approach.
Figure 3
Mesurement of the L1-S1 lumbar lordosis at preoperative (A) and postoperative (B) state.

Figure 4
Mesurement of the multifidus muscle: A&B, T2-weighted axial slices of the lumbar spine and the selection of the slices (B); C&D, The gray-scale range of the signal intensity histogram was measured within the cross-sectional area (C) and subcutaneous fat (D); E, The grayscale value of the cross-sectional area region overlap with the subcutaneous fat region.