Chapter 13

Current Literature Evidence for Lumbar Interbody Fusion

13 Current Literature Evidence for Lumbar Interbody Fusion

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Introduction

Lumbar interbody fusion (LIF) is a well-established treatment for disorders affecting the lumbar spine as a result of several etiologies. Degeneration is the most prevalent pathology which affects the disc and the facet joints and may produce spondylolisthesis causing significant impairment of quality of life and higher pain scores. Patients who do not respond to conservative management require surgical intervention such as LIF. Various fusion methods such as anterior lumbar interbody fusion (ALIF), lateral lumbar interbody fusion (XLIF/LLIF), transforaminal lumbar interbody fusion (TLIF), and posterior lumbar interbody fusion (PLIF) exist based on the approach adapted to reach the spine.[1] The record of LIF dates back to Berthold Hadra, who performed the first instrumented spinal fusion procedure in 1891 Austin, TX. Later, Briggs promoted PLIF in 1944 and Jorgen Harms started TLIF in 1982.[2,3,4] The LIF technique has gained considerable refinement in recent years, and the relevant evidence regarding the appropriate fusion method is increasing as numerous studies are being conducted and published every year. Unfortunately, when cumulative evidence are taken together, it fails to definitively support one approach over another.

Multiple meta-analysis studies are done comparing the different LIF methods. For instance, in patients with degenerative lumbar spinal diseases, studies have compared open TLIF with minimally invasive TLIF, ALIF with TLIF, ALIF with posterior pedicle screw fixation (PPF) with standalone posterior approaches, etc. The predominant search databases used in all these studies include Cochrane Library database (including the Cochrane Central Register of Controlled Trials), PubMed (including MEDLINE), and various other sources extending from the date of inception to the commencement of analysis. The "levels of evidence" are an important component for practicing evidence-based medicine (**Table 13.1**).

Understanding this hierarchy and why levels are assigned to publications helps the reader to prioritize information. This does not mean level 4 evidence should be ignored and all level 1 evidence should be accepted as fact. These evidences act as a good guiding tool and majority of systematic reviews/meta-analyses contemplated in this chapter consider from level 1 to 4, however with caution, when interpreting these results. Universally, the primary outcomes analyzed in LIF studies are fusion rates, total blood loss during surgery, length of hospital stay, operation time, complication rates, fluoroscopic time, visual analog score (VAS), numeric rating scale (NRS), Short Form 36 (SF-36),

Table 13.1 Levels of evidence for therapeutic studies

Level	Type of evidence
1A	Systematic review (with homogeneity) of RCTs
1B	Individual RCT (with narrow confidence intervals)
1C	All or none study
2A	Systematic review (with homogeneity) of cohort studies
2B	Individual cohort study (including low-quality RCT, for example, < 80% follow-up)
2C	"Outcomes" research; ecological studies
3A	Systematic review (with homogeneity) of case-control studies
3B	Individual case-control study
4	Case series (and poor-quality cohort) and case-control study
5	Expert opinion without explicit critical appraisal or based on physiology bench research or "first principles"

Abbreviation: RCT, randomized controlled trial.
Source: From the Centre for Evidence-Based Medicine, http://www.cebm.net.

Japanese Orthopaedic Association (JOA) back pain evaluation, and Oswestry Disability Index (ODI). The approach in this chapter is to compile the current literature evidence for choosing the ideal LIF method for various disease conditions and also to establish the advantage of one method over another.

Indications for Lumbar Interbody Fusion: (Anterior/Posterior/Lateral)

The advent of new instruments and implants combined with latest technological advances has expanded the spectrum of "indications for performing LIF" in the past decade.[5]

The current indications for LIF are as formulated in **Box 13.1**.

Current Evidence to Support Fusion Over Decompression Alone

The latest study is by Koenig S et al, and they did a meta-analysis of evidence level I to IV studies from 1996 comparing decompression alone and decompression plus fusion in the treatment of degenerative spondylolisthesis (DS).[6] The number of cases that met the inclusion criteria in the decompression cohort was 12 (591 cases), and 13 cases (465 cases) in the fusion cohort. There was significant decrement in pain (legs and lower back), and SF-36 (physical, mental component) showed better patient clinical outcomes in both the cohorts.

Box 13.1 Indications for Lumbar Interbody Fusion

- Spondylolisthesis (usually grade I or II)
- Degenerative disc disease (DDD) causing discogenic low back pain (with or without radiculopathy)
- Recurrent lumbar disc herniation inducing significant mechanical back pain
- Postdiscectomy collapse with neural foraminal stenosis and secondary radiculopathy
- Greater recurrent or > 3 times recurrent lumbar disc herniation with or without pain
- Pseudoarthrosis
- Postlaminectomy kyphosis
- Lumbar coronal and/or sagittal deformities

In the decompression cohort, the values of 29.7 and 35.5 (physical and mental), improved to 41.2 and 48.5 points, respectively. In the fusion cohort, 28.4 and 39.3 points improved to 41.5 and 48.3 points, respectively. The complication rate was 5.8% (95% CI 1.7–2.1) in the decompression cohort and 8.3% (95% CI 5.5–11.6) in the decompression plus fusion cohort. The rate of resurgery was higher in the decompression cohort (8.5%) compared with the decompression plus fusion cohort (4.9%). The majority in the decompression group was older patients with a higher percentage of leg pain and in case of younger patients, additional fusion was performed. A recent study by Chan AK et al compared the 24-month patient-reported outcomes after minimally invasive surgery (MIS)-TLIF and MIS decompression in lumbar DS. Of 608 patients, MIS-TLIF was associated with a lower reoperation rate and superior outcomes in disability, back pain, and patient satisfaction compared with MIS decompression alone.[7]

These studies clearly represent a changing trend toward interbody fusion compared with decompression alone in the recent times mainly due to the better postoperative outcomes and especially with the adaptability for MIS.

Evidences to Show Advantage of Anterior and Lateral Procedures

The three most widely used anterior/lateral LIF procedures include ALIF, transpsoas LLIF, and a prepsoas or anterior to the psoas oblique lumbar interbody fusion (OLIF). The primary surgical goal of any anterior procedure is to implant the largest possible interbody graft within the confines of the surgical exposure to facilitate fusion rates, maximize the segmental lordosis (SL), and provide indirect neural decompression. This is achieved by expansion of bony neural foramen, distraction of ligamentous stenosis occurring at the central canal, distributing the load across the instrumented vertebra, and in addition providing sagittal balance correction.[8] ALIF has efficient and direct access to reconstruct anterior column. It avoids injury to paraspinal musculature and their denervation, particularly when done as a stand-alone

procedure or in combination with percutaneous posterior instrumentation.

A comprehensive meta-analysis of the published data from 2010 to 2019 by Cho et al, evaluating outcome measures such as lumbar lordosis (LL), SL, slip rate, disc height (DH), VAS score, and ODI, compared ALIF/LLIF with PPF against TLIF/PLIF in DS (**Table 13.2**). Despite comparable postoperative outcomes between the two groups, the anterior procedures were superior to posterior ones in terms of restoring the LL, SL, and DH.[9] Another meta-analysis by Teng et al, comparing four different approaches (ALIF, LLIF, PLIF, and TLIF), found similar fusion rates irrespective of the procedure. However, ALIF had superior radiological outcomes and better restoration of postoperative DH and SL. The complication rates were similar between anterior and posterior approaches.[10] A systematic review by Keorochana et al, comparing MIS-TLIF with MIS-LLIF in degenerative lumbar disease, used ODI, VAS, and postoperative complications as outcome measures. A total of 9,506 patients (5,728 MIS-TLIF and 3,778 MIS-LLIF group) were compared and found that the fusion rate was not significantly different between the two techniques.[11]

Thus, anterior LIF procedures overall indicate a comparable fusion rate to posterior LIF procedures and have an advantage of restoring the near normal lumbar spine anatomy. Since ALIF allows for preservation of the posterior ligaments and soft tissue, the likelihood of adjacent segment degeneration (ASD) is less; although, here have been no consistent findings in the literature substantiating this claim. ALIF has its own shortcomings such as retraction of iliac vessels at L4–L5 level that may lead to increased vascular injury or thrombosis with incidence rate of 0 to 18.2%.[12,13] The handling of the hypogastric plexus can cause neural injury with retrograde ejaculation (RE) in males. Certain reports suggest the risk to be as low as less than 1% whereas others report it up to 45%.[14] A prospective study by Sasso et al found that transperitoneal ALIF approach has 10 times greater chance of RE than the retroperitoneal approach.[15] The use of the monopolar cautery should be minimized and bipolar cautery should be preferable.[16] In addition, ALIF is also associated with abdominal hernias. When combined with posterior fixation it involves additional cost and surgery.[14,15] Complications of LLIF include urinary retention, tibialis anterior

Table 13.2 Compilation of meta-analysis and systematic reviews on comparison of anterior/lateral lumbar interbody fusion procedures with other approaches

Comparison	Author	Inclusion period (y)	Number of studies	Outcome measures	Results
Decompression alone vs. with fusion	Koenig et al	21	25	Blood loss, VAS, ODI, SF-36, JOA, NRS	VAS and SF-36 (physical, mental component) improved in both the groups. Rate of resurgery was higher in decompression cohort (8.5%) compared with fusion (4.9%)
ALIF/LLIF with PPF vs. TLIF/PLIF	Cho et al	10	8	LL, SL, slip rate, DH, VAS, ODI, fusion rate	Comparable postoperative outcomes between two groups. Anterior procedures had good restoration of LL, SL, and DH
ALIF vs. PLIF vs. TLIF vs. LLIF	Teng et al	Inception - 2015	40	LL, SL, DH, VAS, ODI, operative outcomes, fusion rate, complications	Similar fusion and complication rates among all procedures. ALIF had superior radiological outcomes and better restoration of DH and SL
MIS-TLIF vs. MIS-LLIF	Keorochana et al	Inception - 2016	58	VAS, ODI, operative outcomes, fusion rate	Fusion rates and postoperative outcomes not significantly different between the two techniques

Abbreviations: ALIF, anterior lumbar interbody fusion; DH, disc height; JOA, Japanese Orthopaedic Association score; LL, lumbar lordosis; LLIF, lateral lumbar interbody fusion; NRS, Numeric Rating Scale; ODI, Oswestry Disability Index; PLIF, posterior lumbar interbody fusion; PPF, posterior pedicle screw fixation; SF-36, Short Form-36; SL, segmental lordosis; TLIF, transforaminal lumbar interbody fusion; VAS, visual analog score.

weakness, and transient sensory deficits. The best available current literature demonstrates 30 to 40% of patients having postoperative deficits, primarily of the proximal leg. However, permanent symptoms are less common, affecting 4 to 5% of cases.[17] Vascular injuries are also less frequent compared with ALIF. Visceral injuries, pneumothorax, and diaphragm injuries are reported at times.

Evidence and Comparison of Posterior LIF Procedures

The major posterior approaches include PLIF and TLIF surgery. PLIF and TLIF provide good outcomes for any lumbar spine disease. However, TLIF has replaced PLIF due to its advantages such as higher rates of fusion, minimal complications, and similar postoperative outcomes.[18] In 2003, Foley et al[19] demonstrated that MIS-TLIF has even less perioperative complications than traditional open TLIF. Fujimori et al compared the clinical and radiological outcomes of prospective cohort of TLIF (24 cases) and PLIF cases (32 cases) in DS. The fusion rate was better in TLIF (96%) as opposed to PLIF (84%) and in addition the DH was better restored in TLIF group. ODI improvement and LL were similar in both the groups.[20]

There are multiple meta-analyses available in literature comparing the PLIF and TLIF with other lateral/anterior procedures and MIS-TLIF over open TLIF (**Table 13.3**). de Kunder et al did a meta-analysis to compare the effectiveness of TLIF and PLIF in reducing disability and rate of intra- and postoperative complications in patients with DS. TLIF was better in terms of complication rate, blood loss, and operation duration. Clinical outcomes were comparable, with a slightly lower postoperative ODI score for TLIF.[4] Another study by Zhang et al compared the perioperative results and complications associated with PLIF and TLIF, and collected evidence for choosing the better fusion method. They found that PLIF had a higher complication rate and TLIF reduced the rate of durotomy. No statistical difference was found between the two groups with regards to clinical satisfaction, blood loss, vertebral root injury, graft malposition, infection, or the rate of radiographical fusion.[21] However, PLIF has its own limitations as the procedure involves retraction of the neural tissue for cage and graft insertion along with epidural bleeding. To overcome this, TLIF was introduced which has less perioperative complications and less bleeding. In addition, TLIF can also be safely administered above L3 level. Lee et al concluded that 10% of patients would undergo additional surgery for treating ASD within 10 years after index posterior lumbar fusion. They showed PLIF showing higher incidence of ASD and age > 60 years being independent risk factor.[22]

Comparison of MIS-TLIF Over Open TLIF and Other LIF Procedures

Xie et al performed meta-analysis of prospective and retrospective studies that compared MIS-TLIF with open TLIF. They found that MIS-TLIF was associated with a significant decrease in VAS score, ODI index, and blood loss along with early ambulation and shorter hospital stay compared with open TLIF. However, there were no significant differences in the fusion rate, complication rate, operation time, or need for resurgery.[23] Qin et al compared the clinical efficacy and safety between MIS-TLIF and open TLIF in treatment of single-level DS by systematic review and meta-analysis. MIS-TLIF was more efficacious and safe technique with reduced tissue trauma, quicker postoperative recovery, and better long-term functional outcomes.[24] A similar conclusion was obtained by meta-analysis of seven RCTs proving MIS-TLIF has less blood loss than open TLIF. However, in their study there was no significant difference in the length of hospital stay, postoperative VAS, and ODI.[25] Even in the obese patients MIS-TLIF was found superior to open TLIF.[26] In case of choosing an ideal LIF procedure for degenerative disc disease (DDD), a network meta-analysis of prospective studies comparing PLIF (open and MIS), TLIF (open and MIS), and ALIF showed that MIS-PLIF resulted in lower pain scores than open TLIF/open PLIF. MIS-PLIF also had low ODI score than open TLIF/open PLIF/ALIF. They concluded that MIS-PLIF may be a better procedure for DDD and open TLIF may not be recommended.[27]

Table 13.3 Compilation of meta-analysis and systematic reviews on comparison of posterior lumbar interbody fusion procedures

Comparison	Author	Inclusion period	Number of studies	Outcome measures	Results
PLIF vs. TLIF	Zhang et al	Inception - 2013	7	Operative outcomes, fusion rate, blood loss, complications	PLIF has high complication rate. No difference between two groups in clinical satisfaction, blood loss, root injury, graft malposition, infection, or fusion
PLIF vs. TLIF	de Kunder et al	Inception - 2016	192	VAS, ODI, complications, operative outcomes	TLIF has less complication rate, blood loss, and duration of surgery. Comparable clinical outcomes between groups
Open TLIF vs. MIS-TLIF	Xie et al	Inception - 2015	24	VAS, ODI, operative outcomes, fusion rate, blood loss, complications	MIS-TLIF has significant decrease in VAS, ODI, and blood loss; early ambulation and short hospital stay. No significant difference in fusion/complication rate, operation time/need for resurgery
Open TLIF vs. MIS-TLIF	Li et al	Inception - 2018	7	VAS, ODI, operative outcomes	MIS-TLIF has less blood loss. No significant difference in the length of hospital stay, postoperative VAS, and ODI
Open TLIF vs. MIS-TLIF	Qin et al	9	6	VAS, ODI, operative outcomes, fusion rate, complications, length of hospitalization, resurgery	MIS-TLIF is more efficacious and safe with less tissue trauma, quicker recovery, better long-term functional outcomes
Open TLIF vs. MIS-TLIF in obese individuals	Xie et al	Inception - 2017	7	VAS, ODI, operative outcomes, complications, length of hospitalization	MIS-TLIF is superior to open TLIF
PLIF (open and MIS) vs. TLIF (open and MIS) vs. ALIF in DDD	Lin EY	Inception - 2018	8	VAS, ODI, operative outcomes	MIS-PLIF has lower pain scores than open TLIF/PLIF and better ODI than open TLIF/open PLIF/ALIF

Abbreviations: ALIF, anterior lumbar interbody fusion; DDD, degenerative disc disease; DH, disc height; JOA, Japanese Orthopaedic Association score; LL, lumbar lordosis; MIS, minimally invasive surgery; NRS, Numeric Rating Scale; ODI, Oswestry Disability Index; PLIF, posterior lumbar interbody fusion; SF-36, Short Form-36; SL, segmental lordosis; TLIF, transforaminal lumbar interbody fusion; VAS, visual analog score.

Recommendation on the Appropriate Approach Required by Demonstration of Case-Based Scenarios Compiled Through Literature Evidence

Case 1

A 45-year-old female with unilateral L5 radiculopathy (VAS: 7/10) presents with secondary L4–L5 spondylolisthesis, disc prolapse, facetal hypertrophy, and preserved intervertebral DH. The ideal method would be TLIF and the choice of performing it as open or MIS should be based on the surgeon's expertise (**Fig. 13.1**). However, MIS-TLIF is preferred over open TLIF due to the better postoperative outcomes as discussed.[23,24,25]

Case 2

A 57-year-old patient presents with weakness of bilateral ankle dorsiflexion and neurogenic

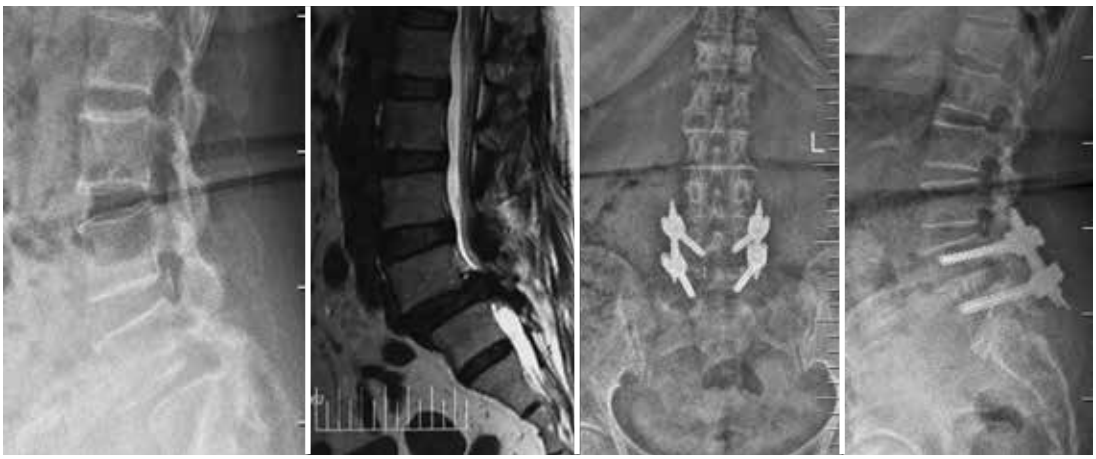

Fig. 13.1 L4–L5 spondylolisthesis managed with minimally invasive surgery transforaminal lumbar interbody fusion.

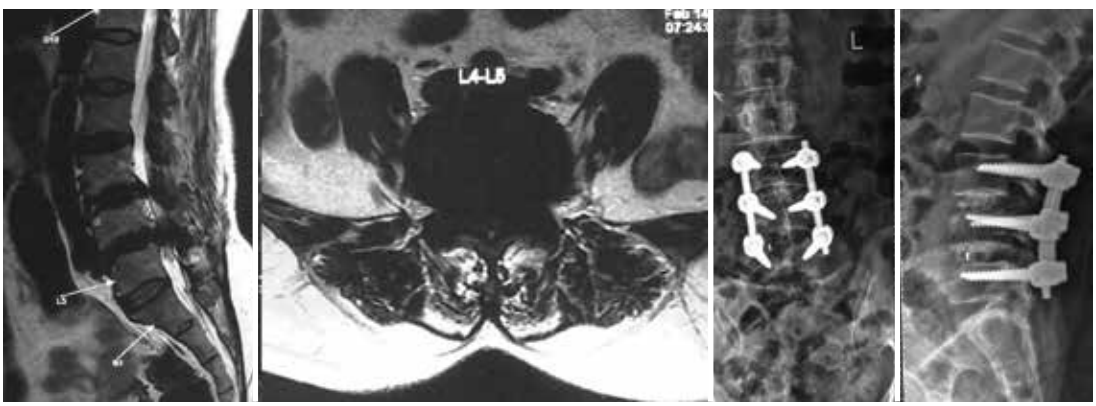

Fig. 13.2 L3–L5 lumbar canal stenosis with neurological deficits managed with open posterior interbody fusion.

claudication with magnetic resonance imaging (MRI) showing L3–L4 and L4–L5 lumbar canal stenosis, significant facetal hypertrophy, and preserved DH (**Fig. 13.2**). The surgery performed would be a two-level TLIF/PLIF as the DH is already better and there is the need to achieve a good decompression of the neural canal.[4]

Case 3

A 45-year-old female presents with significant back pain (VAS: 4/10), radicular pain in the distribution of L3 root with MRI showing L3–L4 DDD with instability, vacuum phenomenon, and significantly reduced disc space. This is an ideal case for anterior procedure, such as OLIF/ALIF, as it helps to increase the intervertebral DH and indirect foraminal decompression, and achieve desirable fusion (**Fig. 13.3**).[8,9,10]

Case 4

A 78-year-old patient presenting with back pain (VAS: 7/10) and neurogenic claudication for 100 m is diagnosed for degenerative lumbar scoliosis and flat back deformity from L2–S1 level. The patient will be benefitted by multilevel ALIF/OLIF and augmentation with PPF (**Fig. 13.4**). This procedure will be the treatment of choice for obtaining a better spinal balance in addition to neural decompression.[8]

Conclusion

In conclusion, it is evident that LIF, irrespective of the type of approach, remains an effective treatment option for a range of spinal disorders. Limited evidence is available for comparison of

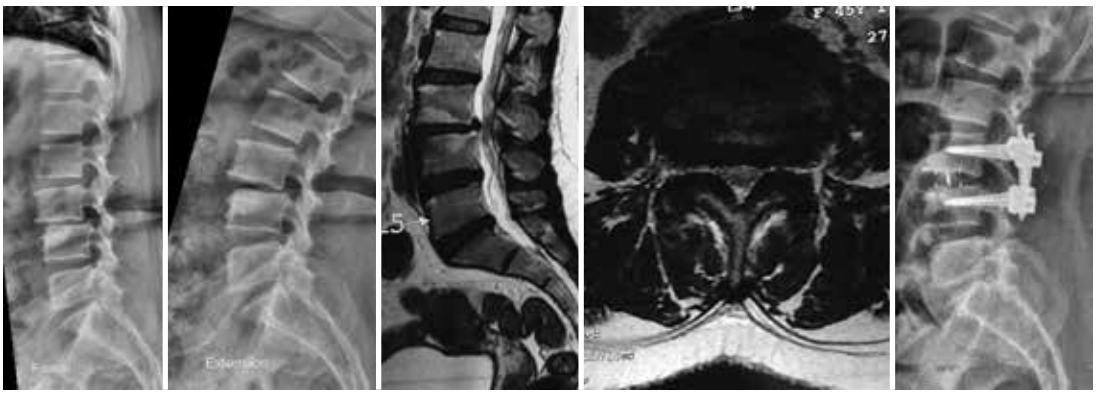

Fig. 13.3 L3–L4 degenerative disc disease with exiting nerve root pathology treated by oblique lumbar interbody fusion.

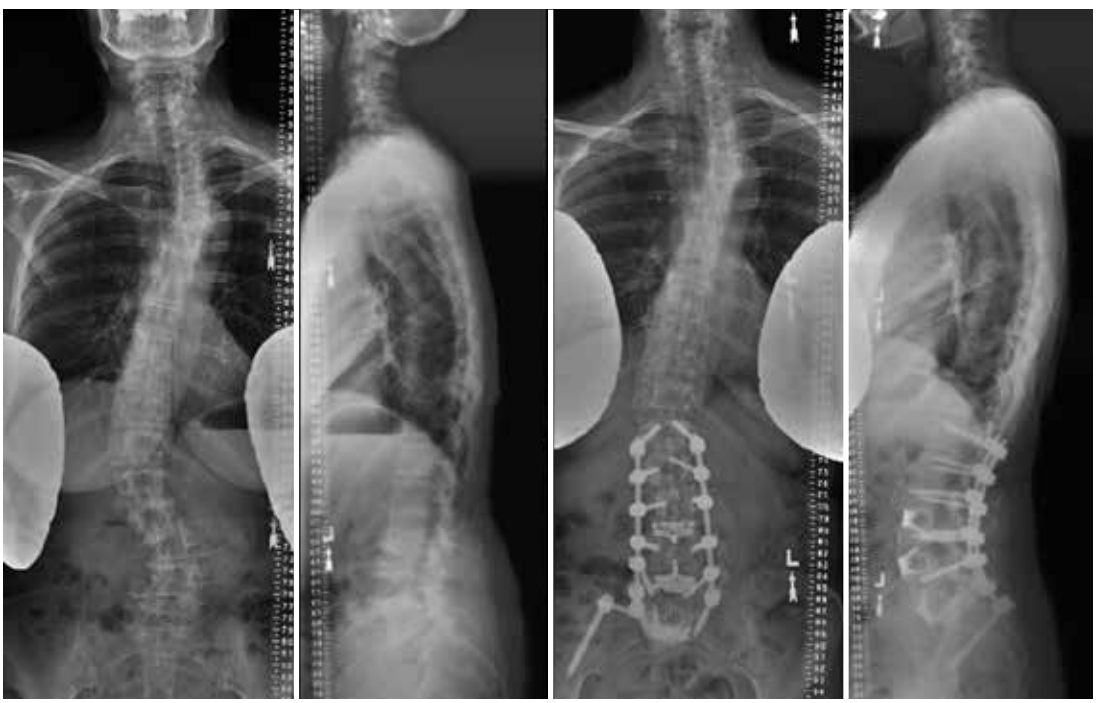

Fig. 13.4 Adult spinal deformity with imbalance successfully intervened by multilevel anterior lumbar interbody fusion and posterior instrumentation.

the superiority of one approach over another in terms of fusion or clinical outcomes. This is because there are minimal/no class I studies available to propose a definite LIF approach for a specific disease condition. Literature in LIF also lacks a strong comparison between approaches. Overall, MIS-TLIF results in a good fusion rate, better functional outcomes, less blood loss, and shorter ambulation and hospital stay in the management of DS. Furthermore, it is associated with less complication rates or resurgery. However, MIS techniques are costly and hence in limited resource setup, open TLIF should be the procedure of choice with better ODI scores compared with other open techniques. ALIF procedures achieve better postoperative DH and postoperative SL; however, PLIF has the greatest blood loss and does not have any advantage over the others in an ideal situation. Despite the type of approach, any surgery when meticulously done showed that postoperative outcomes and complication rates are similar across all approaches.

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