Comparison of the clinical efficacy of two fixation methods combined with OLIF in the treatment of lumbar spondylolisthesis

Xinliang Zhang
Xi'an Jiaotong University School of Medicine
Yunshan Guo
Xi'an Jiaotong University School of Medicine
Yibing Li (max701ml@163.com)
Xi`an honghui hospital https://orcid.org/0000-0001-8471-8279

Research article

Keywords: OLIF, anterior approach, single rod-screw, percutaneous pedicle screw

Posted Date: March 30th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-346686/v1

Abstract

Background

To observe the clinical efficacy of an anterior single rob-screw fixation (ASRSF) combined with the oblique lumbar intervertebral fusion (OLIF) approach compared with a posterior percutaneous screw fixation(PPSF) combined with OLIF in the treatment of lumbar spondylolisthesis.

Methods

This is a retrospective case-control study. Patients with lumbar spondylolisthesis treated with either ASRSF combined with OLIF or PPSF combined with OLIF from January 2016 to January 2018 were enrolled in this study. None of the patients had posterior decompression. The visual analog scale (VAS) and Oswestry dysfunction index (ODI) were used for clinical efficacy assessment. The pre- and post-operational disc height, height of foramen, subsidence and migration of cages, fusion rate, and surgery-related complications were compared between the two groups.

Results

Fifty-three patients were included in this single-center study. According to the fixation methods, patients were divided into the ASRSF group (group A, 25 cases) and the PPSF group (group B, 28 cases). There was no statistical difference in surgery-related complications between groups. There was a significant difference in the VAS score at 1 week post-surgery(2.3 ± 0.5Vs3.5 ± 0.4, $P = 0.01$), and 3 months post-operation (2.2 ± 0.3VS 3.0 ± 0.3, $P = 0.01$). Comparison of post-operative imaging data showed that there was a significant difference in the height of the foramen between groups at 3 months post-surgery(18.1 ± 2.3 mm Vs 16.9 ± 1.9 mm, $P = 0.04$). At 24 months post-surgery, the ODI was 12.65 ± 3.6 in group A and 19.1 ± 3.4 in group B ($P = 0.01$). Twelve months after surgery, the fusion rate in group A was 72.0% and78.6% in group B (not statistically significant, $P = 0.75$). Fusions were identified in all patients at 24 months post-surgery.

Conclusion

Compared to PPSF, ASRSF combined with OLIF for lumbar spondylolisthesis can reduce post-operative low back pain in the early stages, maintain the height of the foramen superiorly, and improve the performance of lumbar function.

Background

With the aging population, degenerative spinal disease (DSD) has become an important pathological cause of immobility and incapacitation in elder adults. Globally, the incidence of DSD exceeds 43.1%, of which 35.3% have severe dysfunction [1–4]. The incidence of DSD in low- and middle-income classes is 4 times higher than that of the high-income class. DSD has increasingly become a social issue that seriously affects the quality of life of many people [2, 3, 5]. Among DSD patients, the incidence of lumbar spondylolisthesis is more than 12.5% [2, 3].

After the failure of conservative treatments, patients with lumbar spondylolisthesis often require surgery. The primary surgical goal is decompression and long-term stability in the target segments. Fusion is typically the most efficient treatment in this type of surgery. Currently, commonly used fusion methods include transforaminal lumbar interbody fusion (TLIF), anterior lumbar interbody fusion (ALIF), posterior lumbar interbody fusion (PLIF), and oblique lumbar intervertebral fusion (OLIF). OLIF technology has attracted attention from surgeons due to its advantages in reducing trauma, improving safety, and restoring lumbar lordosis. In recent years, with the application of the standalone cage, the surgical procedure was simplified but had uncertain post-operative stability [6]. Considering early post-operative stability, OLIF often requires combined posterior fixation with iatrogenic soft tissue impairment. From the perspective of soft tissue protection, OLIF combined with posterior percutaneous screws has become a more mainstreams procedure having superior stability and better clinical outcomes [7–10]. However, due to the lack of anatomical landmarks, the risk of screw misplacement and nerve damage is relatively high [7, 8].

Anterior single screw fixation is commonly used in anterior surgery for deformity correction and debridement. This treatment has shown excellent performance in maintaining stability and reducing iatrogenic trauma. It was speculated whether this treatment could provide additional stability in the OLIF procedure. Thus, the present study aims to analyze the clinical efficacy of the anterior single screw rod combined with OLIF compared to using a posterior percutaneous pedicle screw combined with OLIF in the treatment of lumbar spondylolisthesis.

Materials And Methods

Study design

This retrospective case-control study included patients who underwent OLIF surgery for lumbar spondylolisthesis from January 2016 to January 2018 in Xi'an Jiaotong University Affiliated Honghui hospital medical center. This study was approved by the Ethics Committee of Xi'an Jiaotong University (approval number: 201606012). Given the retrospective nature of the study, patients’ informed consents were not necessary.

The diagnosis of spondylolisthesis was based on pre-operative X-ray examination. Inclusion criteria include: imaging confirmed lumbar spondylolisthesis located from lumbar 2 to lumbar 4, clinical symptoms related to spondylolisthesis, such as low back pain and claudication, 4–6 weeks of conservative treatments including brace fixation and medications yet without symptoms alleviation, degree of slippage classified as Meyerding Grade I or II, and patient follow-up for more than 24 months.

Exclusion criteria were: previous history of lumbar spine surgery,post-operative residual symptoms that required secondary direct decompression, incomplete medical data records.

Surgical procedures

All operations were performed by the corresponding author. The left side approaches were used in all cases. The presence of scoliosis did not affect the side of the surgical approach. After a 5-cm skin incision was made, 6-10cm anterior to the mid-portion of the marked disc, the surgeon approached the retroperitoneal space by blunt dissection and mobilization of the peritoneum anteriorly to expose the anatomical oblique lateral corridor. The soft tissue was expanded, then the working channel was placed, and if necessary, the segmental blood vessels were ligated. After discectomy and endplate preparation, the appropriate cage(Clydesdale spinal system, Medtronic, Memphis, TN,USA; 12mm in height×50mm in length×18mm in width, 6°lordotic, 3.27cc graft volume) was inserted, and filled with demineralized allogeneic bone matrix (Shanxi Aorui Medical Technology Inc, Shanxi, China).

In the anterior single rod-screw group (ASRSF, group A, Legacy spinal system, Memphis, TN, USA), the position of the fusion cage was determined under fluoroscopy and the docking point of the screw was located at the middle part of the vertebral body. In the posterior percutaneous screw group(PPSF, group B, Ruizhi Medical Technology Inc, Shanghai, China), screws were inserted under biplane fluoroscopy. Both groups did not undergo posterior decompressions.

Non-steroidal anti-inflammatory drugs combined with muscle relaxants were used for post-operative analgesia. The back muscle function was exercised by swimming and gymnastics named “skydiver to superman to swimmer,”as recommended by the North American Spine Society (NASS).

Data collection

Demographic data including gender, age, bone density (BMD), body mass index (BMI), and surgical segments were collected. VAS was used to rate low back and lower extremity pain.The ODI index was used to evaluate pre- and post-operative lumbar function. Follow-ups were performed at 1 week, 3 months, 12 months, and 24 months after surgery.

All patients underwent routine pre-and post-operative standing anteroposterior and lateral plain X-ray and flexion-extension plain X-ray to assess inter-segmental stability. CT scan was used to evaluate the presence of migration or subsidence of cages, and to identify bone fusion. Subsidence was defined as a cage sinking into an adjacent vertebral body by $>$2mm,based on comparisons with previous CT images. Cage migration was defined as a posterior movement of the cage by $\geq$ 3mm compared with the immediately post-operative image. CT scan was also used to measure the height of intervertebral space and foramen before and after the operation. The imaging measurement was independently performed by two independent radiographers who did not participate in the study. The intra-class correlation coefficients of all variables were greater than 0.85. CT images were sliced 2 mm thick. The height of intervertebral space was defined as the vertical distance between the tangent lines of the upper and lower endplate dome. The height of the foramen was defined as the distance from the lower position of the upper pedicle to the upper position of the lower pedicle in the target segment. The intervertebral fusion was evaluated with the Bridwell standard, in which grade 1 and 2 were considered to be clinical fusion.

Data analysis

Statistical analysis was performed using SPSS 18.0 for Windows (IBM, Armonk, NY, USA). Normally distributed continuous variables were presented as means ± standard deviation, and were analyzed with the Student’s t test. Non-normally distributed continuous variables were presented as medians (range) and they were analyzed with the Wilcoxon test. Categorical variables were presented as frequencies, and were analyzed with the Pearson Chi-Square test or the Fisher’s exact test, as appropriate. All tests were two-tailed, and P values < 0.05 were considered statistically significant.

Results

Demographic data for the patients in this study are shown in Table 1. A total of 53 patients were included in this study. According to the fixation method, patients were divided into the ASRSF group(group A, n = 25) and the PPS group (group B, n = 28). No significant difference in demographic data was established between groups (Table 1). VAS scores of pre-operative low back pain were 5.1 ± 1.3 in group A and 5.3 ± 1.6 in group B without significant difference (P = 0.88). VAS scores of leg pain were 4.5 ± 2.3 in group A and 3.9 ± 2.9 in group B, the difference was not significant (P = 0.65). The pre-operative ODI was 38.1 ± 4.6 in group A and 37.2 ± 3.0 in group B, no significant difference was found between groups (P = 0.44) (Table 2).

Table 1
Comparison of patients’ demographic parameters and pre-operative imaging parameters

	ASRSF + OLIF	PPSF + OLIF	P
N	25	28	
Gender			
Male	12	17	0.42
Female	13	11	
Age	43.3 ± 7.8	47.4 ± 8.9	0.81
BMI	28.4 ± 9.0	26.7 ± 7.7	0.66
BMD	-1.3 ± 1.2	-1.9 ± 1.0	0.53
Segment			
L2,3	6	3	0.38
L3,4	10	11	
L4,5	9	14	
Degree of slippage			
I°	16	19	0.78
II°	9	9	

ASRSF, anterior single rod-screw fixation; PPSF, percutaneous pedicle screw fixation.

No significant difference was found in pathological segment distribution (P = 0.38) or the degree of slippage(P = 0.78) between the two groups (Table 1). The pre-operative lumbar lordosis was 34.6 ± 4.1° in group A and 35.5 ± 3.8° in group B, and the difference was not significant(P = 0.41). The pre-operative intervertebral space height was 10.8 ± 2.4 mm in group A and 10.3 ± 2.1 mm in group B without significant difference (P = 0.46). The height of the pre-operative foramen was 12.5 ± 1.6 mm in group A and 12.5 ± 1.4 mm in group B, without significant difference between groups (P = 0.92).

The post-operative clinical results were also compared. The VAS score of leg pain at 3 months after the operation was 1.1 ± 0.7 in group A and 1.3 ± 0.8 in group B, without significant difference (P = 0.71). One week after surgery, the VAS score of low back pain in group A was significantly lower than in group B(2.3 ± 0.5 vs 3.5 ± 0.4, P = 0.01). Three months post-surgery, the reported low back pain in group A was still significantly lower than in group B (2.2 ± 0.3 vs 3.0 ± 0.3, P = 0.01). The superiority of group A in reducing low back pain vanished at 12 months after surgery(Table 2). At 24 months post-surgery, the post-operative ODI was 12.65 ± 3.6 in group A and 19.1 ± 3.4 in group B, with a significant difference (P = 0.01).

There was no significant difference in the ODI between groups at 1 week, 3 months, and 12 months post-surgery.

Table 2
Comparison of the VAS score of low back pain and ODI index before and after surgery

	ASRSF + OLIF	PPSF + OLIF	P
N	25	28	
VAS			
Pre-operation	5.1 ± 1.3	5.3 ± 1.6	0.88
1 week post-operation	2.3 ± 0.5	3.5 ± 0.4	0.01*
3 months post-operation	2.2 ± 0.3	3.0 ± 0.3	0.01*
12 months post-operation	2.2 ± 0.8	2.4 ± 0.8	0.34
24 months post-operation	2.3 ± 0.6	2.3 ± 0.7	0.87
ODI			
Pre-operation	38.1 ± 4.6	37.2 ± 3.0	0.44
1 week post-operation	25.1 ± 4.6	27.2 ± 6.0	0.47
3 months post-operation	17.0 ± 5.2	17.9 ± 6.3	0.58
12 months post-operation	19.3 ± 5.6	20.4 ± 7.5	0.55
24 months post-operation	12.65 ± 3.6	19.1 ± 3.4	0.01*

* The difference was statistically significant.ASRSF: anterior single rod-screw fixation. PPSF: percutaneous pedicle screw fixation.

Three months post-surgery, the foramen height was 18.1 ± 2.3 mm in group A and 16.9 ± 1.9 mm in group B, showing a statistical difference (P = 0.04). Twelve months after the operation, there was no significant difference concerning the change in foramen height. No statistical difference was found in the height of the intervertebral space between the two groups at any follow-up time (Table 3). There was a significant difference between the pre- and 12 months post-surgeryimaging parameters between the two groups (Table 4).

The Bridwell method was applied in the fusion assessment with grade I and II considered as successful fusion. Twelve months after the operation, 18 cases achieved fusion in group A (fusion rate 72%), and 22 in group B (fusion rate 78.6%). There was no significant difference between the two groups ($\chi^2 = 0.31$, P = 0.75). All patients achieved fusion at 24 months post-surgery. No subsidence was found in any patients during follow-ups.

In terms of complications, one patient in group A encountered a limited cage migration at 3 months post-surgery. There were four cases of post-operative abdominal distension, two cases of dysuria, and two cases of transient numbness at the anterolateral portion of the thigh in group A. No instrument complication occurred. In group B, there was one case of posterior subcutaneous hematoma, two cases of screw misplacement (no neurological complications), one case of superficial skin infection, three cases of abdominal distension, and one case of transient thigh numbness. There were no statistical differences in complications between the two groups($\chi^2 = 4.71$, P = 0.31).A typical case is shown in Fig. 1.

Table 3
Comparison of imaging parameters between the two groups

	ASRSF + OLIF	PPSF + OLIF	P
N	25	28	
Intervertebral space height			
Pre-operation	10.8 ± 2.4mm	10.3 ± 2.1mm	0.46
3 months post-operation	14.1 ± 1.0mm	14.5 ± 0.9mm	0.12
12 months post-operation	14.0 ± 1.0mm	14.3 ± 1.0mm	0.38
Foraminal height			
Pre-operation	12.5 ± 1.6mm	12.5 ± 1.4mm	0.92
3 months post-operation	18.1 ± 2.3mm	16.9 ± 1.9mm	0.04*
12 months post-operation	16.9 ± 2.1mm	16.6 ± 2.3mm	0.60
Lumbar lordosis			
Pre-operation	34.6 ± 4.1°	35.5 ± 3.8°	0.41
3 months post-operation	45.7 ± 5.6°	45.7 ± 6.3°	0.97
12 months post-operation	45.2 ± 5.6°	44.2 ± 3.6°	0.44

* The difference was statistically significant. ASRSF: anterior single rod-screw fixation. PPSF: percutaneous pedicle screw fixation.

Table 4
Comparison of imaging parameters before and 12 months after surgery

	ASRSF + OLIF	P	PPSF + OLIF	P
N	25		28	
Intervertebral space height				
Pre-operation	10.8 ± 2.4mm		10.3 ± 2.1mm	
12 months post-operation	14.0 ± 1.0mm	0.02*	14.3 ± 1.0mm	0.01*
Foraminal height				
Pre-operation	12.5 ± 1.6mm		12.5 ± 1.4mm	
12 months post-operation	16.9 ± 2.1mm	0.01*	16.6 ± 2.3mm	0.01*
Lumbar lordosis				
Pre-operation	34.6 ± 4.1°		35.5 ± 3.8°	
12 months post-operation	45.2 ± 5.6°	0.03*	44.2 ± 3.6°	0.03*

* Comparing with pre-operative imaging parameters, the difference was statistically significant. ASRSF: anterior single rod-screw fixation. PPSF: percutaneous pedicle screw fixation.

Discussion

Due to advantages in reducing soft tissue damage, improving lumbar lordosis, and reducing nerve tissue disturbance, OLIF has attracted recent attention from spine surgeons. OLIF has been found to increase the cross-sectional area of the dural sac by a median of 30.2%, and increase the neural foramen area by an average of 30.0% [11–14]. Compared with traditional posterior TLIF surgery, the probability of nerve root injury was about 1.3% in OLIF the procedure [12, 14]. No patients in this study experienced post-operative nerve root edema or direct nerve root injury. This indicated that OLIF was a superior technique in protecting nerve tissue.

Since OLIF does not involve iatrogenic damage to the posterior structure, the impairment of spinal stability is limited. There has been some controversy about whether additional fixation is necessary [6, 14]. However, due to the different elasticity modulus between the cage and the endplate, there is a risk of subsidence when the cage is used alone [14, 15]. Therefore, the insertion of pedicle screws is necessary for patients with endplate damage, osteoporosis, or post-operative residual radicular symptoms that require posterior surgeries [13, 15]. Lin et al. [16] evaluated 52 patients who underwent OLIF without posterior instrumentation, and reported a fusion rate of 81.9% at 24 months after surgery as assessed by CT scan imaging. Kim et al. [17] reported a 12month fusion rate of 92.9% in 29 OLIF patients with posterior pedicle screw fixation as assessed with CT. In the present study, no cage subsidence nor nonfusion were found within 24 months post-surgery, which further confirmed that limited internal fixation can reduce the risk of cage subsidence and promote intervertebral space fusion.

In this study, the intervertebral space fusion rate at 12 months post-surgery was 72% in group A and 78.6% in group B, which were relatively low. We presume the major negative factor for the inferior fusion rate was the material of the bone graft. Compared with iliac crest or bone morphogenic protein, using allogeneic bone could result in a lower fusion rate [11, 13].

Posterior percutaneous screw fixation could reduce paraspinal muscle damage where iatrogenic impairment to the paravertebral soft tissues is still unavoidable.This could lead to muscular atrophy and low back pain. Secondarily, given the lack of anatomical reference markers, percutaneous pedicle screw implantation has a relatively higher incidence of screw misplacement compared with open surgery [7, 8]. Utilizing a corridor of OLIF for segmental fixation can effectively reduce the risk of screw misplacement for the direct procedure of implantation and the massive docking area for screws.

In this study, when compared with PPSF, ASRSF resulted in lower back pain at 1 week and 3 months after surgery. The ODI index was also lower in the ASRSF group at 24 months post-surgery, which confirmed the superiority of ASRSF in relieving pain and improving lumbar function. This may be due to evidence of paraspinal muscle protection.

The height of the intervertebral foramen was comparatively better maintained at 3 months post-surgery in the ASRSF group compared with the PPSF group. It was presumed this might originate from the relatively close position to the central axis of the spine in the anterior fixation group, which diminishes the "self-locking" phenomenon in the posterior fixation that could result in a reduction of the intervertebral foramen area [18]. However, this superiority disappeared at 12 months post-surgery, which might be related to a possible increase in lumbar lordosis.

ASRSF showed acceptable stability in the debridement of intervertebral space and anterior vertebrectomy, which confirmed the single screw rod could provide stability given that the posterior column was intact [19–21]. In this study, there was no internal fixation migration in the anterior group, supporting the stability for anterior fixation solely. The possible reason comes first from the inaction of the posterior column in the OLIF procedure. Second, the average age of the patients in this study was 43.3 years and the pre-operative BMD was around − 1.3, which equally contributed to maintaining stability and the excellent skeletal condition of the participants.

In summary, ASRSF combined with OLIF for lumbar spondylolisthes could reduced early post-operative low back pain more effectively, increased the area of foramen, and improved post-surgerylumbar function compared with the clinical manifestation of PPSF with OLIF. In addition, it provided sufficient stability for intervertebral space fusion.

The present study had some limitations. First, this study was a retrospective one. Due to the lack of case selection, there might be a selection bias. Second, this study was a single-center study with a relatively small sample size, therefore it was impossible to evaluate independently based on surgical segments. Finally, since patients in this study were relatively young with ideal bone quality, further research is needed on whether the conclusions made here are appropriate for elderly patients. Large-scale randomized controlled studies are needed to draw definite conclusions.

Abbreviations

ASRSF
anterior single rod-screw fixation.
PPSF
percutaneous pedicle screw fixation.

Declarations

Ethics approval and consent to participate

This study was approved by the Ethics Committee of Xi'an Jiaotong University (approval number: 201606012). All aspects of this study were conducted with adherence to the current version of the Declaration of Helsinki, the guidelines established by the International Conference on Harmonization of Good Clinical Practice, and the laws of China.

Consent for publication

All participants signed informed consent forms for publication.

Availability of data and materials

All data analyzed during this study are included in this published article.

Competing interests

The authors declare that they have no competing interests.

Funding

Not applicable.

Authors’ contributions

XLZ and YBL contributed to the idea of this study. XLZ and YSG searched literatures and screened them independently. YSG played an important role in analyzing the outcomes. XLZ and YBL wrote the first draft and polished and approved the final version.

Acknowledgements

Not applicable.

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Figures

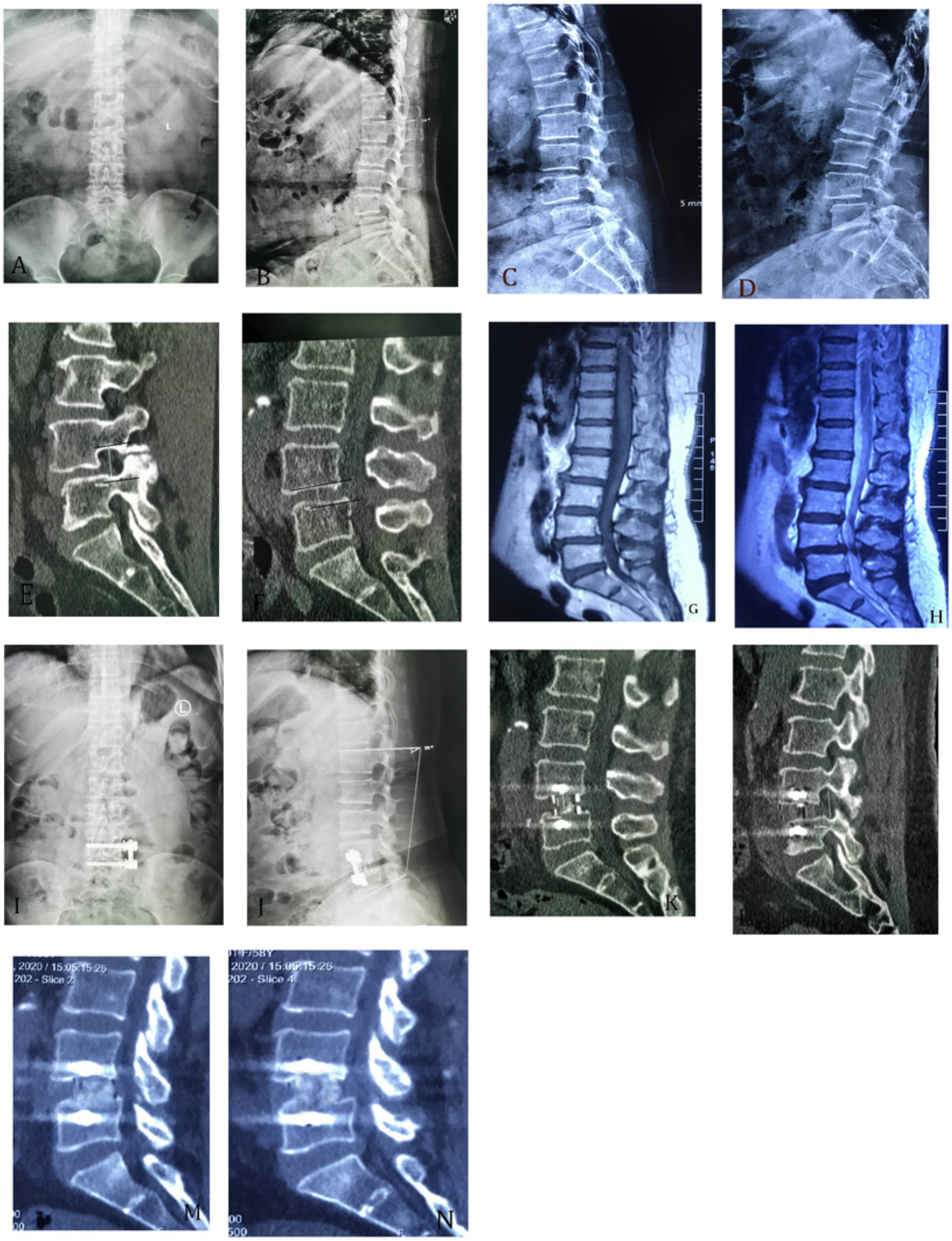

Figure 1

A typical case. A-D, pre-operative radiographies with lordosis of 14°; E, height of intervertebral foramen before surgery; F, height of intervertebral space before surgery; G, pre-operative MRI T1 weighted imaging H ,pre-operative MRI T2 weighted imaging; I-J post-operative radiographies with lordosis of 29°; K, post-operative intervertebral space height; L, post-operative intervertebral foramina height; M, 12 months post-surgery,solid fusion at upper endplate of L4. N, 24 months post-surgery solid fusion at the upper and lower endplates.