

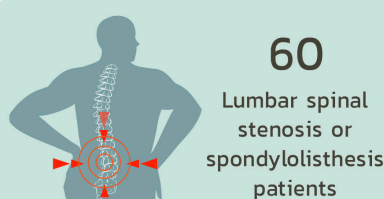
Differential Fusion Techniques in Uninstrumented Posterolateral Lumbar Fusion: A Retrospective Self-Control Study, Technical Notes and Radiological Outcomes

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Reverse sandwich technique for uninstrumented posterolateral lumbar fusion

Dual-sided approach in the “reverse sandwich” technique, may improve vascularization and foster a more favorable biological environment for fusion without apparent biomechanical differences observed in this study.



Undergoing uninstrumented posterolateral lumbar fusion by a senior spine surgeon using posterior midline approaches with iliac bone grafting customized to each patient in single tertiary care center.

The fusion technique was tailored for each patient, with a slight variation between sides. On the left side, the “bread and jam technique” was employed, where the cortical side of the iliac bone graft faced laterally, accompanied by scattered autograft on the medial side.

Conversely, on the right side, the “reverse sandwich technique” was used, wherein the cortical side of the iliac bone graft was positioned medially, with scattered autograft on the medial side.

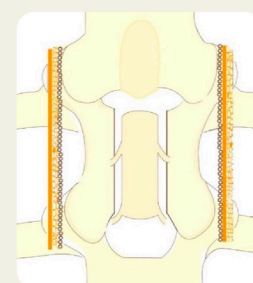


Fig 1. Schemas of fusion techniques

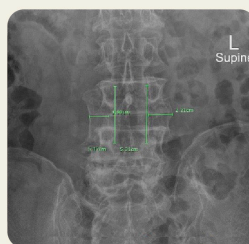


Fig 2. Demonstration of radiographic measurement

Radiographic assessments at 3, 6, 9, 12, and 24 months postoperatively evaluated fusion mass sizes.

The “reverse sandwich” technique, incorporating cancellous bone on both sides of the graft, potentially enhances fusion outcomes compared to the “bread and jam” technique, which uses cancellous bone on one side.

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ABSTRACT

Objective: To compare two surgical techniques, the “bread and jam” and “reverse sandwich,” for uninstrumented posterolateral lumbar fusion in treating degenerative lumbar spine disease, focusing on their impact on fusion outcomes.

Materials and Methods: This retrospective study at Siriraj Hospital analyzed data from patients undergoing uninstrumented posterolateral lumbar fusion between January 2002 and December 2016. Procedures were performed by a senior spine surgeon using posterior midline approaches with iliac bone grafting customized to each patient. Radiographic assessments at 3, 6, 9, 12, and 24 months postoperatively evaluated fusion mass sizes, assessed independently for reliability.

Results: Sixty patients (50 women, mean age 63.17 years) were included, predominantly diagnosed with spinal stenosis with spondylolisthesis (79.66%). The main symptoms were radiculopathy (47.46%) and neurogenic claudication (40.68%). Most surgeries targeted one spinal level (71.19%). Fusion mass size differed significantly between the right and left sides at 3, 9, and 24 months, with the right side consistently larger. However, no significant differences were noted at 6 and 12 months.

Conclusion: The “reverse sandwich” technique, incorporating cancellous bone on both sides of the graft, potentially enhances fusion outcomes compared to the “bread and jam” technique, which uses cancellous bone on one side. This dual-sided approach in the “reverse sandwich” technique, may improve vascularization and foster a more favorable biological environment for fusion without apparent biomechanical differences observed in this study. Further research is needed to corroborate these findings and elucidate their biological mechanisms.

Keywords: Lumbar fusion; posterolateral fusion; bone graft; surgical technique; degenerative lumbar spine disease (Siriraj Med J 2025; 77: 194-199)

INTRODUCTION

Lumbar fusion is commonly executed in patients experiencing lumbar instability due to structural anomalies (such as lumbar spondylolysis and spondylolisthesis) or degenerative conditions (like degenerative lumbar spondylolisthesis and intervertebral disc issues). Various surgical techniques for lumbar fusion encompass posterior fusion, posterolateral fusion, interbody fusion via various approaches (posterior lumbar interbody fusion (PLIF), transforaminal lumbar interbody fusion (TLIF), oblique lumbar interbody fusion/anterior to psoas (OLIF/ATP), lateral lumbar interbody fusion (LLIF) and anterior lumbar interbody fusion (ALIF).^{1,2}

In 2023, Andresen reported the efficacy of uninstrumented posterolateral fusion for lumbar spondylolisthesis, no difference in patient-reported outcomes was found between 2 groups (Oswestry Disability Index, visual analogue scale, EuroQol-5 Dimension-3 Level, Short Form-36).³ Posterolateral fusion has shown a successful fusion rate up to 84%.^{4,5} The posterolateral fusion is usually performed with an iliac bone graft and laminectomy bone. The surgical technique has been reported with various techniques since 1953.⁶

In addition to uninstrumented techniques, multi-level instrumented fusion has also been shown to provide good clinical outcomes and is considered safe for patients with

extensive degenerative lumbar disease, as demonstrated in studies focusing on the use of posterior long-segment fusion.⁷

Our study aims to evaluate the 2 surgical techniques of posterolateral fusion without instrumentation in 1-3 levels of degenerative lumbar spine surgery.

MATERIALS AND METHODS

We performed the retrospective study using data from the medical database of the Department of Orthopaedic Surgery, Faculty of Medicine Siriraj Hospital, Mahidol University. The study was approved by the Siriraj Institutional Review Board (COA no. Si 368/2019). Due to the retrospective nature of this study, written informed consent was not obtained.

All patients with degenerative spinal stenosis or spondylolisthesis who underwent primary 1-3 level of uninstrumented posterolateral lumbar fusion at Siriraj hospital during January 2002 to December 2016 were enrolled. The exclusion criteria consisted of patients with previous lumbar spine surgery, previously diagnosed postoperative deep surgical site infection, unable to collect data up to 1-year follow-up, and patients who received revision surgery within 1 year.

The primary outcome was the fusion mass size which was measured by plain radiograph of the lumbar spine

in anteroposterior view at 3 months, 6 months, and 1 year post-operative period. Baseline characteristics of patients were collected, which are age, gender, level of surgery, comorbidities, and history of smoking.

Surgical technique

The surgery was performed by a senior spine surgeon, fellowship-trained with 30 years of experience. All patients underwent a standard posterior midline approach, which included laminectomy and posterolateral fusion with an iliac bone graft, but without spinal instrumentation.

The iliac bone graft was harvested from the left iliac wing via a separate incision. A bone segment, measuring 1 cm by 1 cm and length matching the length from the upper to the lower facet, was extracted using a chisel. To preserve iliac crest integrity, the harvest site was maintained at least 1-2 cm from its edge. Cancellous bone was also collected using a bone chisel.

To prepare the grafting site, soft tissue was meticulously detached from the vertebral arch beneath the periosteum, exposing transverse process from the uppermost to the lowest level. Cortical bone on the exterior of the transverse and articular processes was scraped away to expose spongy bone and create a pocket for graft placement. The lateral one-third of the facet joint was hinged open to form an additional pocket. The harvested iliac bone graft and the bone chips from laminectomy, were placed into these pockets.

The fusion technique was tailored for each patient, with a slight variation between sides. On the left side, the “bread and jam technique” was employed, where the cortical side of the iliac bone graft faced laterally, accompanied by scattered autograft on the medial side. Conversely, on the right side, the “reverse sandwich technique” was used, wherein the cortical side of the iliac bone graft was positioned medially, with scattered autograft on the medial side. Illustrations of the surgical techniques are presented in Fig 1.

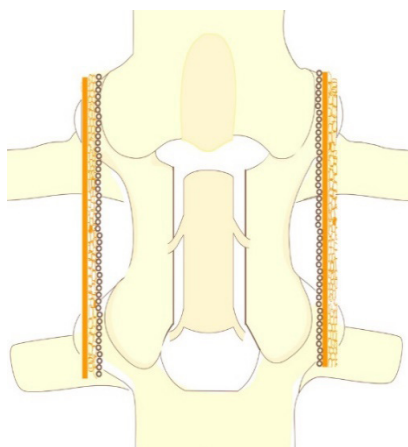


Fig 1. Schemas of fusion techniques

Radiographic assessment

Plain radiographs were obtained for all patients at a minimum follow-up of two years. The presence and extent of the fusion mass were evaluated on anteroposterior radiographs by one orthopedic surgical resident and one spine surgery fellow. These evaluations were conducted twice, with a two-week interval between assessments. Both assessors reviewed the postoperative radiographs blindly, without prior knowledge of the fusion techniques employed on either side. The width of the fusion mass was measured from the midpoint between the two pedicles at the uppermost and lowermost operated levels, as demonstrated in Fig 2.

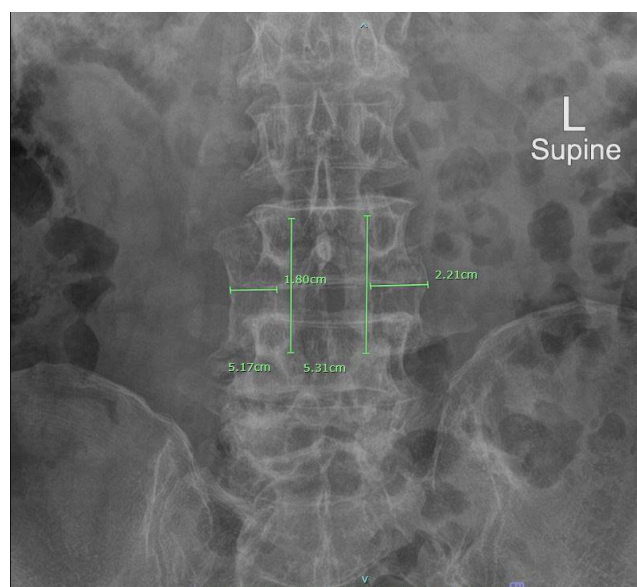


Fig 2. Demonstration of radiographic measurement

The intra-observer reliability for the assessment of fusion mass size was high, with ICCs ranging from 0.98 to 1.00, indicating excellent agreement between repeated measurements by the same rater. The inter-observer reliability was moderate, with ICCs ranging from 0.40 to 0.59, suggesting a fair degree of agreement between different raters.

Statistical analysis

To determine differences between the left and right sides, paired t-tests or Wilcoxon signed-rank tests were utilized, depending on the distribution of the data as determined by the Shapiro-Wilk test. The reliability of the radiographic measurements was assessed using the Intraclass Correlation Coefficient (ICC) to gauge both inter-rater and intra-rater consistency. Validity was established by correlating measurements with recognized benchmarks, and agreement on fusion classification between raters was measured using Cohen's Kappa. All statistical analyses were

performed with SPSS Statistics for Windows, Version 17.0 (SPSS Inc., Chicago, IL, 2008), and a p-value of less than 0.05 was considered statistically significant.

RESULTS

We included 60 patients in our study. There were 50 women (84.57%) and the average age of all participants was 63.17 ± 9.51 years. 3 patients (5.08%), had a history of smoking. The majority of patients, 47 out of 60 (79.66%), were diagnosed with spinal stenosis with spondylolisthesis, while the remaining 12 (20.34%) had spinal stenosis. The main symptoms were radiculopathy (28 patients, 47.46%) and neurogenic claudication (24 patients, 40.68%). Surgery was mostly done at one level of the spine (42 patients, 71.19%), with fewer having two (12 patients, 20.34%) or three levels operated on (5 patients, 8.47%).

Radiographic outcome

Fusion mass was measured from plain radiograph in anteroposterior view at 3,6,9,12,24 months postoperatively. At 3 months, the right side fusion masses were significantly larger (2.65 ± 0.57 cm) than the left (2.46 ± 0.40 cm) with a p-value of 0.01. However, at 6 and 12 months, the fusion mass sizes were not significantly different, with p-values of 0.39 and 0.49, respectively. At 9 months, a significant difference reappeared with the right side being

larger (2.95 ± 0.56 cm) compared to the left (2.68 ± 0.47 cm), p-value 0.01. This trend of significant difference persisted at the 24-month assessment, where the right side again showed a larger size (2.86 ± 0.54 cm) than the left (2.71 ± 0.55 cm), with a p-value of 0.01, indicating a statistically significant difference at longer-term follow-ups.

DISCUSSION

The study results indicate that the “reverse sandwich” technique, used on the right side, resulted in significantly larger fusion masses at 3, 9, and 24 months postoperatively compared to the “bread and jam” technique used on the left side. This suggests that the “reverse sandwich” technique may be more effective in promoting bone fusion in the both early and long-term postoperative periods.

In a retrospective study conducted by Brodsky et al., a correlation of 64% was shown between pre-operative plain radiography and surgical exploration. The study focused on 214 lumbar fusion exploration procedures performed on patients who had previously had posterior lumbar fusion (PLF).⁷ In their study, Kant et al. (1995) found that plain radiography demonstrated a sensitivity of 89% and specificity of 60% in its ability to predict solid fusion. The radiographic images, when analyzed for fusion, had a positive predictive value (PPV) of 76%.⁸

TABLE 1. Baseline characteristics.

N = 59	N (%) Mean $\pm$ SD
Female	50 (84.75%)
Age (years)	63.17 $\pm$ 9.51
History of smoking	3 (5.08%)
Diagnosis	
Spinal stenosis with spondylolisthesis	47 (79.66%)
Spinal stenosis	12 (20.34%)
Main Clinical presentation	
Radiculopathy	28 (47.46%)
Neurogenic claudication	24 (40.68%)
Mechanical low-back	6 (10.17%)
Neurological deficit	1 (1.69%)
Number of level of surgery	
1 level	42 (71.19%)
2 levels	12 (20.34%)
3 levels	5 (8.47%)

TABLE 2. Radiographic outcome.

	Right fusion mass size (cm)	Left fusion mass size (cm)	P-value
3 Month	2.65 ±0.57	2.46 ±0.40	0.01*
6 Month	2.57 ±0.61	2.56 ±0.56	0.39 ^a
9 Month	2.95 ±0.56	2.68 ±0.47	0.01*
12 Month	2.75 ±0.56	2.67 ±0.50	0.49 ^a
24 Month	2.86 ±0.54	2.71 ±0.55	0.01** ^a

The high intra-observer and inter-observer reliability for fusion assessment demonstrates the consistency and reproducibility of the radiographic evaluation method used in this study. This strengthens the validity of the findings and suggests that the assessment method can be reliably used in future studies.

Differences in fusion mass size between the ‘reverse sandwich’ and ‘bread and jam’ techniques may result from bone graft placement and its impact on the biological environment, rather than biomechanical factors. During the bone graft healing process, the establishment of an adequate blood supply is important for the formation of new bone.⁹ In the “reverse sandwich” technique, the cancellous bone is situated on both sides of the graft, potentially providing a more favorable environment for fusion due to increased blood supply and osteogenic potential. This bilateral cancellous placement may enhance the vascularization of the graft site, increase surface area, promoting more robust bone growth and fusion. The use of autologous bone graft, particularly iliac crest bone, is effective in promoting fusion due to its osteoconductive, osteoinductive, and osteogenic properties. The “reverse sandwich” technique may further leverage these properties by creating a more surface area conducive environment for bone healing and remodeling. The structural strength and rigidity of cortical bone contribute to graft stabilization and minimize the risk of migration, while vascularized cancellous bone enhances new bone formation through improved vascular and cellular integration, thereby accelerating the fusion process.

This study has several limitations that should be acknowledged. First, the sample size was relatively small, with only 60 patients included. While the self-controlled design minimized inter-patient variability, the limited number of cases reduces the generalizability of the findings and may have impacted the statistical power to detect differences in fusion outcomes across

the techniques. Future studies with larger cohorts and multicenter trials are needed to confirm the results and strengthen the evidence. Additionally, while the current study suggests that the “reverse sandwich” technique might be a preferred method for uninstrumented fusion to different bone graft placement technique, further research is necessary to confirm these findings in a larger patient population and to explore the biological mechanisms including cellular and molecular processes, involved in bone growth and fusion that could responsible for the observed differences between the two different bone graft placement techniques. Moreover, long-term clinical outcomes of patients undergoing these different techniques should be evaluated to determine if the larger fusion mass associated with the “reverse sandwich” technique translates into improved clinical outcomes, such as pain relief and functional improvement. Additionally, comparing these techniques of uninstrumented posterolateral fusion with instrumented posterolateral fusion could provide a broader context of difference between instrumented and uninstrumented fusion.

Furthermore, it is important to note that while plain radiographs were used in this study, their accuracy in assessing fusion can vary. Our hospital did not routinely perform CT scans to detect fusion mass during the study period, relying instead on plain radiographs, which has limitations in accurately assessing fusion. Future research may benefit from utilizing computed tomography (CT) scans for more precise evaluation. Including patient-reported outcome measures (PROMs) in future studies would also provide valuable insights into the impact of different fusion techniques on patients’ quality of life and functional status.

CONCLUSION

In conclusion, the “reverse sandwich” technique, with cancellous bone on both sides of the graft, may

provide a superior environment for fusion compared to the “bread and jam” technique, in which cancellous bone is limited to one side. Enhanced vascularization on both sides in the “reverse sandwich” technique may improve the biological environment for fusion without significant differences in biomechanics. Further research is warranted to validate these findings and elucidate the underlying biological processes.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request. The data are not publicly available due to privacy or ethical restrictions.

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DECLARATION

Grants and Funding Information

None

Conflict of Interest

The authors hereby declare no personal or professional conflicts of interest relating to any aspect of this study.

Registration Number of Clinical Trial

This study is retrospective, clinical registration is not required.

Author Contributions

C.C. Project administration, conceptualization, and illustrated figure. H.K. Collecting data and editing manuscripts. K.M. Collecting data, analyzing data, and editing manuscripts. B.S. Project administration,

conceptualization, collecting and analyzing data, and writing and editing manuscripts.

Use of Artificial Intelligence

None

Ethics approval

The protocol for this study was approved by the Siriraj Institutional Review Board (SIRB) (COA no. Si 368/2019), and written informed consent was not obtained due to the retrospective nature of this study.

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