

Quantitative comparison of clinical outcomes and decompression parameters between extreme lateral lumbar interbody fusion and transforaminal lumbar interbody fusion in treating lumbar spinal stenosis: a 3-year retrospective cohort study

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Research article

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Abstract

Background This retrospective cohort study was conducted to compare the clinical efficacy and decompression parameters of extreme lateral lumbar interbody fusion (XLIF) with transforaminal lumbar interbody fusion (TLIF) in treating lumbar spinal stenosis (LSS).

Methods From January 2012 to June 2016, 1455 patients with LSS who underwent surgery were reviewed and 83 cases were included (40 cases for XLIF and 43 cases for TLIF). The operative time, blood loss, accumulated fluoroscopy time, visual analogue scale (VAS), Oswestry Disability Index (ODI), fusion rate and complications were evaluated. Moreover, decompression parameters were compared, including the sagittal disc height (DH), the foraminal height (FH) and area (FA), the lumbar lordosis (LL), the transverse area of the dural sac (DS), as well as the rate of change loss of these parameters.

Results The baseline was consistent between two groups. The mean follow-up time was 36.9 months. Both of XLIF and TLIF yielded clinical improvements. XLIF had advantages over TLIF in blood loss, operative time, hospital stay and complication. The fusion rate, postoperative VAS and ODI scores were comparable. Particularly, XLIF showed analogous, or even better, capacity of ameliorating decompression parameters to TLIF, especially regarding DH, LL and the maintenance of decompression.

Conclusions Compared with TLIF, XLIF is advantageous to avoid blood loss, shorten the operative time, hospital stay and maintain the decompressive effect in treating LSS.

Background

Lumbar spinal stenosis (LSS) is an irritating disease caused by narrowing of the spinal canal and compression of the dural sac (DS) or nerve roots. The incidence is 47.2% in the elderly population [1]. Surgical intervention is usually recommended when conservative treatment is invalid [2]. Standard strategy includes decompression alone or decompression plus spinal fusion. Traditionally, the posterior approach, typically open transforaminal lumbar interbody fusion (TLIF), is preferred due to the allowance of decompression, interbody fusion and stability reconstruction in a single incision. Despite the good clinical outcomes, certain drawbacks are noticeable, such as relatively long operation time, massive trauma, excessive blood loss, risk of nerve root injury and cerebrospinal fluid leak, as well as a prolonged recovery time [3]. Moreover, the surgical effectiveness is not always consistent with patients' clinical satisfaction rate. Although the fusion rate of TLIF is generally 90–95%, a patient satisfaction rate of only 63–83% has been reported [4]. Besides, the incidence of dural matter tear is as high as 2–20% [5]. Thus, searching for an optimized surgical approach has long been the research focus.

As a promising alternative, the minimally invasive extreme lateral lumbar interbody fusion (XLIF), which allows anterior access to the target intervertebral space via a lateral approach through the psoas major muscle and placement of a relatively large cage within a 2–3 cm incision, has been increasingly utilized to treat LSS. XLIF seeks to provide indirect decompression via restoring native disc and foraminal heights, which leads to stretch and tightness of the remaining annular fibers, distraction of the posterior longitudinal ligament, unbuckling of the ligamentum flavum and enlargement of the intraspinal space [6]. Its advantages contain little trauma, relatively short operation time, little blood loss, fast postoperative recovery and low complication morbidity. The major concern of using XLIF for spinal stenosis lies in the profound efficacy in neural decompression, which is difficult to evaluate and remains controversial. So far, few efforts have been made to give a comprehensive comparison between XLIF and TLIF in treating LSS by means of evidence-based medicine.

Thus, this controlled trial was plotted to compare the clinical efficacy, fusion effectiveness and complication between XLIF and TLIF. More importantly, the radiologic parameters reflecting the decompression result were extracted and compared, with the purpose to verify the effectiveness of indirect decompression resulted from XLIF.

Methods

Patients

From January 2012 to June 2016, 1455 patients with LSS who have undergone surgery in our hospital were evaluated. The inclusion criteria were as follows: 1) one-level LSS; 2) clinical manifestations including low back pain, unilateral leg pain, numbness and

neurogenic intermittent claudication; 3) failed conservative treatment for > 6 months; 4) consistent radiologic diagnosis. The exclusion criteria included: 1) congenital or iatrogenic lumbar spinal stenosis; 2) accompanied by spondylolisthesis, tumor, infection, congenital spinal deformity or other serious medical diseases; 3) history of abdominal surgery; 4) patients lost to follow-up. All procedures were performed by the same surgeons. This study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of Southwest Hospital. All subjects provided informed consents.

Surgical Approach

The XLIF procedure was performed as described previously [6]. A polyetheretherketone (PEEK) XLIF cage (DePuy Synthes, USA) filled with allogeneic bones (BIOGENE, Dasting Bio-Tech Co., Ltd, China) was implanted into the disc space for each patient. To improve interbody fusion, 20 ml of bone marrow was extracted and repeatedly infiltrated through allogeneic cancellous bone chips using the Bone Growth Promotor (FWS Medical Device Co., Ltd., Chongqing, China) for cell enrichment. Then, bilateral percutaneous pedicle screw (PPS; DePuy Synthes, USA) fixation was performed. TLIF was performed as described previously [7]. The disc space was filled with autologous cancellous bone particles in the anterior one-third region and then implanted with a PEEK cage filled with allogeneic bones.

Postoperative evaluation and follow-up

The operative time, blood loss, intraoperative fluoroscopy time, length of hospital stay and complications were recorded. Postoperatively, the clinical improvements in neurological symptoms were evaluated using the visual analog scale (VAS) and the Oswestry Disability Index (ODI).

Radiological evaluation was mainly dependent on X-rays. Bony fusion was assessed by CT scans and dynamic X-rays performed at 6 months postoperatively, according to the definition by Ray et al. [8]. All radiographic parameters were measured using the tools of picture archiving and collecting system (PACS). The sagittal disc height (DH), foraminal height (FH) and area (FA), as well as lumbar lordosis (LL), were calculated before, after surgery and at the final follow-up (FFU). The transverse area of the DS was measured on CT scans preoperatively and at 3 months postoperatively. The changes of these parameters were obtained by postoperative (Post-op) or FFU values minus preoperative ones. Then, the postoperative rate of change (RC) was calculated as follows: (Post-op-FFU)/Post-op. For XLIF, the length of the intervertebral disc bulge (DB) was measured using the sagittal CT scans and the rate of change was calculated.

Statistical Analysis

Data were described as mean \pm SD and analyzed using SPSS 20.0 software (IBM Corp., Armonk, New York, USA). Paired T test was applied to compare pre- and postoperative values. The difference in parametric change was compared between groups using the independent samples T-test. A p-value < 0.05 was considered statistically significant.

Results

Patient Demographics

Eventually, 40 and 43 cases were included in the XLIF and traditional TLIF groups, respectively. The demographic characteristics were consistent between groups ($p > 0.05$, Table 1). Complete follow-up was achieved in all cases, with a mean time of 36.9 months (12–55 months).

Table 1
Demographic characteristics of patients

Group	Number	Gender		Age (y)	VAS score	ODI index (%)	Stenosis level		
		Male	Female				L2/3	L3/4	L4/5
XLIF	40	23	17	60.1 ± 9.3	6.8 ± 1.2	73.1 ± 12.7	4	16	20
TLIF	43	27	16	61.2 ± 8.6	7.0 ± 1.4	73.0 ± 16.3	3	15	25
P value	-	>0.05		>0.05	>0.05	>0.05	>0.05		

VAS, visual analogue scale. ODI, Oswestry Disability Index.

Clinical Outcomes

Clinical outcomes were listed in Table 2. The blood loss, operative time and duration of hospitalization were significantly less in the XLIF group. Intraoperative fluoroscopy time of XLIF (37.2 s) was notably longer than that of TLIF (20.3 s, $p < 0.01$). No significant difference was found between groups with regard to VAS score, ODI and fusion rate. Postoperatively, the VAS score and ODI were markedly improved by both XLIF and TLIF, as compared with preoperative values. In terms of complication, the incidence of hip-flexion weakness and anterior hip pain was dramatically higher in the XLIF group. However, the symptoms spontaneously disappeared within 2 weeks postoperatively. The morbidity of dural rupture-induced cerebrospinal fluid leakage was significantly lower for XLIF. No surgical nerve injury, hematoma formation or infection was recorded. The incisions healed uneventfully. Neurologic symptoms were significantly relieved in both groups. Neither reoperation nor postoperative spinal instability was reported.

Table 2
Intra- and postoperative data

Group	Number	Operative time (min)	Intraoperative fluoroscopy time (s)	Blood loss (ml)	Hospitalization period (d)	VAS	ODI (%)	Fusion state	Cerebrospinal fluid leakage	Hip flexion disorder
XLIF	40	68.9 ± 17.8	37.2 ± 12.8	63.8 ± 30.5	6.3 ± 1.5	0.9 ± 0.7	6.9 ± 4.5	37/40	0/40	6/40
TLIF	43	151.1 ± 23.3	20.3 ± 6.6	291.2 ± 102.9	7.5 ± 1.6	0.9 ± 0.8	8.1 ± 6.4	41/43	5/43	1/43
p value	-	<0.01	<0.01	<0.01	<0.01	>0.05	>0.05	>0.05	<0.05	<0.05

VAS, visual analogue scale. ODI, Oswestry Disability Index.

Radiographic Assessment

Radiographic parameters were detailed in Fig. 1. In both of two groups, there was a significant difference in the DH, FH, FA, LL and DS for all patients before and after surgery. Compared with Post-op values, the DH, FH and FA were observably reduced at FFU in both of two groups. However, no significant change was found for LL. For DH, the increment after surgery was slightly higher in XLIF than TLIF. Although RC of DH (RC-DH) showed no difference, the increment at FFU was notably higher in XLIF. For LL, the increments after surgery and at FFU were markedly higher in XLIF than TLIF. No significant difference was found in RC. For FA, TLIF led to dramatically higher increments after surgery and at FFU, as compared with XLIF. RC of FA (RC-FA) was comparable. For FH, the increment after surgery in TLIF was just slightly higher. However, the increment at FFU tended to be marginally higher in XLIF. RC of FH (RC-FH) of XLIF was significantly less than that of TLIF. For DS, the increment after surgery was higher in TLIF than XLIF, but no remarkable difference was found. After XLIF, the average change rate of the bulging length was 63.5%. Representative images of radiologic assessment were provided in Fig. 2.

Discussion

The core surgical strategy for treating LSS is sufficient decompression. Decompression alone is effective, but destruction of posterior elements and facetectomy may lead to spinal instability [9]. To address this issue, minimally decompressive surgery has been nominated. Another method is decompression plus spinal fixation and fusion, such as TLIF [7]. However, certain complications are noticeable, including bleeding, local stiffness, deep infection, grafting fracture and fusion failure [10]. Moreover, decompression is associated with potential intraoperative cerebrospinal fluid leakage and postoperative epidural hematoma [11]. Such context leads to a situation where XLIF is applicable to spinal fusion without direct decompression.

During TLIF, extensive dissection of the paraspinal muscles is likely to damage the deep nerves that innervate the muscles and cause paraspinal muscle denervation. These changes may result in slow recovery, intractable low back pain and further static and dynamic imbalance [12, 13]. For XLIF, the retroperitoneal approach allows the preservation of the anterior and posterior tension band system of the motor unit [14, 15]. Compared with traditional TLIF, the XLIF cage has a larger footprint spanning bilateral cortical rims, by which DH can be effectively restored with possible higher segmental stability, especially with the assistance of fixation. Moreover, larger amount of bone grafts and wider fusion interface bring considerable benefits to the interbody fusion [16]. Increasing evidence support the utilization of XLIF for treating various types of LSS. Using XLIF, Alimi et al. treated 23 patients with unilateral LSS [6]. Postoperatively, the height of the affected nerve root canal was significantly increased with improved VAS and ODI scores. Also, for patients with complicated LSS in the adjacent segments of lumbar fusion, XLIF seems to be an advantageous approach. Wang MY et al. reported clinical improvements in radiating pain and successful interbody fusion in all 21 patients [17]. Besides, XLIF was recommended to treat LSS complicated with osteoporosis or obesity due to the excellent biological stability and minimal invasion [18]. Even so, there is still a lack of comprehensive comparison between XLIF and traditional strategy. In this study, XLIF showed apparent advantage in blood loss, operative time and length of hospitalization. This was mainly due to the minimally invasive feature of XLIF. Longer fluoroscopy time of XLIF might be primarily attributed to the cage implantation, where more caution was required on the position to avoid neural and vascular injury. No significant difference was detected in clinical outcome between XLIF and TLIF, indicating the effectiveness of indirect decompression provided by XLIF.

As with complications, current literature provides estimable reference information. Rodgers WB et al. demonstrated that among 600 XLIF cases with degenerative disc and facet joint diseases, only 0.7% encountered nerve injury and 1.8% required additional surgery [18]. In another study, 235 patients were enrolled and the rate of sensory nerve injury and psoas muscle weakness was 1.6% and 1.6%, respectively. Moreover, the incidence of lumbar plexus injury was 2.9%, lower than that of TLIF (4.1%) [19]. For XLIF, lumbar plexus nerve injury is relatively common at the L4/5 level and associated with female gender and prolonged operative time [20]. For open TLIF, the reported complication rate was 8–12% [21] and higher (17.9%) in overweight or obese patients [22]. In the present study, the major complications of XLIF were hip-flexion disorder and anterior hip pain, which disappeared within postoperative 2 weeks. The cerebrospinal fluid leakage was more frequent for TLIF. Such phenomenon was mainly due to the distinctions in the operative approach and the decompression manner. Moreover, no surgical nerve injury, hematoma formation, or infection was induced by either XLIF or TLIF. The relatively mild complication of XLIF might partially account for the shortening hospital stay. Collectively, both of XLIF and TLIF were effective in the treatment of LSS. However, XLIF was likely to be more advantageous.

Nowadays, the major concern for treating LSS with XLIF is the indeterminacy of decompression. Several studies have shown good improvement in the radiographic outcomes of indirect decompression by comparing parameters before and after XLIF. As inferred above, the XLIF cage can improve the decompression parameters postoperatively. For example, Oliveira L et al. reported that XLIF increased the DH, FH, FA and DS by 41.9%, 13.5%, 24.7% and 33.1%, respectively [23]. Consistently, we found that postoperatively, both of XLIF and TLIF were outstanding in improving the radiographic parameters, as illustrated by the striking increases of DH, LL, FH, FA and DS. Whereas, comparing XLIF with TLIF is still necessary, with particular regard to interpreting and judging the efficacy of XLIF. Herein, we found that after XLIF, the DH and LL had a greater increase. Moreover, the improvement of FH and FA after TLIF was just slightly better than XLIF. This mild difference might be associated with the change of DH and LL as larger DH and LL meant smaller foraminal space. Unconspicuous advantage of TLIF was also found in the increase of DS. Even so, XLIF showed a better performance over TLIF in the variation of FH at the FFU. Meanwhile, the superiority of XLIF in increasing DH and LL was still remarkable. Also, it was worth noting that the RC-FH was significantly higher for TLIF, indicating greater power of XLIF in preserving decompression. In addition, the RC-DH and RC-LL were < 5% and comparable between XLIF and TLIF, suggesting their ability in maintaining the postoperative spinal stability. Collectively, these findings demonstrated that for treating LSS, both of XLIF and TLIF were effective from the perspective of radiography and XLIF owned analogous, or even better, capacity of ameliorating decompression parameters to TLIF.

Still, certain limitations exist. Firstly, stratification analysis and comparison (e.g, LSS type, lesion level and cage size) were infeasible due to the restriction of sample size. Secondly, patients with severe spinal disorders were not included, such as tumor, infection and congenital spinal deformity, which might cause bias. In fact, several studies have advised surgeons to choose XLIF for LSS with caution, especially when uncontained disc herniation, serious facet degeneration, osteophyte formation with calcified discs, or bony lateral recess stenosis is involved [16]. Factors predicting effective indirect decompression of XLIF remain elusive. There has been evidence suggesting that indirect decompression after XLIF is particularly influenced by the degree of reduction in the length of the intervertebral disc bulge and therefore, LSS accompanied by rather large bulging is recommended for XLIF [14]. In spite of this, no reference level of the bulging length has been given. In this study, the change rate of the bulging length was 63.5%, which seemed comparable to the reported value [13]. Based on available literature and our experience, cage width and height may serve as important factors determining successful and sustained indirect decompression [24].

Conclusions

In the present study, we retrospectively compared the effectiveness of XLIF and TLIF in treating LSS. Both of XLIF and TLIF provided improvements in regard to clinical symptoms and radiographic parameters. XLIF had advantages over open TLIF in blood loss, operative time, hospital stay and complications. The fusion rates and postoperative VAS and ODI scores were comparable. XLIF owned analogous, or even better, capacity of ameliorating decompression parameters to TLIF.

Abbreviations

LSS	Lumbar spinal stenosis
DS	Dural sac
TLIF	Transforaminal lumbar interbody fusion
XLIF	Extreme lateral lumbar interbody fusion
PEEK	Polyetheretherketone
PPS	Percutaneous pedicle screw
VAS	Visual analog scale
ODI	Oswestry Disability Index
PACS	Picture archiving and collecting system
DH	Disc height
FH	Foraminal height
FA	Foraminal area
LL	Lumbar lordosis
FFU	final follow-up
Post-op	Postoperative
RC	Rate of change
DB	Disc bulge

Declarations

Ethics approval and consent to participate: This study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of Southwest Hospital. Informed consent was obtained from all individual participants included in the study.

Consent for publication: The authors affirm that human research participants provided informed consent for publication of the images in Figure 2.

Availability of data and materials: The data and materials are available.

Competing interests: The authors declare that they have no competing interests.

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Authors' contributions: QYH and HWL designed this study and performed critical revision of the manuscript; JCX and PC collected data and wrote this paper. JZX analyzed the data. QYH and HWL performed the surgeries.

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Figures

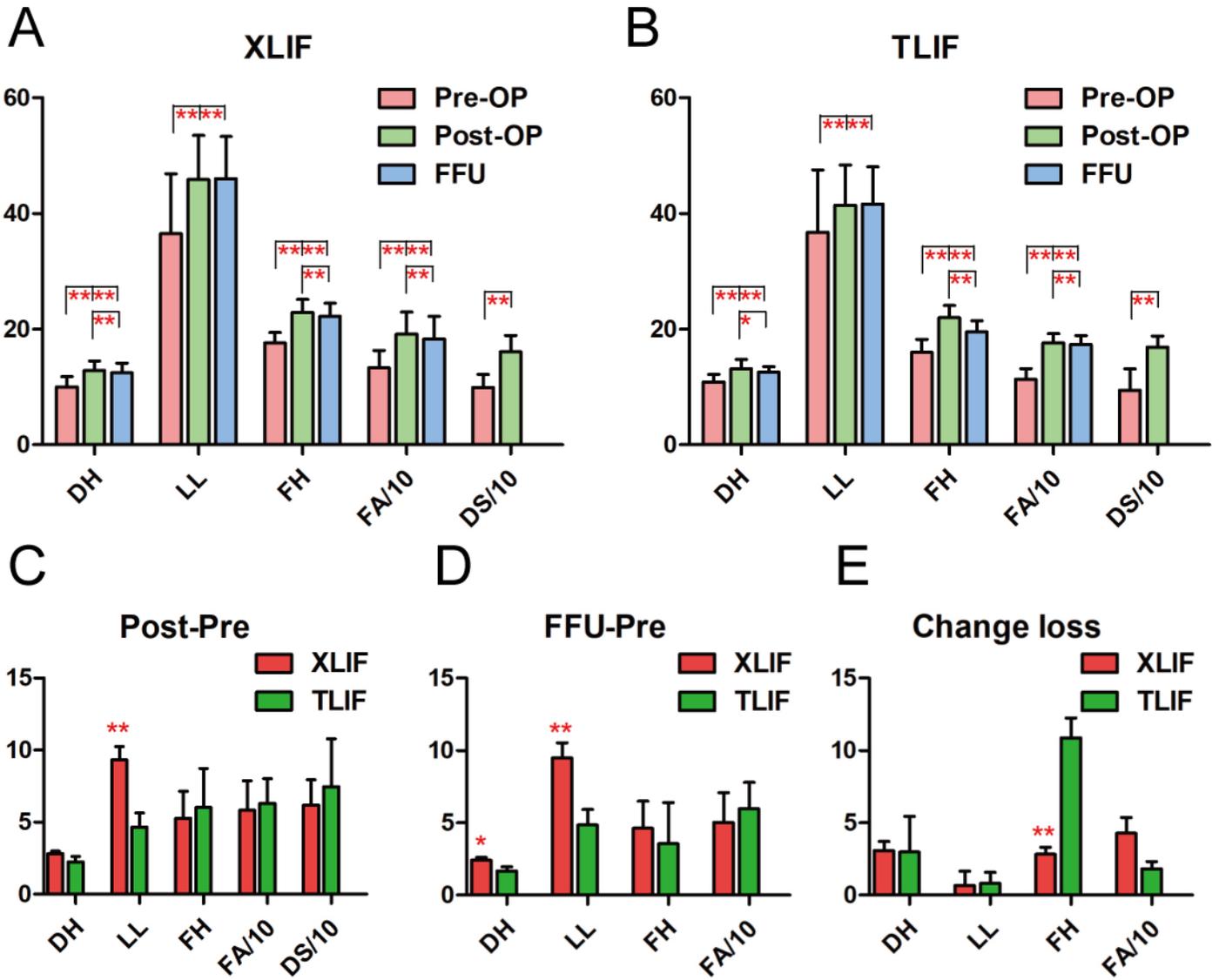


Figure 1

Comparison of radiographic parameters. XLIF, extreme lateral lumbar interbody fusion. TLIF, transforaminal lumbar interbody fusion. Pre-OP, preoperatively. Post-OP, postoperatively. FFU, at the final follow-up. DH, disc height (mm). LL, lumbar lordosis (degree). FH, foraminal height (mm). FA, foraminal area (mm²). DS, the area of the dural sac (mm²). Post-Pre, postoperative values minus preoperative values. FFU-Pre, values at the final follow-up minus preoperative values. *, p<0.05. **, p<0.01.

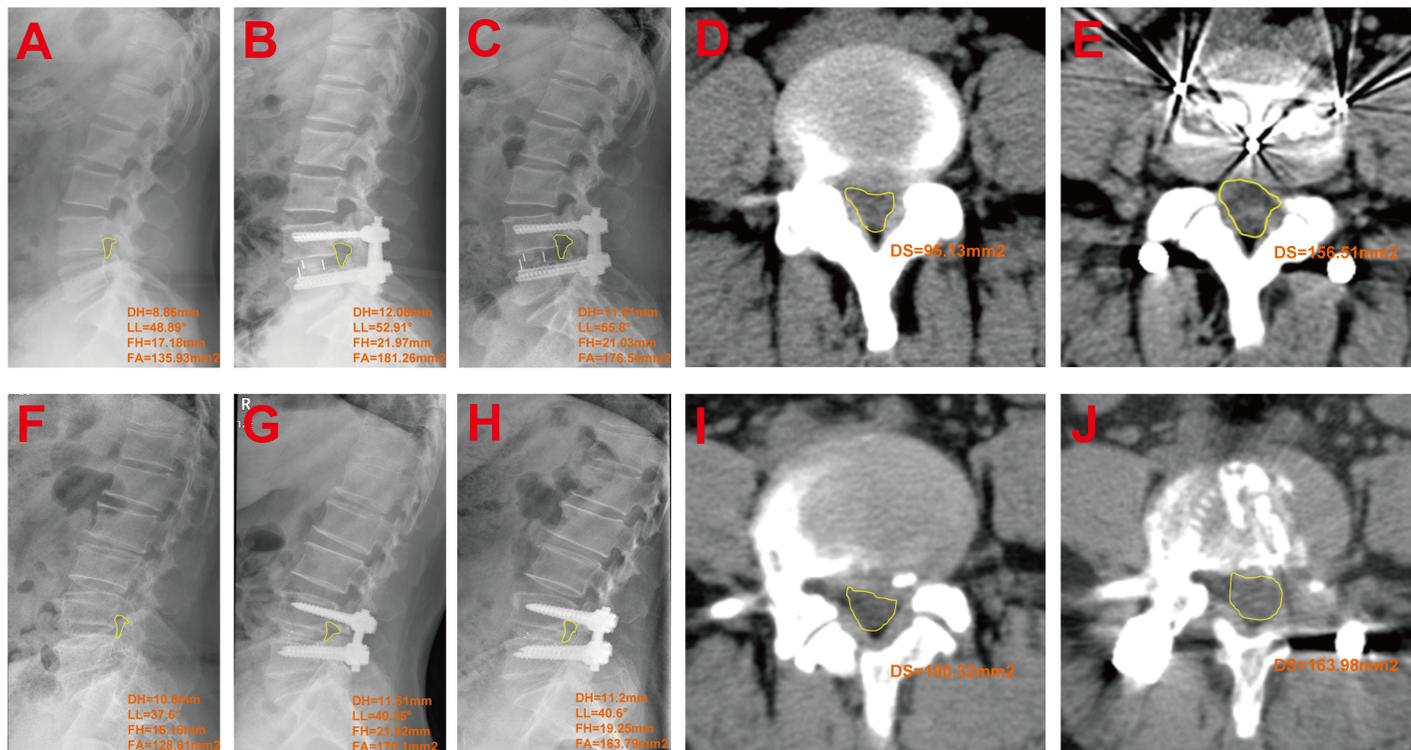


Figure 2

Representative images of radiologic assessment. (A-E), the representative images of extreme lateral lumbar interbody fusion (XLIF). (F-J), the representative images of transforaminal lumbar interbody fusion (TLIF). (A&F), preoperative lateral X-rays. (B&G), postoperative lateral X-rays. (C&H), lateral X-rays at the final follow-up. (D&I), preoperative transverse CT. (E&J), postoperative transverse CT. DH, disc height (mm). LL, lumbar lordosis (degree). FH, foraminal height (mm). FA, foraminal area (mm²). DS, the area of the dural sac (mm²).