A comparison of the Wiltse versus midline approaches in degenerative conditions of the lumbar spine

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OBJECTIVE The objective of this study was to determine if there is a significant difference in surgical site infection (SSI) when comparing the Wiltse and midline approaches for posterior instrumented interbody fusions of the lumbar spine and, secondarily, to evaluate if the reoperation rates and specific causes for reoperation were similar for both approaches.

METHODS A total of 358 patients who underwent 1- or 2-level posterior instrumented interbody fusions for degenerative lumbar spinal pathology through either a midline or Wiltse approach were prospectively followed between March 2005 and January 2011 at a single tertiary care facility. A retrospective analysis was performed primarily to evaluate the incidence of SSI and the incidence and causes for reoperation. Secondary outcome measures included intraoperative complications, blood loss, and length of stay. A matched analysis was performed using the Fisher's exact test and a logistic regression model. The matched analysis controlled for age, sex, comorbidities, number of index levels addressed surgically, number of levels fused, and the use of bone grafting.

RESULTS All patients returned for follow-up at 1 year, and adverse events were followed for 2 years. The rate of SSI was greater in the midline group (8 of 103 patients; 7.8%) versus the Wiltse group (1 of 103 patients; 1.0%) ($p = 0.018$). Fewer additional surgical procedures were performed in the Wiltse group ($p = 0.025$; OR 0.47; 95% CI 0.23–0.95). Proximal adjacent segment failure requiring reoperation occurred more frequently in the midline group (15 of 103 patients; 14.6%) versus the Wiltse group (6 of 103 patients; 5.8%) ($p = 0.048$). Blood loss was significantly lower in the Wiltse group (436 ml) versus the midline group (703 ml); however, there was no significant difference between the 2 groups in intraoperative complications or length of stay.

CONCLUSIONS The patients who underwent the Wiltse approach had a decreased risk of wound breakdown and infection, less blood loss, and fewer reoperations than the midline patients. The risk of adjacent segment failure in short posterior constructs is lower with a Wiltse approach.

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KEY WORDS spine; Wiltse; midline; surgical approach; lumbar

WITH an aging population and high expectations for a better quality of life, spinal fusion surgeries are being performed with increasing frequency in patients with significant medical and surgical comorbidities.^{11,12} Many of these patients have an increased risk of postoperative wound infection and reoperations and

longer hospital stays with increased costs of care.^{1,20,23–25} As a result, surgeons are examining options to reduce surgical site infection, and in doing so have revisited the utility of the Wiltse paraspinous approach as a potential alternative to minimizing wound complications in this high-risk group of patients.^{2,3,6,8,11,16}

ABBREVIATIONS BMP = bone morphogenetic protein; SSII = spine surgical invasiveness index.

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The Wiltse approach to the posterior lumbar spine was first described in 1968. It was proposed as an alternate direct approach to the facet joint and transverse process, rather than the conventional midline approach.^{34,35} As a muscle-splitting approach through the sacrospinalis muscle and between the multifidus and longissimus, the Wiltse approach theoretically leads to less tissue destruction and blood loss and potentially improved postoperative pain. With time, the approach evolved to be applicable to multiple indications with a growing number of proposed advantages, including the facilitation of 2 surgeons working concurrently, more direct pedicle screw insertion trajectories, easier decompression of far lateral disc herniations, and a surgical trajectory that enables decompression of the contralateral canal.^{7,36} One of the potential limitations of the Wiltse approach is that central decompression is technically more difficult to achieve, but this is overcome as one gains familiarity with the approach.^{30,31}

There are numerous studies that have evaluated the effect of dissection time and extent of surgical retraction during midline spine surgery on local muscle function, vascularity, and viability. Studies in animals and humans have consistently shown that prolonged paraspinal muscle retraction predisposes patients to increased pain and a higher degree of tissue necrosis and puts them at a potentially greater risk of infection.^{2,9,10,18} Methods for minimizing soft-tissue injury have been proposed. Minimally invasive technologies have taken advantage of the paraspinal approach by way of percutaneous access points.

In this study, we compared the paraspinal Wiltse approach to the standard posterior midline approach in patients who underwent 1- or 2-level decompression with interbody fusion of the lumbar spine. The primary objective was to determine the difference in the rates of postoperative surgical site infection through a rigorous matched analysis. Secondary objectives included comparing the reoperation rates and evaluating the specific causes for reoperation.

Methods

Study Design

A retrospective cohort of consecutive patients with prospectively collected data who were admitted for surgical management of degenerative lumbar spine conditions were identified and enrolled between March 2005 and January 2011. Only patients with a full data complement over a 2-year follow-up period were included. Our methods for prospectively collecting adverse event data have been previously published.^{19,27,28} All patients underwent decompression and pedicle screw instrumentation through either a standard midline or Wiltse approach. The standard technique with either approach at our institution is to perform a complete facetectomy of at least 1 of the facets and insert the interbody cage through the foramen (transforaminal lumbar interbody fusion) while visualizing and protecting the exiting and traversing nerve roots. All patients had an interbody device inserted. Patients underwent a complete laminectomy if a midline approach was used, or a full laminectomy if a Wiltse approach was chosen. A standard Wiltse interval through the longissimus and multifidus was used, and the facet joint capsule was ex-

posed. After pedicle screw instrumentation, the facet joint was removed/osteotomized. If further central decompression was required, the soft tissues were dissected off the lamina more medially to allow for bilateral laminectomy and flavectomy while carefully protecting the dura and displacing the cauda contents ventrally. A full central decompression was achieved with this approach.

Those patients included for analysis had a primary diagnosis of degenerative lumbar pathology with instability (degenerative/isthmic spondylolisthesis or anticipated intraoperative facet resection) and required a 1- or 2-level instrumented fusion. Patients were excluded if they had a traumatic spinal injury, tumor, or preoperative neurological deficit or required noninstrumented fusion or greater than 2-level fusion. A 2% chlorhexidine with isopropyl alcohol skin preparation was used on all patients preoperatively at 1 day before their operation and immediately preoperatively. Standard antibiotic prophylaxis was also used in all patients.

Patient Outcomes

Patient age, sex, prior spine surgery, and medical comorbidities were recorded preoperatively using a standardized format. Patients were categorized into 1 of 5 age groups for the purposes of this analysis (age ranges 17–44, 45–54, 55–64, 65–74, and ≥ 75 years). These categories facilitated comparisons between more comparable patients with roughly equal numbers in each group. The total operative time and intraoperative and postoperative blood loss were recorded by a blinded observer. The number of levels fused, bone graft type/bone graft substitute, and incidence of intraoperative adverse events (e.g., unintentional/incidental durotomy, hardware malposition requiring revision) were recorded. Bone morphogenetic protein (BMP) (Medtronic) was used at the surgeons' discretion.^{13,33} The length of stay in the hospital was calculated for both groups based on the day of admission and discharge. Finally, the spine surgical invasiveness index (SSII) was calculated for both groups to ensure that any treatment heterogeneity based on the diagnosis was accounted for by comparing similar cases in terms of their risk of infection. SSII was reported to ensure that each group was comparable based on the complexity of the surgical case, and SSII represents the best predictor for risk of infection.^{4,22}

All study patients were evaluated clinically and radiographically at 3, 6, and 12 months following surgery. All clinical encounters for 2 years were included in the data analysis of this study. Our referral/re-referral patterns and geographic demographics are such that all subsequent clinical encounters would have presented back to our quaternary care center. Surgical site infection and the need for a repeat surgical procedure were recorded throughout the study period. Infection was recorded using the definition of the Centers for Disease Control and Prevention.¹⁴ A wound infection was documented by positive intraoperative cultures and demonstrated erythematous skin changes and purulent discharge. A wound complication included wound dehiscence without positive intraoperative cultures with minimal erythema or discharge. When repeat surgery was needed during the study period, fusion was assessed radiographically or intraoperatively by the direct

observation of any fusion mass present and mechanical manipulation of the surgical levels.¹⁷

Statistical Analysis

The statistical analysis was performed using the SPSS statistical software package (version 22.0; SPSS). We performed a matched analysis since we expected to find differences in patient characteristics between approaches. To ensure a more robust comparison, we controlled for potential confounders and analyzed the data using the Fisher's exact test, odds ratios, and 1-sided p values.

For the matched analysis, 1 midline patient was matched to 1 Wiltse patient based on sex, age group at admission (17–44, 45–54, 55–64, 65–74, or ≥ 75 years), preoperative comorbidities (diabetes, other, or none), number of index operative levels (1, 2, or 3), number of instrumented vertebral levels (1 or 2), and bone graft used (autograft only, autograft and synthetic autograft [i.e., not BMP], or BMP/BMP only/none).

For the secondary analysis, a logistic regression model comparing the odds of an additional admission requiring repeat surgery versus the approach (midline or Wiltse) was performed. This was also done to control for as many variables as possible in a matched fashion. Finally, a tertiary analysis evaluating the reasons for reoperation was performed.

Results

A total of 358 patients were included in the final analysis. No patients were lost to follow-up at 1 year, and the adverse event and reoperation data were collected for a total of 2 years after the index procedure. Two hundred fifty-five patients underwent a midline approach, and 103 patients underwent bilateral Wiltse approaches. The most common indications for surgery were isthmic spondylolisthesis and degenerative spondylolisthesis. Table 1 lists the complete diagnostic details and primary surgical indications for all midline and Wiltse patients. There was a statistically significant difference in patient age, with the Wiltse group being younger by approximately 5 years (Wiltse 54.6 years vs midline 59.6 years; $p = 0.002$). Wiltse patients differed in terms of the number of levels addressed surgically, in addition to the number of instrumented levels, demonstrating a significantly higher number of 1-level surgeries. Only 1-level surgery was performed in 81 of 103 Wiltse patients (78.6%), whereas midline surgeries tended to address more vertebral levels; only 154 of 255 (60.4%)

patients underwent 1-level instrumented surgery as the index procedure ($p < 0.001$).

BMP augmented with a local autograft was used significantly more often in the Wiltse group (60.2%) than in the midline group (43.9%) ($p < 0.0001$). Midline patients also relied on local autograft alone (46.3%) for a greater majority of cases ($p < 0.0001$). No other differences existed with regard to using BMP alone or another synthetic bone graft (Table 2). A mixture of BMP and local bone autograft was placed within the interbody device and along the transverse processes after decortication. There were no significant differences in the use of iliac crest bone graft between the groups ($p = 0.865$).

There was no difference in the mean length of the procedure, with midline surgeries lasting roughly 4.1 hours and Wiltse surgeries lasting 3.9 hours ($p = 0.263$). Intraoperative blood loss was significantly lower in the Wiltse group (average 436 ml), whereas the midline group lost on average 703 ml ($p < 0.001$). The incidental durotomy rate was the same for each group (4.5% midline vs 4.9% Wiltse; $p = 0.805$). The average length of stay for midline patients was 1.5 days longer than the Wiltse group. Although this finding is clinically significant, it was not found to be statistically significant ($p = 0.069$). There was no significant difference in patients requiring a repeat surgery during their hospital stay for infection, hardware malposition, or pseudomeningocele ($p = 0.363$). Table 3 details all variables that were compared and demonstrates that there were no other significant differences when comparing approaches. The groups were similar in terms of complexity, and SSII was 10.74 ± 2.63 for the Wiltse group and 10.54 ± 2.72 for the midline group.

To additionally control for these differences, a matched analysis was then performed. It was possible to match 66% of the cohort for all 6 possible confounding variables, and 85.5% of the cohort was matched for 5 or more variables (sex, age, preoperative comorbidities, number of index operative vertebral levels, number of instrumented vertebral levels, and bone graft used). For example, 85.5% of patients were matched for sex, age, preoperative comorbidities, number of index operative vertebral levels, and number of instrumented vertebral levels, but 15% of patients could not be matched with respect to the type of bone graft used.

Case-control analysis of the matching cohorts revealed a lower infection rate in the Wiltse group (1 of 103 patients; 1.0%) in comparison with the midline group (8 of 103 patients; 7.8%) ($p = 0.018$). The odds ratios for each of the control variables are shown in Table 4.

Patients who underwent the Wiltse approach demon-

TABLE 1. Distribution of various pathologies addressed by approach*

Diagnosis	Midline (n = 255)	Wiltse (n = 103)
Isthmic spondylolisthesis	55 (21.6)	54 (52.4)
Degenerative spondylolisthesis	134 (52.5)	35 (34.0)
Spinal stenosis w/o spondylolisthesis	40 (15.7)	5 (4.9)
Disc protrusions	16 (6.3)	8 (7.8)
Other	10 (3.9)	1 (1.0)

* Values are presented as the number of patients (%).

TABLE 2. Distribution of patients who received bone graft or bone graft substitute to promote fusion*

Bone Graft	Midline	Wiltse
Autograft only	118 (46.3)	25 (24.3)†
Autograft & synthetic (no BMP)	12 (4.7)	2 (1.9)
Autograft & BMP	112 (43.9)	62 (60.2)†
BMP only	12 (4.7)	13 (12.6)

* Values are presented as the number of patients (%).

† Significant at $p < 0.0001$.

TABLE 3. Detailed comparisons between each technique

Variable	Wiltse	Midline	Statistical Test Comparing Approaches	p Value
Sex			Fisher's exact test	0.292
Male	53	114		
Female	50	153		
Age at admission, yrs	54.6	59.6	Fisher's exact test	0.002*
Previous spine surgery			Fisher's exact test	1.000
Yes	27	68		
No	76	187		
No. of index procedure vertebral levels			Fisher's exact test	<0.001*
2	81	154		
3	21	101		
4	1	0		
No. of index procedure instrumented vertebral levels			Fisher's exact test	0.006*
2	81	162		
3	22	93		
Iliac crest bone graft used			Fisher's exact test	0.865
Yes	13	35		
No	90	220		
>1 surgery required during stay			Fisher's exact test	0.363
Yes	2	22		
No	101	244		
CSF leakage/dural tear			Fisher's exact test	0.805
Yes	5	16		
No	98	239		
Additional admission requiring repeat surgery			Fisher's exact test	0.006*
Yes	12	63		
No	91	192		
Intensive care unit stay			Fisher's exact test	0.383
Yes	6	9		
No	97	246		
Recoded comorbidities (diabetes, other)			Fisher's exact test	0.645
Yes	32	79		
No	71	176		
Distant-site infection			Fisher's exact test	0.450
Urinary tract infection	5	19		
Bacteremia	0	1		
Pneumonia	1	0		
None	97	234		
Readmission w/ infection after distant-site infection			Fisher's exact test	1.000
Yes	1	2		
No	102	253		
Length of stay (days)	6.0	7.5	2-sample t-test	0.069
Index procedure operative time (hrs)	3.9	4.1	2-sample t-test	0.263
Index procedure blood loss (ml)	436	703	2-sample t-test	<0.001*

* Statistically significant at $p < 0.05$.

strated reduced odds (OR 0.47; 95% CI 0.23–0.95) of an additional admission requiring repeat surgery compared with patients who underwent surgery through the midline approach.

Adjacent-segment pathology differed with approach;

15 of 103 (14.6%) midline patients required revision surgery within 2 years of the index procedure. This result was again statistically significant compared with the 6 of 103 (5.8%) Wiltse patients who required a repeat operation for adjacent-level pathology ($p = 0.048$) (Table 5).

TABLE 4. Odds ratios for the variables used in the matched analysis

Variable	OR (95% CI)
Wiltse vs midline	0.47 (0.23–0.95)
Male vs female	1.37 (0.79–2.38)
Age group at admission in yrs (reference: ≥ 75 yrs)	
17–44	0.35 (0.12–1.02)
45–64	0.37 (0.13–1.05)
55–64	0.46 (0.18–1.17)
65–74	0.68 (0.28–1.64)
Recoded comorbidity (reference: none)	
Diabetes	0.55 (0.21–1.41)
Other	0.75 (0.37–1.52)
2 index procedure vertebral levels vs 3 & 4 levels	0.45 (0.10–2.08)
2 index procedure instrumented vertebral levels vs 3 levels	1.20 (0.26–5.56)
Recoded index procedure bone graft (reference: BMP only)	
Autograft only	0.78 (0.23–2.61)
Autograft & synthetic (not BMP)	0.73 (0.12–4.38)
Autograft & BMP	1.06 (0.33–3.44)

Discussion

We present the largest study comparing the Wiltse approach to the more conventional midline approach for decompression and fusion of the degenerative lumbar spine. Matched analysis revealed significant differences in complications when comparing these approaches. We have identified several advantages of the Wiltse approach, including lower infection risk, shorter hospital stay, fewer readmissions requiring surgery, and a lower risk of reoperation, specifically for adjacent-segment pathology within 3 years of the index surgery.

The potential to reduce the infection rate from 7.8% to 1.0% is statistically and clinically significant and has tremendous implications for optimizing infection prevention for 1- and 2-level fusion surgeries of the degenerative lumbar spine. By controlling for sex, age, preoperative comorbidities, number of instrumented vertebral levels, and the use of bone grafting, there is additional robustness to these results. Additionally, the SSII values for each group were similar, indicating that the complexities of each case were essentially the same for each group. This is important information because it indicates that each group was comparable despite not being matched for diagnosis. These findings would support implementing the Wiltse approach for the treatment of 1- or 2-level degenerative spinal pathologies of the lumbar spine. Although the infection rate for the midline patients may appear high, it is consistent with the previously published infection rate at our center and other recent publications that evaluated degenerative lumbar spondylolisthesis.^{5,21}

Many potential barriers exist in the adoption of this surgical approach. Often, surgeons who are trained using a midline approach assume that decompression of central stenosis cannot be as adequately or safely performed from lateral to medial. There is a presumed risk of incidental

TABLE 5. Causes for reoperation*

Variable	Matched	
	Wiltse	Midline
No. of patients	103	103
Wound complication	0 (0)	4 (3.9)
Complication of instrumentation	3 (2.9)	7 (6.8)
Pseudarthrosis	2 (1.9)	0 (0)
Adjacent-level pathology	6 (5.8)†	13 (12.6)†

* Values are presented as the number of patients (%).

† Indicates a statistically significant difference in adjacent-level pathology with each approach.

durotomy or unintended exiting nerve root injury due to poor visualization. The results of our study, however, demonstrate that there was no significant increase in incidental durotomy or iatrogenic nerve root injury rates when using the Wiltse approach.

Minimally invasive approaches to the spine take advantage of a muscular split for purposes of decompression and instrumentation. For similar reasons, mostly due to the lack of surgeon familiarity, these approaches have not gained widespread use, as expected, over the past decade when the technology was originally introduced. A significant learning curve has been demonstrated when learning a new surgical technique in a number of publications, especially those related to neurological injury.^{26,29,32} We would propose that the same learning curve would not necessarily exist with the adoption of the Wiltse approach for 2 reasons. First, the Wiltse approach allows excellent visualization of the lateral bony anatomy and safe landmarks are readily identified. Second, this study was performed over the years in which the majority of surgeons at our center were learning the Wiltse approach. Our results demonstrate no major differences in intraoperative complications, which also included the malposition of hardware or repeat operations for inadequate decompressions. Surgeons' experience ranged from 5 to 23 years in independent practice.

Approaching the spine through the midline often results in subperiosteal dissection and heavy retraction of the muscular tissue, not only to expose the transverse processes but also to gain an acceptable trajectory for pedicle screw instrumentation. During this central subperiosteal dissection, in order to gain adequate excursion of the tissue, the midline incision is often extended both superiorly and inferiorly with additional dissection. It is possible that with this additional dissection the supraspinous, interspinous, and adjacent facet capsules are being violated unintentionally. There are many other studies that demonstrate much greater injury to the surrounding tissues with a midline approach.^{6,15} This is possibly the start of the cascade that leads to a greater incidence of adjacent segment pathology with the midline approach, which our data support. Also, a more lateral pedicle screw entry point has a much lower incidence of violating the adjacent facet and capsule of the caudal level. This process is multifactorial, however, and therefore we cannot draw any firm conclusions.

Limitations

The major limitation of this study is the absence of health-related quality-of-life data. Although we have demonstrated a difference in infection rates and need for repeat surgery, we do not have clinical data to suggest that this made any impact on the overall patient outcomes at 1 and 2 years. We can make conclusions that the morbidity associated with repeat operations would be significant, but we have not demonstrated this with our data. Early on in this trial, there was some uncertainty that adequate central decompression could be obtained from a paraspinal approach. The procedure was initially used more in L5–S1 isthmic spondylolisthesis. As surgeons became more familiar with the paraspinal approach, utilization increased and more degenerative spondylolisthesis patients with central stenosis were treated with a midline approach. Pathological variation within this spectrum of degenerative cases, however, should not influence our primary outcome of infection. Further studies comparing each surgical approach are required if firm conclusions are to be made about the actual clinical outcomes. This is especially true when analyzing the length of stay with each procedure. Despite a shorter mean length of stay of 1.5 days, this was not statistically significant and may represent the lack of power to truly determine a difference in this outcome. Also, the analysis of adjacent-segment changes did not account for the preoperative status of the adjacent disc, and therefore we cannot make definitive statements regarding the exact role of fusion versus natural history in our observations of adjacent segment failure.

In addition, a limitation of this study is inherent to its design, in that although the data were prospectively collected, the analysis is retrospective. This introduces a potential source of bias, and although the use of matched data decreases the likelihood of making inappropriate comparisons, we were unable to match all variables that could potentially confound our results. This included the collection of some potential confounders such as body mass index. Future prospective analyses with tighter control and strict inclusion/exclusion criteria could potentially improve the validity of the results.

Conclusions

When feasible, the Wiltse or paraspinal muscle-splitting approach should be preferred for patients undergoing decompression and fusion of the lumbar spine, in particular for individuals with an increased risk of infection. There is a higher probability of adjacent-segment pathology in patients undergoing 1- or 2-level lumbar fusions with the midline approach. There were no differences in the reoperation rates for pseudarthrosis or complications of instrumentation in our matched data set.

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Disclosures

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