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# Multiple-Level Low-Grade Lumbar Spondylolisthesis: Instrumented Posterolateral Fusion Using a Local Bone Graft

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## ABSTRACT

**Background Data:** Lumbar spondylolisthesis is a major cause of back pain. It occurs most commonly at only one spinal level. Multiple-level lumbar spondylolisthesis is uncommon, with few reports available in the literature. It can be treated by instrumented posterolateral fusion (PLF) using iliac crest bone graft (ICBG) with possible reported donor site complications. A reasonable alternative is local bone graft obtained from the laminae and spinous processes harvested during neural decompression.

**Purpose:** To evaluate the outcome of multiple-level spondylolisthesis treated by PLF using a local bone graft.

**Study Design:** Prospective clinical case series.

**Patients and Methods:** Eleven patients (6 males and 5 females) with mean age 48.18 ± 9.7 years with multiple-level lumbar spondylolisthesis who underwent PLF using local bone graft in our University Hospital between 2015 and 2017 were evaluated. The mean duration of low back pain (LBP) was 11.36 ± 1.8 (range, 9–14) months. Operation time and blood loss were recorded. Clinical outcomes were evaluated using the Visual Analogue Scale (VAS) and Oswestry Disability Index (ODI), while fusion was evaluated using the Lenke classification for posterolateral fusion.

**Results:** The mean operative time was 87.7 ± 19.1 minutes, while blood loss was 541.8 ± 135.5 ml, and the mean follow-up period was 34.55 ± 3.2 months. VAS and ODI improved significantly from preoperatively to postoperatively and at last follow-up ($p < 0.05$) with no significant difference in terms of gender or age. Radiologically, solid bone fusion was achieved in 23 out of 27 operated levels (85%). One screw was broken, and two patients had superficial wound infections.

**Conclusion:** Our data suggest that instrumented PLF using local bone graft can effectively be used to manage multiple-level lumbar spondylolisthesis with satisfactory outcome and avoid ICBG donor site morbidity. (2020ESJ222)

**Keywords: Spondylolisthesis, Lumbar fusion, Back pain, Local bone graft**

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## INTRODUCTION

Spondylolisthesis is the forward slip of one vertebra relative to the caudal vertebra. It mostly occurs in the lumbar region with two main types: spondylolytic type with a defect in the pars interarticularis (spondylolysis) and degenerative type.[3,8,17,27,29,35,36] The incidence of lumbar spondylolisthesis is 4%–6% of the general population.[9,31] Degenerative spondylolisthesis commonly occurs as a single level, with 95% of cases at the fourth and fifth lumbar vertebrae.[39] Multiple-level lumbar spondylolysis and spondylolisthesis are not common, with few studies reported on them.[10,12,19,20,25,26,37-39] The reported incidence is only 1.48% of patients with back pain and 0.3% of 2000 persons examined by computed tomography.[11,38,39]

While instrumented posterolateral fusion (PLF) is a rapid traditional effective fusion technique for the treatment of spinal instability,[1] posterior lumbar interbody fusion (PLIF) and transforaminal lumbar interbody fusion (TLIF) are more commonly used nowadays to treat spondylolisthesis owing to their theoretical advantages. However, previous reports did not prove any superiority of PLIF or TLIF versus instrumented PLF regarding the clinical outcomes, complication rates, operating time, and blood loss.[40] Moreover, PLIF has been associated with several complications such as significant paraspinal iatrogenic injury, difficulty to correct the coronal imbalance and restore lordosis, and retraction injury of nerve roots.[13] Furthermore, a high incidence of adjacent segment disease (ASD) has been reported with PLIF.[14,21]

Several types of fusion materials have been described in the literature.[4] Iliac crest bone graft (ICBG) used to be the gold standard, but it has been associated with donor site-related complications.[23,29] Thus, local bone graft harvested from wide decompression seemed to be a good alternative.

This study aims to prospectively evaluate the outcomes of instrumented PLF and a local bone graft in patients with multiple-level low-grade lumbar spondylolisthesis.

## PATIENTS AND METHODS

We **prospectively** evaluated eleven patients with multiple-level lumbar spondylolisthesis who underwent operation in our Orthopaedic Department between May 2015 and May 2017 using instrumented PLF technique using local bone graft harvested from the laminae and spinous processes, which were removed for neural decompression.

We included patients with radiological evidence of isthmic or degenerative multiple-level lumbar spondylolisthesis who experienced chronic lumbar back pain and/or neurological symptoms such as sciatica or intermittent claudication pain, not responding to conservative treatment for at least six months with impact on their quality of life and complete clinical, radiological, follow-up, and contact data. Patients with severe osteoporosis, morbid obesity (BMI >40), single-level spondylolisthesis, and spondylolysis alone without spondylolisthesis were excluded. All patients formally consented to surgery and inclusion in this study. Our IRB approved the study.

**Patients' Characteristics:**

Six cases were males (54.5%) and five (45.4%) were females. The mean patient age was 48.18 ± 9.7 (range, 30–60) years. All patients had chronic LBP and four patients had sciatica. The mean duration of LBP was 11.36 ± 3.13 (range, 9–14) months. Ten cases (90.9%) were manual workers. Six patients (54.5%) had double-level spondylolisthesis, while five patients suffered from three-level (45.4%) spondylolisthesis with a total of 27 levels. Out of the 27 levels, the most affected level is L4-L5 (10 levels, 37%), followed by L3-L4 (8 levels, 29.7%), then L5-S1 (6 levels, 22.3%) with the least at L2-L3 (3 levels, 11%). Sixteen levels (59.2%) were of grade I Meyerding classification, and 11 levels (40.8%) were of grade II (Table 1). All patients were neurologically free preoperatively.

**Outcome Assessment:**

Preoperatively, all cases were assessed clinically by the 10-point Visual Analogue Scale (VAS), where 0 indicated no pain and 10 indicated the worst score for both back and leg pain, and Oswestry Disability Index (ODI). The radiological assessment included plain radiographs (anteroposterior, lateral, and dynamic views) and magnetic resonance imaging (MRI) and CT in some cases (claustrophobic).

Postoperatively, patients were examined at 1, 3, and 6 months and then at six-month intervals clinically for back and leg pain VAS, ODI, and neurological deficits and radiologically (plain radiographs) for hardware complications, screw purchase, construct integrity, and fusion. Radiological fusion was evaluated using the Lenke classification for posterolateral fusion[15] (Table 2).

**Surgical Procedure:**

After general anesthesia, the patient was positioned on the Jackson spinal frame in the prone position. The traditional posterior midline approach was conducted with meticulous subperiosteal dissection and hemostasis until exposure of the affected levels from the midline to the tips of the transverse processes bilaterally. Subsequently, the transverse processes of the slipped vertebrae and the next one were prepared by meticulous decortication using bone nibbler or bone bur. Transpedicular screws were inserted in the pedicles of slipped vertebrae and the next one using long crown (reduction) screws in the slipped vertebrae to facilitate rod-to-screw construction. Screw purchase, direction, and length were checked fluoroscopically. Laminectomy of the affected levels was performed together with harvesting the spinous processes of the one or two vertebrae nearby, followed by the application of the well-prepared bone obtained from the decompression over the well-decorticated transverse processes. Finally, the wound was closed in layers over suction (Figures 1 and 2).

**Statistical Analysis:**

Description of means and standard deviation for quantitative variables and frequencies and percentage for qualitative variables were calculated using SPSS Version 22.0 (IBM Corp, Armonk, NY). Preoperative and postoperative results were compared using paired sample *t*-test. The level of significance was set at $p < 0.05$.

## RESULTS

The mean operative time was 87.7 ± 19.1 minutes, with a statistically significant difference between patients with double-level and triple-level spondylolisthesis (75.83 ± 8.6 minutes and 102 ± 18.8 minutes, respectively, $p = 0.014$). The mean blood loss was 541.8 ± 135.5 ml, with a statistically insignificant difference between patients with double-level and triple-level spondylolisthesis (515 ± 120 and 574 ± 158 ml, respectively, $p = 0.5$). The mean hospital stay was 1.7 ± 0.6 (1–3) days (Table 3).

The mean follow-up time was 34.55 ± 3.2 (range, 28–38) months. VAS scores for LBP improved significantly from 7.5 ± 1 preoperatively to 2.1 ± 0.9 at 6 months postoperatively ($p = 0.043$) and 1.6 ± 0.6 at last follow-up ($p = 0.025$). VAS scores for leg pain improved significantly from 8 ± 1 preoperatively to 2.5 ± 0.9 at 6 months postoperatively ($p = 0.031$) and 1.2 ± 0.7 at last follow-up ($p = 0.016$). ODI improved significantly from 45.91 ± 10.9 preoperatively to 26.1 ± 6.2 at 6 months postoperatively ($p = 0.000$) and 14.1 ± 7 at last follow-up ($p = 0.000$) (Tables 4).

Radiological fusion has been achieved in 23 out of 27 levels (85%), including solid big bilateral trabeculae (type A Lenke classification) in 18 levels and solid unilateral fusion with small contralateral trabeculae (type B Lenke classification) in 5 levels. There was no reported postoperative neurological injury in any case. Two cases were complicated by superficial wound infection and managed by systemic antibiotics and frequent dressings. The construct integrity was maintained till the last follow-up in all cases except for a screw breakage that occurred in one case without clinical impact.

**Table 1.** Demographic data.

| Parameters | | Results |
|---|---|---|
| Age/years | | 48.18 ± 9.7 |
| Gender | Males | 6 (54.5%) |
| | Females | 5 (45.5%) |
| LBP | | 11 (100%) |
| Sciatica | | 4 (36.4%) |
| Duration of symptoms/months | | 11.36 ± 3.13 |
| Level | 2-level | 6 (54.5%) |
| | 3-level | 5 (45.5%) |
| | L3-L4 | 8 (29%) |
| | L4-L5 | 10 (37%) |
| | L5-S1 | 6 (22.3%) |
| Grade | Grade I | 16 (59.2%) |
| | Grade II | 11 (40.8%) |
| Slip type | Degenerative | 6 (54.5%) |
| | Isthmic | 5 (45.5%) |

**Table 2.** Lenke classification for posterolateral fusion.[15]

| Grade | Description |
|---|---|
| **Grade A** | Definitely solid with bilateral stout fusion masses present |
| **Grade B** | Possibly solid with unilateral large fusion mass and a contralateral small fusion |
| **Grade C** | Probably not solid with a small fusion mass bilaterally |
| **Grade D** | Definitely not solid with bone graft resorption or obvious pseudoarthrosis bilaterally |

**Table 3.** Summary of perioperative data.

| Parameters | Results |
|---|---|
| Operative time/minutes | 87.7 ± 19.1 |
| Operative blood loss/ml | 541.8 ± 135.5 |
| Hospital stay/day | 1.7 ± 0.6 (1–3) |
| Follow-up/months | 34.55 ± 3.2 (28–38) |

**Table 4.** Summary of clinical outcomes.

| Parameters | Preoperatively | 6 months postoperatively | Last follow-up |
|---|---|---|---|
| Back pain VAS | 7.5 ± 1 | 2.1 ± 0.9 | 1.6 ± 0.6 |
| Sciatica VAS | 8 ± 1 | 2.5 ± 0.9 | 1.2 ± 0.7 |
| ODI | 45.91 ± 10.9 | 26.1 ± 6.2 | 14.1 ± 7 |


**Figure 1.** A 38-year-old farmer (A) plain X-ray lateral radiograph (B) T2 weighted image sagittal MRI with double-level first-degree lytic spondylolisthesis at L4-L5 and L5-S1 levels, (C) postoperative, (D) last follow up lateral radiograph and (E) 3D CT scan anterior and posterior views showing good PLF with local bone.

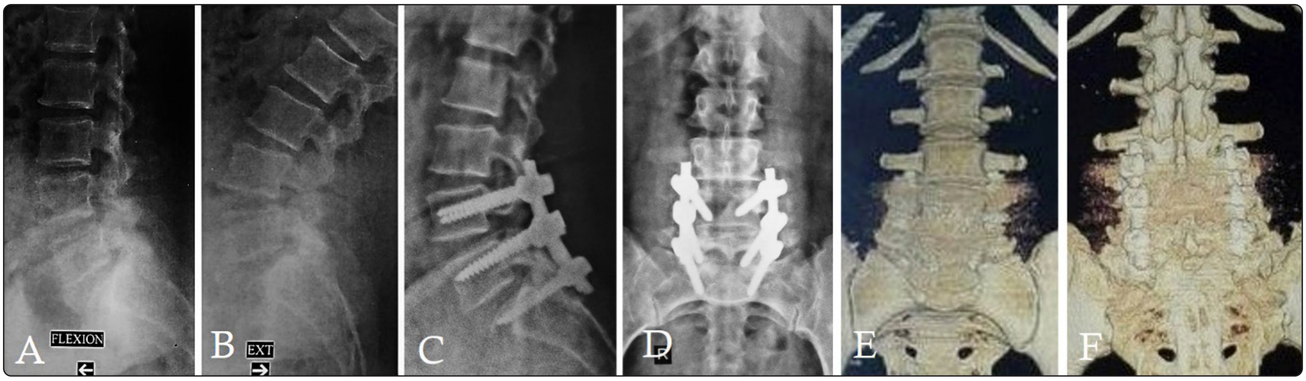


**Figure 2**. A 48-year-old housewife lateral radiographs (A) in flexion and (B) extension views showing double level first-degree degenerative spondylolisthesis at L4-L5 and L5-S1 levels, postoperative (C) lateral and (D) anteroposterior radiographs after PLF, 3D CT sacn (E) anterior view and (F) posterior view showing good PLF with local bone graft.

## DISCUSSION

Lumbar spondylolisthesis, either isthmic or degenerative, is a common condition encountered by spine surgeons. Conservative management is the standard treatment for low-grade spondylolisthesis. Nonsurgical treatment options include rigid lumbosacral brace, bed rest, lifestyle modification, chiropractic manipulation, and physiotherapy.[6,16] However, surgical management is necessary for patients not responding to conservative treatment. Multiple surgical options have been proposed, including isthmic repair, PLF, and PLIF.[20,33] However, there is no consensus on which surgical treatment is the best.

PLF and PLIF are amongst the most used fusion techniques. PLIF has several theoretical advantages over PLF as it provides indirect foraminal decompression, restores the disc height, achieves better fusion rates, and eliminates the disc as a source of back pain.[7,18,32] However, this approach may associated with technical difficulties and a high risk of neurological injury and dural tear.[13] In a retrospective study by Okuda et al.,[21] 1000 patients underwent PLIF for a degenerative lumbar disease, where 9.0% developed ASD and required revision surgery. On the contrary, PLF is a much simpler and safer technique with satisfactory outcomes. A systematic review and meta-analysis conducted by Chen et al.[5] concluded that both surgical approaches had similar surgical, functional, and radiological outcomes. Besides, Lee et al.[14] conducted a risk factor analysis for ASD and reported that the incidence of ASD requiring surgery at ten years after PLF was significantly lower than that of PLIF (6.7% and 11.7%, respectively).

Recently, various fusion materials have been made available for spine surgeons, including autograft, allograft, and other synthetic materials.[4] Synthetic grafts lack the physiological properties of autologous grafts, and allografts are associated with a high risk of disease transmission and immunological complications. Thus, autologous ICBG has been the gold standard fusion material in lumbar spine arthrodesis because it provides a large quantity of osteogenic, osteoconductive, and osteoinductive corticocancellous bone.[22] Nevertheless, it has been associated with adverse events, such as infection, hematoma, fracture, impaired wound healing, and donor site pain.[34] In order to avoid the morbidities associated with ICBG, other autologous graft sites have been suggested, such as local bone graft harvested from the laminae and spinous processes during spinal canal decompression.[2,28,30,34]

Previous studies have documented that local bone grafts and ICBGs were able to achieve favorable union rates not only in one- or two-level lumbar fusion but also in three-level lumbar fusion surgery, with no statistically significant difference.[23] Similarly, Abou-Madawi et al.[2] compared local bone graft with ICBG as fusion materials for patients with low-grade isthmic or degenerative spondylolisthesis. They found no significant difference between the two groups in terms of clinical outcomes (VAS, ODI, and patient's satisfaction) and radiological parameters (fusion rate, slip reduction, segmental angle, and disc height). Tuchman et al.[34] conducted a systematic review to reach a more solid conclusion regarding the best fusion material. Little evidence demonstrated no difference between local and ICBG regarding fusion rates, back pain, leg pain, and functional results, whereas moderate evidence suggested a higher incidence of donor site-related complications in the ICBG.

Accordingly, we assumed that PLF with local bone graft would provide a safe and effective approach for managing spondylolisthesis while avoiding complications related to donor site or fusion techniques other than PLF. Unfortunately, limited data were found in the literature on the safety and efficacy of PLF using local bone graft for managing multiple-level spondylolisthesis. Therefore, we studied the surgical, clinical, and radiological outcomes of PLF using local bone graft to manage 11 cases with multiple-level lumbar spondylolisthesis. Overall, we demonstrated favorable outcomes in terms of operation time, blood loss, VAS, ODI, fusion rate, and postoperative complications.

In this case series, the mean operative time was 87.7 ± 19.1 minutes, while the operative blood loss was 541.8 ± 135.5 ml. Sengupta et al.[27] reported the outcome of local bone versus autogenous ICBG in LPF of the lumbar spine and showed that blood loss was significantly less in the local graft group (293 ± 71 ml) than that in the ICBG group (366 ± 161 ml).

Our series showed satisfactory clinical and functional results in terms of postoperative VAS and ODI.

Other reports on PLF using local bone graft showed similar results. In a study conducted by Sengupta et al.,[28] leg pain improved in 75% of the patients in the local bone group and 64% in the ICBG group, while back pain improved in 75% of the patients in both groups. ODI also improved in both groups, 36% in the local bone group and 32% in the ICBG group. Both VAS scores and ODI did not show a statistically significant difference between the two fusion grafts.

Regarding the fusion rates, Park et al.[23] demonstrated that fusion rate decreased with an increasing level in local bone grafts from 100% to 95.8% and 85.7% for one-, two-, and three-level fusion, respectively. However, no significant difference was detected when compared to fusion rates with ICBG. On the other hand, others reported significantly lower fusion rates of only 20% with local grafts in multiple-level fusion.[28] In our study, PLF with local graft achieved a solid fusion rate of 85%.

We encountered some minor complications related to surgical wounds or hardware complications, which were managed conservatively with no significant effect on patients' outcomes. Although multiple-level spondylolisthesis is a risk factor for developing ASD,[24] none was detected in our series due to the short follow-up period. However, based on previous reports,[14] incidences of ASD requiring surgery after PLF is expected to be low. Local bone graft enabled us to avoid donor site-related complications while providing fusion material of adequate quantity and good quality with satisfactory patients' outcomes.

The main limitation of this study is the lack of comparison between the different fusion techniques. Another limitation is the small number of cases which can be explained by the uncommon presentation of such cases. Therefore, future studies with larger sample sizes and comparing different options of lumbar fusion are recommended.

## CONCLUSION

Our data suggest that instrumented PLF using local bone graft can be effectively used to manage multiple-level lumbar spondylolisthesis with satisfactory outcomes and avoid ICBG donor site morbidity.

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# الملخص العربي

## الانزلاق الفقاري متعدد المستويات: العلاج باستخدام الالتحام بين النتوء المستعرض للفقرات ورقعة عظمية محلية

**البيانات الخلفية:** يعتبر الانزلاق الفقاري من الاسباب الشائعة لآلام أسفل الظهر ويحدث غالبا على مستوى واحد فقط عن طريق انزلاق فقرة واحدة على الفقرة التي تليها، ولكنه قد يحدث على عدة مستويات. يتم علاجه جراحيا عن طريق عمل سمكرة باستخدام رقعة عظمية من عظام الحوض لذات المريض والذي يترتب عليه بعض المضاعفات. كما يمكن استخدام رقعة عظمية موضعية من العظام الناتجة عن توسيع القناة الشوكية.

**الغرض:** استعراض نتائج علاج 11 حالة انزلاق فقاري متعدد المستويات بواسطة الالتحام بين النتوء المستعرض ورقعة عظمية موضعية.

**تصميم الدراسة:** سلسلة حالات سريرية بأثر مستقبلي.

**المرضى والطرق:** تم إجراء هذه الدراسة في الفترة من 2017 الي 2019 لمراجعة النتائج السريرية والاشعاعية لعدد 11 مريضا (6 ذكور و5 إناث) متوسط أعمارهم اربعين سنة وتتراوح بين الثلاثين الستين عاما يعانون من آلام أسفل الظهر لفترة متوسطها 11,36 شهرا تتراوح بين 9 و14 شهرا نتيجة انزلاق فقاري متعدد تم علاجهم عن طريق عمل لحام بين النتوء المستعرض للفقرات المنزلقة والفقرة التالية لهم باستخدام العظام الناتجة من ازالة الصفائح الخلفية والنتوء الشوكي للفقرات المنزلقة. تم تسجيل الوقت الجراحي المستغرق وكمية الدم المفقودة؛ بالإضافة الي تقييم المرضى بواسطة VAS وODI والتقييم الاشعاعي للالتئام بواسطة نظام Lenke.

**النتائج:** تم متابعة المرضى لفترة متوسطها 34,55 شهرا تتراوح بين 28 و38 شهرا. متوسط الوقت الجراحي 87,7 دقيقة بينما متوسط الدم المفقود اثناء الجراحة 541,8 مل. تحسنت النتائج الوظيفية اللي تم تقييمها بواسطة VAS وODI بشكل ملحوظ حيث P value < 0.05 مقارنة بالنتائج قبل اجراء العملية وبدون فروق ذات دلالة إحصائية فيما يتعلق بأعمار او جنس المرضى. تحقق الالتحام بناء على النتائج الاشعاعية في 23 مستوى منزلق من اجمالي 27 مستوى. تم تسجيل حالة واحدة لكسر بأحد المسامير وحالتين عدوى سطحية بالجرح تم معالجتهما تحفظيا.

**الخلاصة:** وجد ان الانزلاق الفقاري المتعدد المستويات يمكن علاجه بنفس كفاءة الانزلاق الفقاري ذي المستوى الواحد عن طريق الالتحام بين النتوء المستعرض ورقعة عظمية موضعية مع تجنب الأضرار الناجمة عن الرقعة المأخوذة من عظام الحوض.