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# ANTERIOR LUMBAR INTERBODY FUSION (ALIF): A REVIEW OF THE PROCEDURE AND ASSOCIATED COMPLICATIONS

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Degenerative disc disease and facet joint disease involving the lumbar spine are common in the aging population and are the most frequent causes of disability. Surgical interbody fusion of degenerative levels is the most common management technique. This is an effective treatment option to stabilize the spine and reduce mechanical pain and provides indirect decompression of the neural elements while restoring lordosis and correcting the deformity. Depending on the direction of the approach to the vertebral column, various techniques have been described. Anterior lumbar interbody fusion (ALIF) offers clear and wide visualization of the disc allowing the use of large interbody grafts, which provide a significant biomechanical advantage over other types of fusion. The transperitoneal approach is a much older technique and it is not commonly performed unless in isolated cases with extensive retroperitoneal scaring following multiple abdominal surgeries. The transperitoneal approach has been associated with higher rates of bowel injury, ileus, and retrograde ejaculation, and is limited at the $L_5$–$S_1$ segment, hence many spine surgeons favor a retroperitoneal approach. The major setback of ALIF is the need for great vessel mobilization. This manipulation of the vessels may lead to deep vein thrombosis and a direct vascular injury. This makes vascular anatomy studies in the preoperative stage invaluable in avoiding vascular injury. Other complications include possible injury to intraperitoneal and retroperitoneal organs, especially in patients with previous surgery and adhesions. Manipulation of the intestines causes postoperative ileus which lasts a few days. Sexual dysfunction in form of retrograde ejaculation is another complication seen in patients following ALIF and this has been attributed to injury to the superior hypogastric sympathetic nerves in the lower lumbar region.
This article reviews the ALIF procedure i. e., transperitoneal and retroperitoneal approaches, and the associated intraoperative, early, and late complications.

**Keywords:** anterior lumbar interbody fusion, degenerative disc disease, facet joint disease, lumbar spine, spinal fusion

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## Передний поясничный межтеловой спондилодез: обзор процедуры и связанные с ней осложнения

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Дегенеративные заболевания межпозвоночных дисков и спондилоартроз поясничного отдела позвоночника часто встречаются у пожилых людей и являются самой распространенной причиной инвалидности. Хирургический межтеловой спондилодез на уровне вовлеченных позвонков – наиболее распространенный метод лечения. Это

эффективный подход для стабилизации позвоночника и уменьшения боли, позволяющий косвенно снять компрессию с элементов нервной системы и восстановить лордоз с исправлением деформации. Описаны различные методы спондилодеза с разным доступом к позвоночнику. Передний поясничный межтеловой спондилодез (ППМС) дает возможность широкого обзора межпозвоночного диска, что позволяет использовать большие межтеловые эндопротезы, обладающие значительными биомеханическими преимуществами по сравнению с другими типами протезов. Трансперитонеальный доступ является относительно старым методом и используется редко, за исключением отдельных случаев тяжелого ретроперитонеального рубцевания после операций на брюшной полости. Трансперитонеальный доступ связан с большей частотой повреждений кишечника, кишечной непроходимости, ретроградной эякуляции и ограничен сегментом $L_5$–$S_1$, поэтому многие хирурги предпочитают ретроперитонеальный доступ. Главный недостаток ППМС – необходимость мобилизации множества сосудов, что может приводить к тромбозу глубоких вен и прямой травме сосудов. Поэтому на предоперационной стадии исследование анатомии сосудов является незаменимым этапом, необходимым для избежания травмы сосудов. Другие осложнения связаны с возможным повреждением интраперитонеальных и ретроперитонеальных органов, особенно у пациентов, которые ранее были оперированы и имеют рубцовое сращение. Манипуляции на кишечнике приводят к постоперационной кишечной непроходимости, сохраняющейся несколько дней. Сексуальная дисфункция в форме ретроградной эякуляции является еще одним осложнением у пациентов после ППМС, возникающим в результате травмы верхнего гипогастрального симпатического нерва в нижнем поясничном отделе.
В статье представлен обзор процедуры ППМС, в том числе с трансперитонеальным и ретроперитонеальным доступами, и связанные с ней интраоперационные, ранние и поздние осложнения.

**Ключевые слова:** передний поясничный межтеловой спондилодез, дегенеративные заболевания межпозвоночных дисков, спондилоартроз, поясничный отдел позвоночника, спондилодез

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## INTRODUCTION

There are several benefits of anterior lumbar interbody fusion (ALIF) reported in the literature. Being an anterior approach through the retroperitoneal space or transperitoneal corridor, the posterior elements of the spinal column like paraspinal muscles and ligaments are spared [1, 2]. This makes it a less traumatic option in the management of degenerative diseases of the lower lumbar region with shorter hospital stay and postoperative pain [2, 3] even though the duration of postoperative narcotic use is independent of the surgical technique [4]. Other complications like surgical site infection and nerve injury are also lower in patients undergoing ALIF [5].

An anterior approach to the spine anatomically offers a wider and complete view of the intervertebral disc space. This allows for a more complete discectomy and endplate preparation, and the use of relatively large interbody grafts. This anatomical advantage gives ALIF a biomechanical advantage over approaches to the lower lumbar spine [6]. ALIF is associated with increased postoperative foraminal volume and disc height [7, 8]. The ability to use more lordotic cages at the lower lumbar spine in degenerative spine disease increases the chance of attaining near-physiological lumbar lordosis and sagittal balance [9, 10].

A complete preoperative patient evaluation is required before performing ALIF. of specific importance in these patients is the history of abdominal surgery or radiation therapy. These factors are associated with peritoneal and retroperitoneal adhesions which increases the risk of complications associated with the approach [11, 12].

The anterior lumbar spine approach is limited by the presence of vascular structures, especially above the $L_4$–$L_5$ space. This makes computed tomography angiography an invaluable preoperative study to help understand the vascular anatomy and reduce the risk of injury [13]. Alternatively, or additionally, preoperative magnetic resonance imaging scans are useful to carefully visualize the position of the kidneys and other retroperitoneal structures as well as the lumbosacral spine and intervertebral discs [13–15].

Careful patient selection is important to optimize the postoperative outcome in ALIF. The main commonly discussed surgical indications for ALIF include spondylolisthesis, degenerative lumbar scoliosis, failed posterior fusion, degenerative disk disease, and adjacent segment disease [7, 12]. However, reports of ALIF use in lumbar spine trauma and following tumor resection have been described in the literature [12].

Contraindications of ALIF commonly discussed in the literature include prior abdominal surgery and radiation therapy which increases the risk of adhesions and risk of injury to the surrounding structures, morbid obesity which is a major risk factor for subsidence, fusion failure, and other postoperative complications, and severe aortic atherosclerosis [11].

## TECHNICAL CONSIDERATIONS

There is a lack of high-quality evidence in the spine literature regarding the optimal surgical approach to the $L_5$–$S_1$ segment for anterior lumbar interbody fusion [16]. The most common are the retroperitoneal and transperitoneal approaches for ALIF [17]. The higher rates of bowel injury, ileus, and retrograde ejaculation associated with the transperitoneal approach and the fact that it is limited to the $L_5$–$S_1$ segment have made the retroperitoneal approach

more favorable [17, 18]. Both approaches are described briefly below.

## RETROPERITONEAL APPROACH

For $L_{4-5}$ and $L_5$–$S_1$ levels, the patient is kept in a true supine position. However, for higher levels or multiple level ALIF, positioning the patient in a slight right lateral decubitus position may be helpful.

The left side of the abdomen is preferred for the approach because the aorta is more robust than the vena cava. To relax the iliopsoas during the procedure, flexing the hips may be helpful. Incisions may vary depending on the levels targeted. The skin incision may be either horizontal at the midline (Pfannenstiel) for $L_5$–$S_1$ or paramedian horizontal for higher levels (Fig. 1).

A longitudinal incision is associated with a higher risk of denervation and atonia of the rectus abdominis. The transversalis fascia and arcuate line are identified and detached from the lateral abdominal wall with careful inspection and gentle finger dissection. Once the transversalis fascia is incised, the peritoneal sac is moved medially to access the retroperitoneal space via blunt dissection (Fig. 2).

In case of penetration into the peritoneum, it should be carefully examined to exclude associated bowel injury, then it should be immediately closed using absorbable 3–0 or 4–0 sutures to prevent postoperative hernia and bowel injury.

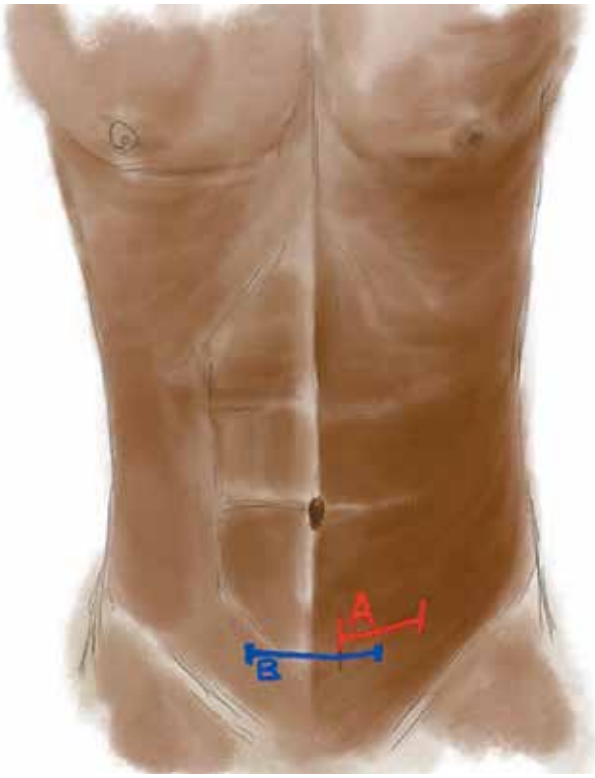


**Fig. 1.** *Shows two skin incisions commonly used in anterior lumbar interbody fusion. A – left lateral incision for retroperitoneal approach. B – Pfannenstiel incision for the transperitoneal approach. Drawing by Dr. Musa Gerald*

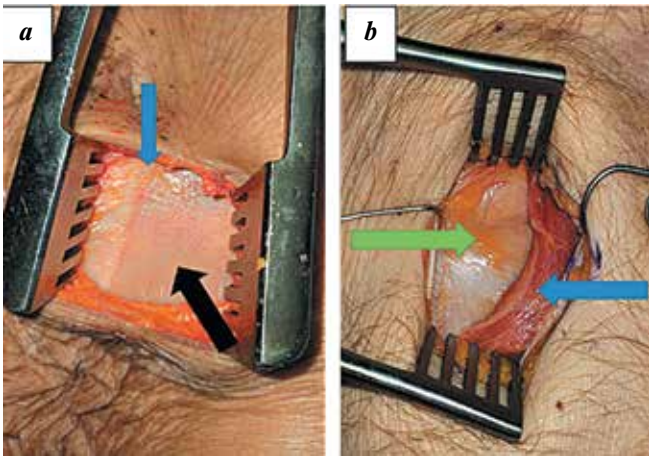


**Fig. 2.** *Cadaver dissections showing the abdominal layers in retroperitoneal approach: a – the linea semilunaris (blue arrow) and rectus abdominis fascia (black arrow); b – the rectus abdominis (blue arrow) and the peritoneum seen under the transversalis fascia (green arrow). Photo curtesy Dr. Castillo Rossi E. B.*

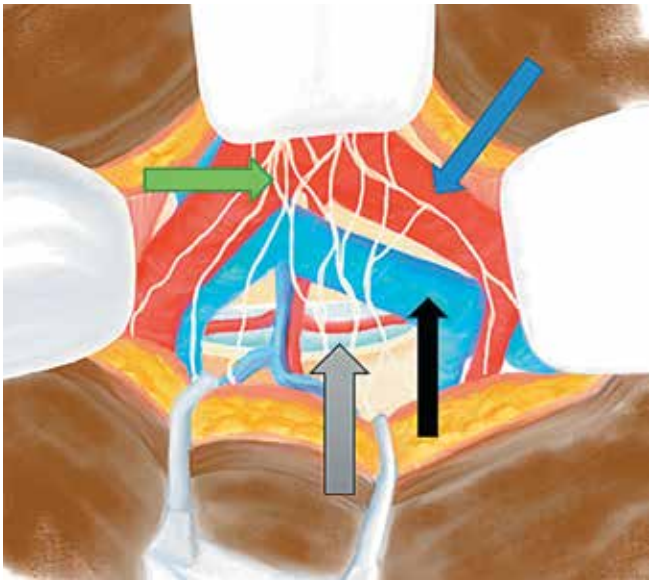

**Fig. 3.** *Shows an enlarged illustration of the midline neurovascular anatomy at the lower lumbar spine, $L_5$–$S_1$ disc (grey arrow). The common iliac arteries (blue arrow) are clearly visible with the internal iliac seen on the left side. The common iliac veins are indicated by the black arrow. The sympathetic nerves are seen on the great vessels (green arrow). The middle sacral artery and vein are shown arising from the bifurcation of aorta and vena cava in the midline. The ureters (not shown here) lie laterally. Drawing by Dr. Musa Gerald*

The landmark to be palpated at this stage is the psoas muscle and the pulsation of the common iliac artery which is usually palpable laterally. The next prominent landmark is the $L_5$–$S_1$ disk and sacral promontory. At $L_5$–$S_1$ level, the middle sacral vessels are seen arising from the aorta and vena cava and should be cauterized. Also present in this area Infront of the $L_5$–$S_1$ disk, are the autonomic nerves. These nerves may easily be damaged by monopolar electrocautery, thereby leading to autonomic dysfunction including retrograde ejaculation (Fig. 3).

The left common iliac artery and vein at $L_{4-5}$ level, must be mobilized from left to right. It should be kept in mind that the iliolumbar vein may be encountered at $L_5$. It should be ligated before mobilizing the left common iliac vein to avoid avulsion and massive bleeding [18, 19]. After the radiological confirmation of the correct level, anterior annulotomy, discectomy, and endplate preparation is performed. The excessive overzealous discectomy should be avoided to prevent penetrating the dorsal annulus fibrosus which can predispose to epidural bleeding or a cerebrospinal fluid leak. Once adequate discectomy has been performed, a trial may be done to verify the cage size, and then the intervertebral cage with morselized autologous or allogeneic bone graft is placed within the disk space [20].

## THE TRANSPERITONEAL APPROACH

The transperitoneal approach is a much older technique and it is not commonly performed unless in isolated cases with extensive retroperitoneal scaring following multiple abdominal surgeries. However, in some institutions, this approach remains the gold standard [16].

This is technique is associated with a high risk of injury to the peritoneal contents and the superior hypogastric plexus. The risk of intestinal obstruction resulting from the scaring is higher in these cases. Manipulation of the intestines causes postoperative paralytic ileus.

However, in cases with a history of multiple abdominal surgeries or a case of revision of an anterior spinal surgery, the transperitoneal technique is still a valuable option to reduce the risk of vascular and ureteral damage. The technique varies from surgeon to surgeon. We describe a summary of the common steps in this technique. A standard midline abdominal incision or a Pfannenstiel incision 5 cm above the pubis and vertical dissection through the Linea alba are made [16]. The peritoneum is sharply opened and the intestines are pushed laterally and are protected using retractors and wet gauze.

The sigmoid colon and mesocolon are retracted away from the midline to the left and the cecum to right. This directly exposes the posterior peritoneum over the vertebral column. The peritoneum is separated from the retroperitoneal space, prevertebral vessels, and nerves by injecting saline into this physiological space. The posterior peritoneum is opened vertically by blunt dissection to expose the anterior vertebral column. Only minimal short bursts of monopolar electrocautery are utilized to prevent injury to the superior hypogastric plexus and resultant retrograde ejaculation [3, 16]. The rest of the procedure is as in the retroperitoneal approach.

## COMPLICATIONS

The major setback of ALIF is the need for great vessel mobilization. This manipulation of the vessels may lead to deep vein thrombosis and a direct vascular injury [21]. Being a retro or transperitoneal approach there is a risk of injury to the abdominal and pelvic organs. Improper closure of the peritoneum or abdominal wall poses a risk of incisional hernia [21]. Injury to the laterally located sympathetic nerves can cause vasodilation in the ipsilateral leg, but almost always resolve spontaneously in the first three to six months after surgery. Retrograde ejaculation is seen in up to 45 % of men and has been attributed to hypogastric plexus injury [22–24]. We classify these complications as intraoperative, early, and late postoperative.

**Intraoperative complications.** Vascular injury is one of the commonest intraoperative complications of ALIF seen in 6.66 % [11] to 18 % [14] of cases. Arterial injury is relatively rare. It usually presents as thrombotic occlusion or intraoperative or delayed massive hemorrhage due to either excessive manipulation or prolonged retractor use causing vascular wall ischemia [25, 26]. Most venous injuries are related to exposure rather than to graft placement [14]. Venous bleeding can be mild and controllable with compression and bipolar coagulation or so catastrophic that a case might have to be abandoned [11]. Venous thrombosis following damage to the iliac veins on the affected side is a real concern. This makes the postoperative doppler study invaluable for follow-up.

B. Kapustka in a review of the ALIF biomechanical analysis stated that although the venous injury is the most common, arterial wall dissection or rupture is the most serious iatrogenic injury; therefore, careful preoperative evaluation of vessels on magnetic resonance imaging or abdominal computed tomography angiography, meticulous preparation and manipulation of the iliolumbar vascular complex is required [27].

Peritoneal perforation due to adhesions is not uncommon during retroperitoneal exposure in patients with a history of abdominal surgery. However, the true rate of peritoneal perforation is difficult to predict as many authors do not report this complication. Primary closure of the peritoneum in cases with perforation has been reported with no complications.

Bowel perforation is a rare complication with the possibility of severe postoperative complications. Adhesions are the major factors for perforation [27]. Unfortunately, the degree of adherence of the bowel to the peritoneum and the retroperitoneal structures cannot be predicted in advance [11]. However, for patients with a history of previous abdominal surgery, intraabdominal sepsis, malignancy, or radiotherapy, the presence of peritoneal adhesions should be anticipated and measures put in place to manage bowel rapture. In the case of bowel perforation, the degree of contamination should be carefully considered before proceeding with the procedure. In the presence of significant contamination, the operation should be abandoned after bowel closure [11].

**Early postoperative complications.** In the early postoperative period, ileus is a common self-limiting complication usually lasting 2 to 3 days after the retroperitoneal approach. However, in patients with extensive bowel manipulation (especially in the transperitoneal approach), multiple

previous abdominal surgeries, retroperitoneal hematoma formation, or excessive narcotic use, ileus may last longer than 3 days [28]. Patients with prolonged ileus are managed with intravenous fluids, nasogastric suction, and intestinal motility enhancers until unequivocal bowel sounds return.

A case of postoperative pancreatitis has been reported and was attributed to faulty retractor placement [11].

Abdominal wound dehiscence after retroperitoneal exposure is rare and has been reported in 0 to 2.3 % of cases [29]. This is associated with systemic factors affecting wound healing or poor surgical technique.

**Late postoperative complications.** Sympathetic nerve injury is a common late complication of ALIF which may be self-limiting, short term, or present with long term complications. Many authors regard sympathetic nerve injury as an unavoidable surgery-related complication of an anterior approach as the superior hypogastric plexus of the sympathetic system is located in front of the $L_5$ and $S_1$ vertebral bodies [30, 31]. Unilateral injury may be asymptomatic or with no long-term sequelae. However, a bilateral injury may cause sexual dysfunction in the form of ejaculatory disturbance. The incidence of retrograde ejaculation following ALIF ranges from 5 to 22 % [11] with complete or partial resolution of the symptom seen in one-third of the patients over 1 to 2 years [32, 33]. Erectile dysfunction has also been reported. However, it is believed to be of psychogenic origin [33, 34] and is unlikely to result from a standard ALIF procedure as the parasympathetic plexus responsible for penile erection is not encountered during ALIF.

Another under-reported late complication during retroperitoneal exposure for ALIF is an injury to the ilioinguinal and the lateral branch of the iliohypogastric nerve. They are commonly injured as they course over the iliac crest. These patients present with numbness or paresthesia affecting the medial upper thigh. Viswanathan Rajaraman reported three patients, two recovered completely by 6months and 1 had only partial recovery [11]. This is in contrast to femoral and genitofemoral nerve injury that occurs in transpsoas approaches.

Deep venous thrombosis is reported as a late complication in ALIF 7 to 8 % of patients due to manipulation of the major vessels during the procedure [35]. Intraoperative preventative measures against deep venous thrombosis include careful vascular tissue handling. This can be accomplished by placing Steinman pins in the vertebral body to keep the vessels retracted [14, 30, 31] and avoiding constant continuous retraction to avoid vessel wall ischemia. The advantages of Hand-held malleable retractors for vascular retraction with the periodic release of pressure when surgery is not being performed near these structures cannot be overemphasized. As required in post major surgery patient care, early postoperative mobilization, routine prophylactic methods such as intraoperative sequential compressive boots, and the use of low-dose heparin are vital for the prevention of this complication.

Injury to the lumbar sympathetic chain located on the lateral aspect of the vertebral bodies has been recognized in the past and is more associated with lateral lumbar interbody fusion than ALIF. Characteristically, the patient complains of a cold limb or foot on the side contralateral to the side of injury. The affected side is warmer due to loss of sympathetic vasoconstriction [11]. Considering that these symptoms can also be seen in cases of arterial thrombosis, the distal pulses should be checked to exclude the possibility of arterial compromise [26].

## BIOMETRICAL RESULTS

Pre- and postoperative three-dimensional computed tomography scan is the gold standard investigation to analyze foraminal parameters [7]. Normal reference values are: foraminal area (FA) from 1.25 to 2.25 $cm^2$, foraminal height (FH) from 11 to 19 mm and foraminal width (FW) from 5 to 12 mm [7, 27]. Symptomatic degenerative lumbar disc disease is associated with lower foraminal parameters [6, 27, 36]. Several authors have reported significant foraminal improvement with ALIF ranging from 40 % [6, 27, 36] to as high as 87 % (for $L_5$–$S_1$ level) [7].

Improvements in lumbar lordosis and posterior and anterior disc height (DH) improvement attributed to ALIF have been highlighted in the literature [27, 37, 38]. The increase in FA following ALIF has shown varying results. Percentage improvement of FA has ranged from 49 % by B. Kapustka et al. who used a mean cage height of 12.31 mm to about 66.7 % achieved by P.J. Rao et al. using only 7 mm disc destruction. However, J.D. Schlegel et al. reported on a cadaveric specimen that an anterior disc distraction of 10 mm caused 40 % FA improvement [39]. This brings into question the relationship between the cage height and the foraminal area. This is however beyond the scope of this review.

There is a significant correlation between ODI questionnaire score and FH, and FA improvement. ODI score improvements in as high as 94 % of patients have been associated with improvement in foraminal parameters [7]. This emphasizes the importance of foraminal parameters as indicators of good outcomes.

## SUBSIDENCE

Subsidence is another rare but important complication seen in ALIF. It is defined in literature as a decrease in the vertical height of the vertebral disc space before complete fusion [7]. The reduction in disc space can detrimentally affect stability, and mechanical correction, and cause chronic pain [40]. Subsidence occurs from as early as 15 days [41] to 3 months [15]. Body mass index is a major factor associated with accelerated subsidence rates [42].

Caudal endplate erosion or overpreparation during discectomy [7] and variations in strength across endplate regions due to variations in bone mineral density [15] are considered risk factors for subsidence. The posteroinferior third of the endplate and the vertebral periphery are stronger than the anterosuperior and the central regions of the

vertebral endplate [41, 43]. This is supported by J.Y. Choi et al., who reported a subsidence rate of 39.1 % at the superior endplate and 17.3 % at the inferior endplate [15].

Furthermore, the rate of subsidence is affected by the type of implant used in the fusion. Several studies in the literature have studied the various implant materials. The sole use of bone grafts in ALIF has been associated with subsidence rates of up to 100 % [37, 44]. As an alternative to bone grafts, metal interbody cages and more recently PEEK [45] have been associated with better disc height and reduced risk of subsidence during fusion [15, 40, 46].

However, studies have shown that subsidence does not impair bony fusion [7, 47] and has no significant effect on the clinical outcomes including VAS back pain, ODI, SF-12 PCS, and MCS scores [7].

## CONCLUSION

Anterior lumbar interbody fusion is a common and effective treatment option to stabilize the spine and reduce mechanical pain and provides indirect decompression of the neural elements while restoring lordosis and correcting the deformity. It is, however, not without complication. The technical considerations and complication profiles are important and should be reviewed regularly to reduce complications and improve the quality of patient education and preoperative informed consent.

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