

Multilevel Magnetic Resonance Imaging Analysis of Multifidus-Longissimus Cleavage Planes in the Lumbar Spine and Potential Clinical Applications to Wiltse's Paraspinal Approach

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Study Design. Retrospective magnetic resonance imaging (MRI)-based study.

Objective. Our goal was to develop Wiltse's paraspinal surgical approach by determining the precise anatomic locations of the intermuscular cleavage planes formed by the multifidus and longissimus muscles. The primary objective was to measure the distances between the midline and the intermuscular planes, bilaterally, on MRI scans at each of the five disc levels between L1 and S1. Secondary objectives included identifying the existence of any correlations between patient demographics and the measured outcomes.

Summary of Background Data. In 1968, Wiltse described an approach to the spine using the natural cleavage plane of the multifidus and longissimus muscles as an entry to the posterior spinal elements. The small direct incisions lessened bleeding, tissue violation, and muscle retraction, which popularized Wiltse's approach among surgeons. A detailed description of the locations of the intermuscular cleavage planes at each lumbar disc level, however, is not available.

Methods. MRI scans of 200 patients taken during routine care (2007–2009) were retrospectively reviewed to gather measurements of the distances from the intermuscular cleavage planes to the midline, bilaterally, at each disc level from L1 to S1. Age, sex, and BMI (body mass index) were obtained to determine correlations.

Results. Mean measurements significantly differed between all disc levels. At L5–S1, the mean distance was 37.8 mm; at L4–L5, 28.4 mm; at L3–L4, 16.2 mm; at L2–L3, 10.4 mm; and at L1–L2,

7.9 mm. The mean female distances were significantly greater than males (2 mm) on both sides of L5–S1 only. No correlation was discovered between BMI, age, height (N = 50), or weight (N = 50) with respect to measured distances.

Conclusion. In the absence of any significant clinical correlation between patient demographics and the entry site in Wiltse's approach, the spine surgeon may use distances described in this paper to apply to a broad base of spine patients regardless of BMI, sex, or age.

Key words: Wiltse, paraspinal approach, lumbar, multifidus, longissimus, sacrospinalis, spine. **Spine 2011;36:1263–1267**

There are varying surgical approaches to the posterior spinal elements.^{1–4} Today's surgical culture favors minimally invasive procedures and tissue preservation, and there is a growing interest with respect to cosmesis.² The single incision, midline approach is common and standard practice when addressing the posterior spinal structures.⁴ In some cases, however, this approach favors dissection, detachment of stabilizing ligamentous structures, and tissue retraction.⁵ In 1953, Watkins described an approach in which he made two lateral cutaneous incisions and subsequently used the cleavage plane between the paraspinal muscles and the fascia overlying the transversus abdominis as his entry.³ His listed indications for this approach included: instability of the lumbosacral spine, Pott's disease (tuberculosis), neoplasm, and disc lesion.³ By 1959, Watkins argued that his approach to grafting the posterolateral spine would yield a higher percentage of successful results than could be obtained grafting through a single, expanded midline incision.⁶

In 1968, Wiltse described a bilateral transsacrospinalis approach (Figure 1A) that caused less bleeding and tissue dissection compared to the single midline incision approach.¹ Wiltse's approach allowed for more direct access to the transverse processes, pedicles, and even the intervertebral discs.^{1,2,4,5,7} It is beneficial when addressing pathology that can be accessed lateral to midline, such as a paracentral or lateral disc herniation. Wiltse stated that the intermuscular cleavage plane is particularly identifiable at the level of the L4–L5 disc, and he described incision sites for this level.² He stated that

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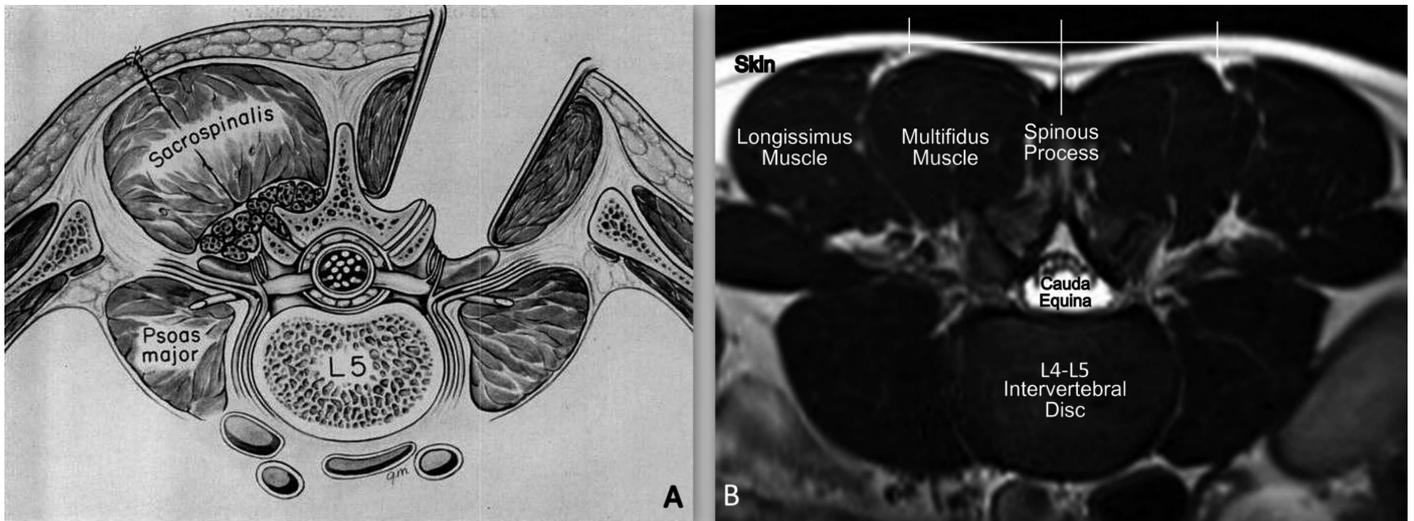


Figure 1. (A) Wiltse’s original approach, as described in 1968. Note that the cutaneous incisions are made directly over the intermuscular cleavage plane. Reproduced with permission from JBJS (www.ejbs.org).¹ (B) Axial MRI view at the level of the L4–L5 intervertebral disc with structures labeled. Measurements were taken between the marked midline and lateral points.

cutaneous incisions should be made “about one and three-fourths inches lateral to the midline.”¹ The sacrospinalis muscle would then be split “about two fingerbreadths lateral to the midline.”⁷ If needed, either iliac crest can be reached easily through the incisions made in this approach, and harvesting from one will usually provide enough bone for both sides.^{1,7}

Wiltse revised his approach in 1988 by replacing the pair of lateral cutaneous incisions with one midline incision (Figure 2). He reasoned that the midline scar was cosmetically superior to the two paraspinous scars and especially advocated the technique in cases of iterative surgery in which the patient already had a midline scar.² The 1988 approach

maintains the anatomic entry between the multifidus and longissimus muscles, though reaching it through the cutaneous midline incision is less direct and requires subcutaneous dissection.^{2,5} Wiltse emphasized the importance of suturing underrmined subcutaneous tissue to the deep fascia during the wound closure of his revised, less-direct technique. Without such suturing, seroma and hematoma formation would be common, an issue not frequently encountered in his original paraspinous approach.^{1,2,7} The two versions have since been compared and the initially described method appears preferable. The incisions are shorter and more direct, and therefore, it requires less subcutaneous dissection and soft tissue damage.^{1,2,5,7}

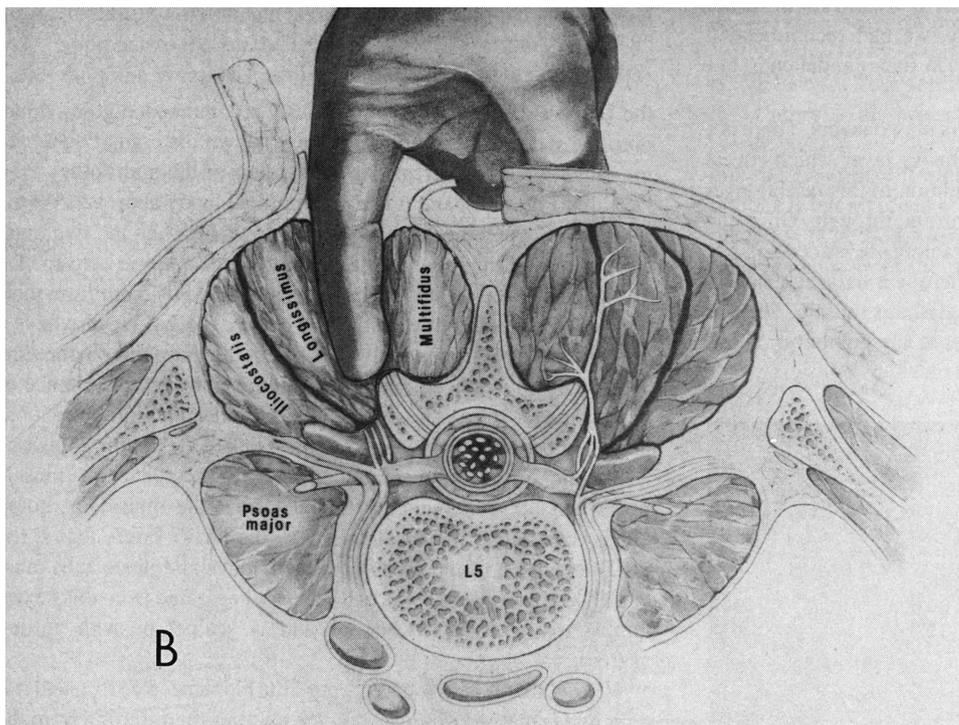


Figure 2. Wiltse’s revised approach, as described in 1988. Note the midline cutaneous incision and resulting retraction of skin. Reproduced with permission from Wolters Kluwer.²

TABLE 1. Descriptive Statistics for the Demographic Data

	N	Statistic	Age (yrs)	BMI (kg/m ²)
Female	128	Mean ± Std	50.5 ± 13.7	28.9 ± 7.4
		Median	50.4	27.7
		Min-max	18.7-75.0	18.0-54.0
Male	72	Mean ± Std	49.7 ± 15.3	29.3 ± 4.8
		Median	51.2	29.0
		Min-max	19.1-74.5	17.0-42.0
Overall	200	Mean ± Std	50.2 ± 14.2	29.1 ± 6.6
		Median	50.5	28.0
		Min-max	18.7-75.0	17.0-54.0

Shown are the mean ± 1 standard deviation, median, and range (minimum-maximum).

Std stands for standard deviation; Min, minimum; max, maximum.

Wiltse's 1988 article notes that the cleavage plane between the multifidus and longissimus muscles moves closer to the midline as one moves superiorly along the lumbar spine.² Today, more than 20 years later, a quantitative, detailed anatomic description of this trend remains unavailable; though in recent years cadaveric studies have provided some data.^{5,8,9} One study of 50 cadavers found the mean distance between the midline and intermuscular cleavage plane, at the level of the spinous process of L4, to be approximately 40 mm but did not measure any other lumbar levels.⁹ The available data, however, as yet lacks the thoroughness required to translate the aforementioned trend into a clinically significant refinement of the Wiltse approach. With ample collection of magnetic resonance imaging (MRI)-based measurements, we have created the first anatomic map of these areas in the

lumbar spine. This is clinically relevant because although the majority of lumbar patients in the United States receive an MRI or CT scan before surgery, some patients do not have access. Additionally, in some cases an MRI scan cannot be performed due to factors such as claustrophobia, pacemaker, spinal cord stimulator, pain pump, or body habitus, and occasionally CT cannot be performed due to the radiation exposure. If a patient falls into one of these categories yet has clear pathology, the average distances in this study may allow the surgeon to proceed without the absolute need for CT or MRI.

MATERIALS AND METHODS

This research was approved and monitored by the Loma Linda University Institutional Review Board (approval no. 59179). All patient identifiers were removed from the images before analyses by an observer blinded to the age and sex of the patient. MRI records of the lumbar spine of 200 patients (128 females, 72 males), taken between 2007 and 2009, were obtained and analyzed with IMPAX 6.3.1.3519 image viewing software (Agfa Corporation, Greenville, SC). MRI scans were taken with a 3-Tesla Siemens coil (Siemens Corporation, Washington DC) in the course of regular patient care. The inclusion criteria were that the MRI scan was recent, and that the patient was between 18 and 75 years of age when scanned. The exclusion criteria included the pediatric and geriatric populations, structural anomalies such as scoliosis or spina bifida, previous instrumentation or decompressive lumbar surgery, and MRI records demonstrating motion artifacts or poorer quality images, such as an open MRI. Patient indicators were collected from IMPAX and subsequently cross referenced using Powerchart 2009.09.1.42 electronic medical record software (Cerner Corporation, Kansas City, MO). Patient information was then collected and analyzed in conjunction with measurements obtained from the IMPAX software to identify any correlations. Patient information, as shown in Table 1, included body mass index (BMI; measured within approximately 3 months of the MRI scan date), age, and sex.

TABLE 2. Summary of Statistics for the Distance at Each Level

	Statistic	L1-L2	L2-L3	L3-L4	L4-L5	L5-S1
Females (N = 128)	Mean ± Std	7.9 ± 2.1	10.4 ± 2.9	15.9 ± 4.6	28.3 ± 7.6	38.5 ± 6.8
	Median	7.8	10.1	15.0	27.9	38.7
	Min-max	2.8-13.8	4.3-21.1	7.0-32.4	11.5-44.4	22.6-56.8
Males (N = 72)	Mean ± Std	7.9 ± 1.9	10.4 ± 2.8	16.8 ± 5.1	28.5 ± 6.7	36.5 ± 5.9
	Median	7.8	10.2	16.0	28.2	36.0
	Min-max	3.9-14.1	5.7-23.4	8.6-35.3	13.3-49.9	14.9-56.7
Overall (N = 200)	Mean ± Std	7.9 ± 2.0	10.4 ± 2.9	16.2 ± 4.8	28.4 ± 7.3	37.8 ± 6.5
	Median	7.8	10.1	15.5	28.1	37.3
	Min-Max	2.8-14.1	4.3-23.4	7.0-35.3	11.5-49.9	14.9-56.8

Shown are the mean ± 1 standard deviation, median, and range (minimum-maximum).

Std stands for standard deviation; Min, minimum; max, maximum.

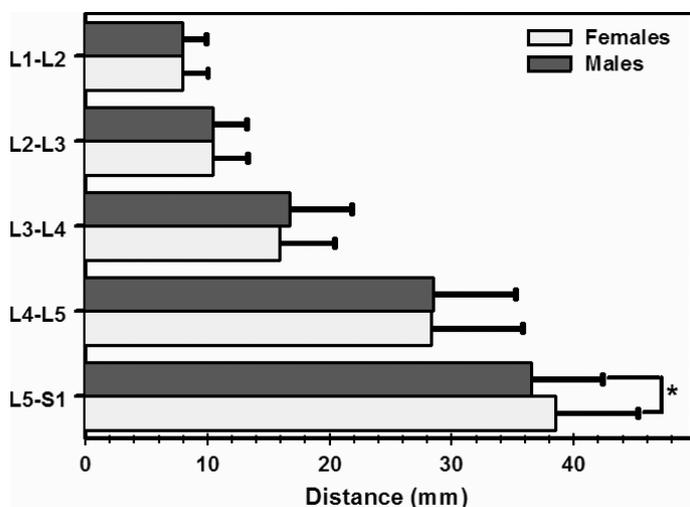


Figure 3. Mean distances measured at each level. The sexes differed significantly ($P < 0.05$) only at L5-S1. At L5-S1, the female mean was 2.0 mm greater than for males at the same level. A distance of 0 represents the midline.

Each intervertebral disc space was identified using a T2-weighted MRI. Axial images were used for our recorded outcomes (Figure 1B), with the aid of sagittal reconstruction for precise measurements. The caliper function in the IMPAX image viewing software was used to make our measurements. The intermuscular plane between the multifidus and longissimus muscles is curvilinear in the axial plane with its concavity facing the spinal elements and its convexity facing the lateral paraspinal skin. Additionally, the superficial end of the plane spirals medially as one moves superiorly along the spine.² This made measurements from the cleavage plane to the midline difficult to standardize. To represent the midline, a line was drawn, which bisected the intervertebral disc and spinous process, out to the skin. For consistency, lines paralleling this midline were drawn from the superficial-most points of the intermuscular planes, out to the skin. The distances between these lines and the midline were then measured (resolution = 0.05 mm) at skin level, bilaterally at each disc space, and recorded (Table 2). This was performed at each of the five disc levels between L1 and S1 in every patient. Interobserver error and intraobserver error was determined by way of four observers measuring five patients with four repetitions bilaterally, at every lumbar disc level. Interobserver error averaged ± 1.14 mm and intraobserver error averaged ± 1.18 mm.

Differences between the left and right sides, for the distance at each level, were analyzed with a paired *t*-test and with a nonparametric (Wilcoxon Signed Rank test) test. Differences for BMI and the distance at each level between sexes were examined by independent *t*-tests and by nonparametric (Mann-Whitney *U*) tests. ANOVA, in conjunction with Tukey tests for comparisons, were used to examine the differences between the five disc levels. Correlations were performed for age, and BMI, with distance at all disc levels. Power analysis was performed for nonsignificant differences and correlations.

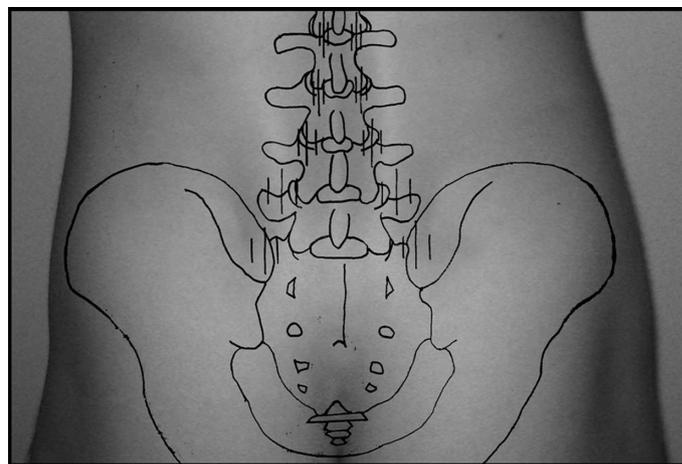


Figure 4. Mean locations of multifidus-longissimus intermuscular cleavage planes \pm one standard deviation, as measured in this study. From L5-S1 to L1-L2, lateral distances depicted (in millimeters) are: 37.8 ± 6.5 , 28.4 ± 7.3 , 16.2 ± 4.8 , 10.4 ± 2.9 , and 7.9 ± 2.0 .

RESULTS

Of the 200 patient MRI records used, 128 were females and 72 were males (Table 1). The mean female age was 50.5 ± 13.7 years, and the mean male age was 49.7 ± 15.3 years. Female mean BMI was 28.9 ± 7.4 kg/m² and male mean BMI was 29.3 ± 4.8 kg/m². The differences in age and BMI between females and males were not statistically significant ($P < 0.05$).

Smaller distances were indeed observed in each superior level of the lumbar spine. Overall mean values for L5-S1 through L1-L2 were 37.8, 28.4, 16.2, 10.4, and 7.9 mm, respectively (Table 2, Figures 3 and 4). Measurements between the midline and the intermuscular cleavage planes on the right and left sides did not significantly ($P < 0.05$) differ at any intervertebral disc level (L1-S1). Females and males significantly ($P < 0.05$) differed only at the L5-S1 level, where the mean female distance was 2 mm greater than the mean male distance. Distances measured at all levels significantly ($P < 0.05$) differed from each other. This was observed in each sex, as well as in the group overall. Distances significantly correlated between levels, with adjacent levels having the greatest correlation. No significant ($P < 0.05$) or strong ($r > 0.500$) correlations were observed between distance at any level and age or BMI.

DISCUSSION

The aim of this study was to determine the specific anatomic relationships of multifidus-longissimus intermuscular cleavage planes in the posterior lumbar spine quantitatively for all levels. These planes are the entry used in the Wiltse approach, and therefore an understanding of the factors influencing their specific locations is surgically relevant.^{1,2} Two hundred MRI scans were measured bilaterally at five lumbar disc levels, yielding the most comprehensive depiction of these areas to date. Up to now, the influences of age, sex, BMI, and disc level on the location of the multifidus-longissimus cleavage

plane were speculative.² This study suggests that disc level is the only factor of clinical significance in determining the intermuscular cleavage plane location, and thereby in determining the optimal cut site for the original Wiltse approach.¹

A study in which one author dissected 50 cadavers (23 females, 27 males; 33 embalmed, 17 fresh) to measure lateral cleavage plane distances at the level of the spinous process of L4 observed a range of 24 to 70 mm and a mean lateral distance of 40.4 ± 7.4 mm. At the L4–L5 level, the present study observed a lateral distance range of 11.5 to 49.9 mm and a mean lateral distance of 28.4 ± 7.3 mm. In the present study, bilateral measurements between easily identifiable points on MRI scans were taken in 200 patients, and mean interobserver and intraobserver errors were determined to be ± 1.14 and ± 1.18 mm, respectively. The cadaver study measured 50 dissected specimens bilaterally and did not report an intraobserver error. Difficulty in ascertaining necessary details prevents a proper comparison of the two studies, however, both found no difference between the sexes and the standard deviations were comparable.

A larger sample size can often strengthen a study, and this is no exception. We could increase the study's power by increasing our sample size, however, initial analysis shows so little variability that correlations between distances measured and BMI or age are not likely to be found. Inaccurate results could potentially be yielded from inconsistent measurement techniques. This was addressed and standardized by using the superficial-most point of each plane as the measurement point. The curvature among planes did vary though, so a possible future direction of this study might be to draw average vectors of the cleavage planes, out to the skin, and use those locations as measurement points. Additionally, this study excluded patients with certain structural anomalies and/or prior lumbar surgeries. The impact of these factors on the distance from midline to cleavage plane is unknown.

As the data in this study showed no significant correlation between distance and patient demographics, the measurements and descriptive statistical results could be used as guidelines to improve the precision of the Wiltse approach. In the upper levels of the lumbar spine (L1–L3), the intermuscular planes lie close to the midline (roughly 1 cm away at each level). For those levels, it can be argued that approaching through a single midline incision would yield preferred results over a dual-incision paraspinal approach, including the potentially reduced pain from one less incision and the improved cosmesis of a single scar.² In the lower levels of the lumbar spine (L3–S1), however, the intermuscular planes lie substantially farther from the midline (roughly 1.5–4 cm away). Here, it can be argued that the dual-incision paraspinal approach would yield preferred results over the midline approach, including reduced tissue disturbance and subcutaneous dissection, which may lead to seroma or hematoma formation.^{1,2,5} The outcome of this study is clinically desirable, as the surgeon can reliably apply distances found in this paper to

a broad base of spine patients without concern for age, sex, or BMI.

➤ Key Points:

- ❑ Surgeons often access spinal structures through the intermuscular cleavage plane formed between the multifidus and longissimus muscles.
- ❑ The exact locations of the intermuscular cleavage planes at all lumbar levels were unavailable in the literature.
- ❑ A retrospective MRI-based study (N = 200) was performed to determine the precise locations of these intermuscular cleavage planes at the disc levels between L1 and S1.
- ❑ Mean lateral distance from the midline differed significantly between levels, but showed no clinically significant correlation with age or BMI, and no clinically relevant differences with sex.
- ❑ From L5–S1 to L1–L2, the lateral distances were approximately 38, 28, 16, 10, and 8 mm, respectively.

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