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*Original Article*

# Comparative study of pressure in multifidus muscle between the classic Wiltse approach and the modified paraspinal muscle approach

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**Abstract:** The goal of this study was to compare the difference of internal pressure in the multifidus muscle under different deep fascia approaches via muscle pressure measurement, so as to provide the basis for clinical selection of deep fascia incision via the Wiltse approach. Twenty patients with lumbar vertebral degeneration were enrolled from September 2009 to January 2013. The patients were treated with different surgical approaches on both sides. One side used the classic Wiltse approach, where the median incision was made and followed by subcutaneous separation to the spinous process, then deep fascia was cut to intermuscular space. The other side used the modified paraspinal muscle approach, where deep fascia was cut along the supraspinous ligament and peeled off under fascia to intermuscular space. Self-designed retractors (2.5 cm-wide) were placed in both groups to measure muscle pressure under the tension of 0 N, 5 N, 10 N, and 15 N. Differences in pressure between patients in the two groups under four states were compared via paired experiment. The pressure on both sides of muscle under tension of 0 N was similar, and there was no difference between the two groups (P=0.139). Under tension of 5 N, 10 N, and 15 N, there were differences between the two groups (P<0.05), and with the increase of tension the pressure difference between the two groups was increased significantly. The incision site of deep fascia is an important factor affecting the pressure of multifidus muscle operation via the Wiltse approach. It is important to choose the appropriate incision mode of deep fascia for reducing the pressure and protecting the multifidus muscle.

**Keywords:** Wiltse approach, space between multifidus and longissimus muscles, muscle pressure measurement, spine

## Introduction

In 1968, Wiltse first described a spinal posterior approach through sacrospinous muscle, where the lateral spinal facet joint was reached through the space between the multifidus and longissimus muscles. The spinal posterior operation via such an approach is characterized by less bleeding, less tissue separation, and small trauma [1-4]. Initially the approach was mainly used for spinal fusion surgery, especially treatment of lumbar spondylolisthesis [5], through which the single-segment or multisegment fusion therapy could be performed. At the same time, the approach was also used for the extirpation of extremely lateral intervertebral disc [6] and the pressure of intervertebral foramen could be reduced via this approach to alleviate the extremely lateral nerve root compression [7]. Vertebral pedicle implantation or spinal canal could also be removed for decompression [8]. Previous studies have shown that separating the paraspinal muscles via traditional median surgical incision and long-time traction of paravertebral muscles during operation can lead to de-neurotrophy of paraspinal muscles, causing chronic lumbar spinal pain after operation, and failed lumbar surgery syndrome [9-11]. However, the paravertebral muscle space approach, namely the Wiltse approach, significantly decreased intraoperative traction of paraspinal muscles [12], significantly reduced exposure and implantation time, retained the integrity of posterior spinal structure and redu-

ced the possible muscle traction and heat injury [13], which contributed to the recovery of postoperative muscle strength [14, 15]. It has been recently reported that the percutaneous puncture screw-setting technique can better protect paraspinal muscles of patients receiving lumbar fusion [16-18].

In 1988, Wiltse improved his approach [8]. The median incision was made and peeled off subcutaneously to the starting point of fascia of intermuscular space, and then longitudinal incision was made in bilateral fascia to the intermuscular space, completing the operation. However, many problems are associated with the actual use of this approach. First, multifidus muscles in lower waist are relatively strong, so it is difficult to expose the facet joints and vertebral plate, and the muscle is easy to slip off repeatedly during operation. Second, as Wiltse described if the subcutaneous suture via the approach is not perfect, it is easy to cause local subcutaneous bursa synovialis and hematoma [8]. Based on modified paraspinal muscle approach, our approach used for a second time cut of the deep fascia directly along supraspinous ligament with peeling off under the fascia to provide a space between the multifidus and longissimus muscles. We expect that this approach can effectively reduce the block of deep fascia and reduce muscle pressure when pulling themedial multifidus muscle, making the exposure operation easier, avoiding the muscle slipping caused by excessive muscle pressure, and better protecting the multifidus muscle to reduce postoperative back pain. In this study, differences in internal pressure of multifidus muscle under the two approaches were compared through the following experiments, so as to test this idea.

## Patients and methods

### *Patients*

Inclusion criteria: patients with lower lumbar vertebral degeneration for whom surgery was ineffective after conservative treatment; patients with instability of the lumbar vertebrae, pure protrusion of the intervertebral disc, degenerative lumbar spinal stenosis, fibrous ring prolapse, or lumbar spondylolisthesis diagnosed according to patients' preoperative chief complaints and physical examination, combined with lumbar dynamic radiograph, lumbar nuclear magnetic resonance and lumbar CT scanning. Exclusion criteria: patients with mental disease; patients with a history of lumbar surgery; patients with degenerative scoliosis; patients with obvious muscle asymmetry on both sides of lower lumbar vertebra suggested by preoperative CT or magnetic resonance imaging; patients with definite surgical contraindication, such as severe heart disease, diabetes mellitus, renal failure, respiratory failure, coagulation dysfunction or other serious medical diseases; patients with severe osteoporosis (T value $\leq$-2.5 in dual energy X-ray absorption measurement); patients who refused to sign the informed consent. According to the above criteria, 20 patients were enrolled by Spinal Surgery Department in the First Affiliated Hospital of Nanjing Medical University from September 2014 to January 2017, including 10 males and 10 females.

### *Instruments*

Newton tensiometer: Digital pull-push dynamometer (Model: HF-200; YueqingBaogu Automation Co., Ltd.); pressure measuring device: CYY-1 automatic fascia pressure measuring instrument (Liyang Wanda Electronics Co., Ltd.); the self-designed retractor was 2.5 cm wide; see Instrument Design: an Exposure Device Used in Paraspinal Muscle Space Surgery.

### *Testing methods*

In TLIF surgery via the Wiltse approach, a median incision was made, the skin was cut and deep fascia was cut along the supraspinous ligament and peeled off under fascia to the space between the multifidus and longissimus muscles. Then the muscle attached to facet joint was peeled off using electric knife. The intermuscular space exposure device was used to place the retractor of spinous process vertebral plate and lateral retractor. The alternative approach was the modified paraspinal muscle technique, where about 4 cm-5 cm intermuscular space was separated and deep fascia was cut to place the 2.5 cm-wide intermuscular space exposure device. Measuring method: The muscle was fixed to tail end of vertebral plate connected with Newton tensiometer using sterile gauze, and the tension of muscle was controlled by the assistant. Muscle pressure was measured under the tension of 0 N, 5 N, 10 N, and 15 N using a muscle pressure measuring device (**Figure 1**). Note: The length of hydraulic connection pipe would affect the

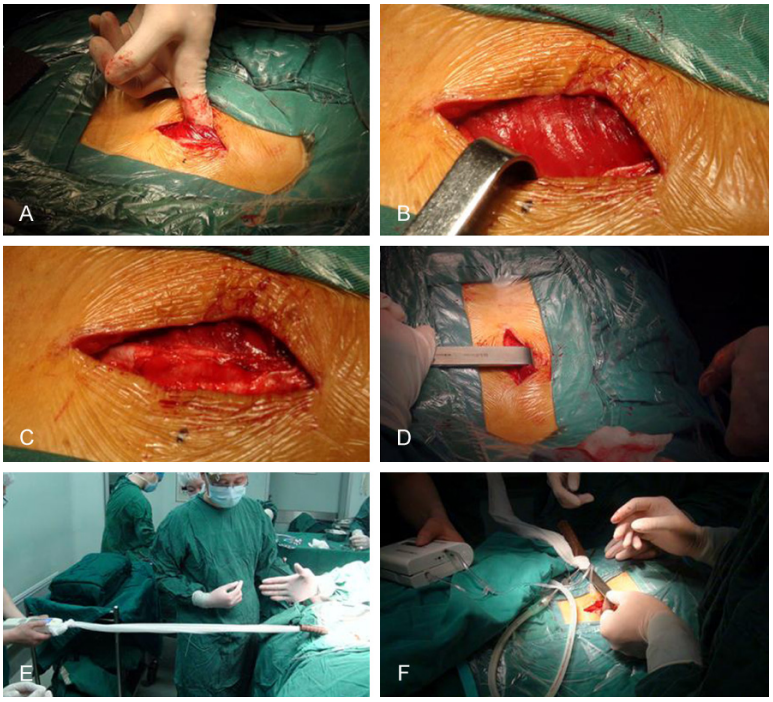


**Figure 1.** Detailed steps for measurement of muscle pressure. A: A median incision was made; B: Exposure of multifidus muscle; C: Isolation of deep fascia; D: Placement of wire retractor; E: Connection of the muscle pressure measuring device; F: Measurement of muscle pressure.

measured value. The same patient was tested using different lengths of hydraulic connection pipe with different values, so all operations used the hydraulic connection pipe with the same specifications. In the pressure measuring process, the retractor was pressed with a finger to prevent slippage, but only the slight vertical force was applied. The pressure measuring device needed to be at the same level as the muscle to be measured. If it was too high, the measured value would be lower or it would be higher. Operation was performed in strict accordance with the principle of aseptic technique, and the probe used in measurement was disposable and was not reused. Measuring instruments could not be sterilized and were not close to the operating table after being wrapped with sterilize cloth.

*Statistical analysis*

The measured pressure values are presented as mean ± standard deviation (SD). Comparison between groups was done using One-way ANOVA test followed by Post Hoc Test (Least Significant Difference). The percentage (%) was used to express the enumeration data and Chi-square test was used for data analysis, and paired t test was used for comparisons of differences among groups. $P< 0.05$ suggested that the difference was statistically significant, and all data were analyzed using SPSS 20.0.

## Results

*Demographic information of the included participants*

According to the inclusion and exclusion criteria, a total of 20 patients were enrolled in the study. Among, there are 10 males and 10 females with the average age of 55.4±7.1. According to the etiology, 2 had single-level lumbar instability, 11 with degenerative lumbar spinal stenosis, 2 annulus fibrosus prolapse, 4 lumbar spondylolisthesis (grade I-II), and another 1 with lumbar spondylolisthesis (grade III-IV). According to the surgical segments, 4 patients received operation at the level of L3/4, 9 at L4/5 and another 7 at L5/S1. Detailed demographic data of the patients are shown in **Table 1**.

*Pressure of multifidus muscle in 2 groups*

Our study showed different results of the pressure under different tension. First, we set the tension of the retractor at 0 N. The results show that the pressure on both sides of muscle was similar, and there was no difference between the two groups (P=0.139). However, under tension of 5 N, the measured data of pressure had a difference between the two groups ($p$=0.001) and with the increase of tension, the pressure difference between the two groups was increased significantly. Under tension of 10 N and 15 N, there were significant differences between the two groups (P<0.001) (**Table 2**).

## Discussion

Spinal surgery completed via the Wiltse approach can allow the spine surgeon to operate as conventional open surgery, and the posterior

**Table 1.** Demographic data for the enrolled patients

| | |
|---|---|
| Gender | |
| Male | 10 |
| Female | 10 |
| Age (year) | 55.4±7.1 |
| BMI | 22.69±2.98 |
| Etiology | |
| Single-level lumbar instability | 2 |
| Single disc herniation | 0 |
| Degenerative lumbar spinal stenosis | 11 |
| Annulus fibrosus prolapse | 2 |
| Lumbar spondylolisthesis (grade I-II) | 4 |
| lumbar spondylolisthesis (grade III-IV) | 1 |
| Segments | |
| L3/4 | 4 |
| L4/5 | 9 |
| L5/S1 | 7 |

**Table 2.** Comparison of pressure in multifidus muscle via different approaches

| Drag force (N) | Pressure in multifidus muscle (kpa) | | *P* value |
|---|---|---|---|
| | Classic Wiltse approach | Paraspinal muscle approach | |
| 0 | 0.38±0.18 | 0.36±0.16 | 0.139 |
| 5 | 3.93±0.77 | 3.26±0.73 | 0.001 |
| 10 | 7.05±1.27 | 3.99±0.73 | <0.001 |
| 15 | 10.01±1.76 | 4.56±0.78 | <0.001 |

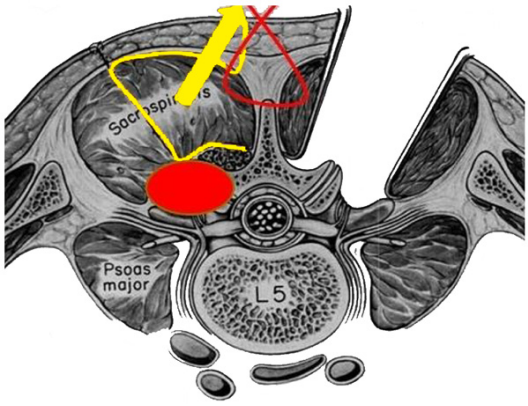


**Figure 2.** Schematic map for the modified Wiltse's Approach. The yellow line refers to the modified approach, and red region represents operation site, the arrow represents the direction of muscle movement after retraction and red line means suturepath from bilateral deep fascia to spinal ligament.

structure is retained completely, characterized by small trauma and rapid recovery after surgery. Now the incision via space between multifidus and longissimus muscles is generally determined based on anatomical data. In an anatomical study on intermuscular space with MRI of 200 patients [19] as the object of study, the distance of intermuscular space in deep fascia layer away from the midline was measured. Based on the results, it is recommended to make the single median incision in L1 to L3, and bilateral incision in L3 to S1. In the anatomical study based on MRI, the site of intermuscular space and exposure range were taken into account. Therefore, it is recommended to make the median incision in L1 to L4, and bilateral incision in L5 to S1. Ohtori et al. [20] selected the surgical approach from the perspective of distribution of nerve fibers, and she analyzed the differences in the distribution of nerve fibers between the traditional median vs. the Wiltse approach, and argued that the traditional open approach damaged more nerve fibers, but Wiltse approach through the bilateral incision damaged fewer nerves. It is recommended to select the bilateral longitudinal incision approach. Several studies have shown that intraoperative muscle pressure, including that caused by compression from surgery and inappropriate position, is closely related to the increased level of creatinine kinase after operation [21-24]. At the same time, a number of studies on intraoperative muscle pressure measurement have shown that the increased muscle pressure caused by intraoperative pulling of retractor is related to the postoperative muscle damage and postoperative low back pain [25-30]. As far as we know, in terms of the Wiltse approach, in addition to the above-mentioned anatomy and nerve fiber distribution factors, intraoperative muscle pressure is seldom considered. We compared the difference in muscle pressure on both sides in the same patient under different tension via different bilateral deep fascia approaches. The results suggest that the pressure measured in the two groups was different under the tension of 5 N and the pressure difference between the two groups was increased with the increase of tension. Under the tension of 15 N, modified paraspinal muscle approach reached 10.01± 1.76 kpa, while the modified paraspinal muscle approach we improved again was 4.56±0.78 kpa, the former of which was about twice of the latter. We believe that the main reason for the pressure difference under stress is the difference in anatomical structure. As shown in

**Figure 2**, in modified paraspinal muscle approach, the inner side of multifidus muscle was blocked by spinous process, the superficial site was blocked by strong deep fascia and the deep site was blocked by vertebral plate, and after retractor was placed, its lateral side was pulled by retractor, so the multifidus muscle is in a closed environment, and intraoperative pulling force will directly act on the muscles, leading to increased muscle pressure. This is the same as patients with osteofascial compartment syndrome, in which multifidus muscle produces the "osteofascial compartment-like effect" in the closed structure. If it lasts too long, muscle will be eventually damaged. In the modified surgical approach, due to the change in deep fascia incision, multifidus muscle can move to the dorsal side, thus avoiding the "osteofascial compartment-like effect". This is why the pressure in the modified surgical approach does not increase significantly under the same tension.

Pipinos et al. [31] argued that ischemia occurs when local blood perfusion cannot meet the needs of tissue metabolism. In the osteofascial compartment syndrome, the increased pressure in fascial cavity will increase the venous pressure, resulting in decreased arterial and venous pressure gradient and secondary local perfusion. Elevated venous pressure will block the venous return, forming the tissue edema. Lymphatic return increases at first, but will be also blocked with increased tissue edema; at this moment, arteriolebegins to bear pressure, leading to muscle and nerve ischemia. After ischemia for 30 minutes, nerve receptors will be changed first, such as paresthesia and hypaesthesia. After ischemia for 4-8 hours, the muscle function will be irreversibly changed, and the nerves will be irreversibly injured after 12-24 hours [31] it is generally believed that the diagnostic criterion of upper arm pressure in patients with osteofascial compartment syndrome is 8.66 kpa, while that of leg is 7.33 kpa. The experiment proved that the average pressure of muscle reached 7.05 kPa under the tension of 10 N, which was close to the diagnostic criterion of leg and the average pressure of muscle reached 10.01 kPa under the tension of 15 N, which was far more than the diagnostic criterion of osteofascial compartment pressure, so the muscle damage is inevitable for patients receiving long-term operation. Our study only confirmed the difference in muscle pressure under the two different approaches, so as to infer its damage effect on muscle. But the actual effect of this factor on muscle damage is still unknown. However, except its effect on muscle pressure, this approach has prominent advantages. First, the exposure of approach becomes simple and effortless due to the decrease in pressure. Second, the approach avoids skin necrosis, local hematomas and bursa cysts caused by wide subcutaneous dissection in classic Wiltse approach [8]. In addition, the approach forms a "labyrinthine" approach because it goes down through fascia, reaches the lateral facet joint through muscle space, and then goes inward (**Figure 2**) so after deep fascia is sutured, the soft tissue can be covered well locally within the operating field, protecting the surgical operation surface and effectively preventing infection. We determined the choice of surgical incision from a new perspective and provided a new way of thinking. However, the "labyrinthine" structure makes it difficult to expose, so a specially designed instrument is needed in exposure. Furthermore, the fascia needs to be pulled outside to expose intermuscular space, so the length of fascia to be cut is longer than that of modified paraspinal muscle approach, and the incision extension of subcutaneous fascia on both ends of surgical incision is a routine operating step.

In conclusion, the incision site of deep fascia is an important factor affecting the pressure of multifidus muscle operation via the Wiltse approach. It is important to choose the appropriate incision mode of deep fascia to reduce the pressure and protect the multifidus muscle, and expose the operating field.

## Disclosure of conflict of interest

None.

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