

# Dilemma in the Surgical Management of Lumbar Canal Stenosis

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## ABSTRACT

For a long time wide decompressive laminectomy, direct visualization and decompression of affected nerve roots, foraminotomy and when necessary discectomy had remained the gold standard to operate patients with lumbar canal stenosis. There was confusion in the literature concerning the role of fusion even in the presence of instability in degenerative lumbar canal stenosis due to absence of prospective randomized clinical trials. This has led to uncertainty about the correct choice of surgical strategy as no evidence based recommendations on the role of instrumented PLIF in older patients. Such thoughts have compelled some to try minimally invasive instrumentation with micro decompression, transforaminal interbody fusion and percutaneous pedicle screws. It has the advantage of short incision, less morbidity, shortened bed rest and early ambulation which is so essential in older patients with comorbid conditions. In this study we discuss the pathogenesis of development of spinal conditions and their treatment options through the history of spinal surgery. Also discussed is the dilemma that exists in spinal surgeons regarding the selection of appropriate treatment strategy for stenosis amongst the elderly.

**Keywords:** Lumbar canal stenosis, Elderly, Surgical management, IDSS, PLIF.

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## INTRODUCTION

Multilevel degeneration with lumbar canal stenosis is common in India even in population younger than 60 years (Figs 1 and 2). The pathological changes involve osteophyte formation at the disk level, facet hypertrophy and ligamentum flavum incurling. Usually the syndrome presents with buttock pains and neurogenic claudication.

For a long time wide decompressive laminectomy, direct visualization and decompression of affected nerve roots, foraminotomy and when necessary discectomy had remained the gold standard to operate patients with lumbar canal stenosis.<sup>1</sup> When there was instability, uninstrumented posterior lumbar interbody fusion (PLIF) was carried out in the past as implants were not then available. I am one of the proponents of uninstrumented PLIF and at one time I have done 1000 PLIFs using my operative technique which is reported in clinical neurosurgery<sup>2</sup> (Figs 3 and 4). However, there was confusion in the literature concerning the role of fusion even in the presence of instability in degenerative lumbar canal stenosis due to absence of prospective randomized clinical trials.<sup>3-6</sup>

Once the implants were introduced, the pedicle screws and interbody cages have been most widely used all over the world to achieve instrumented PLIF in degenerative lumbar canal stenosis. In India PLIF with pedicle screws became popular after the author held a live operative and hands on cadaver workshop in India, in 1989 with Dr Arthur Steffee the inventor of Acromed Pedicle screws in 1985<sup>7,8</sup> (Fig. 5). Pedicle screws are so extensively used, sometimes overzealously, that the growth has risen astronomically following FDA approval.<sup>9</sup>

In elderly patients, the surgical aim of instrumented PLIF involves improving quality of life by relieving pain and stabilizing the unstable or deformed segment irrespective of the level of motion segment involved and irrespective of gender or age group.<sup>10,11</sup>

## DEGENERATIVE LUMBAR STENOSIS

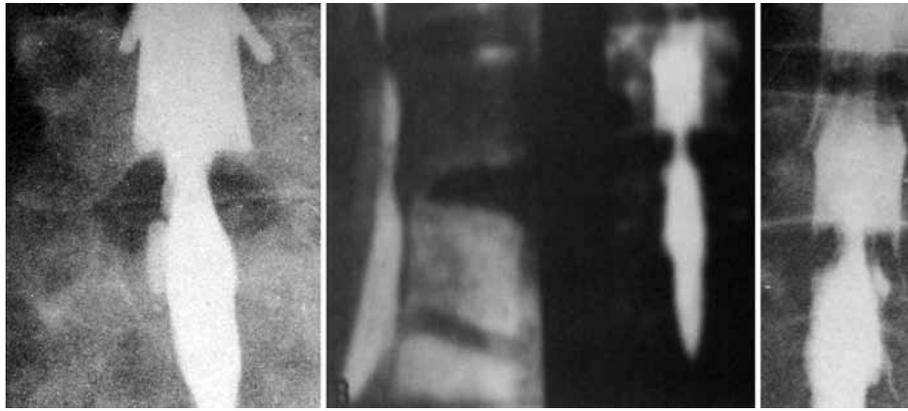
Most commonly the stenosis exists at one or two levels in the lumbar spine. In younger patients, the stenosis is restricted to one level but as age advances there are more patients with two level stenosis and in some there are more than two levels involved.<sup>12-21</sup> Some surgeons have believed in decompression alone for one level stenosis.<sup>22-25</sup> But in elderly patients with degenerative multilevel lumbar canal stenosis with instability, instrumented PLIF becomes mandatory. Among spinal surgeons there is much uncertainty about the correct choice of surgical strategy as no evidence based recommendations on the role of instrumented PLIF in older patients can be formulated in absence of prospective randomized trials.<sup>26</sup>

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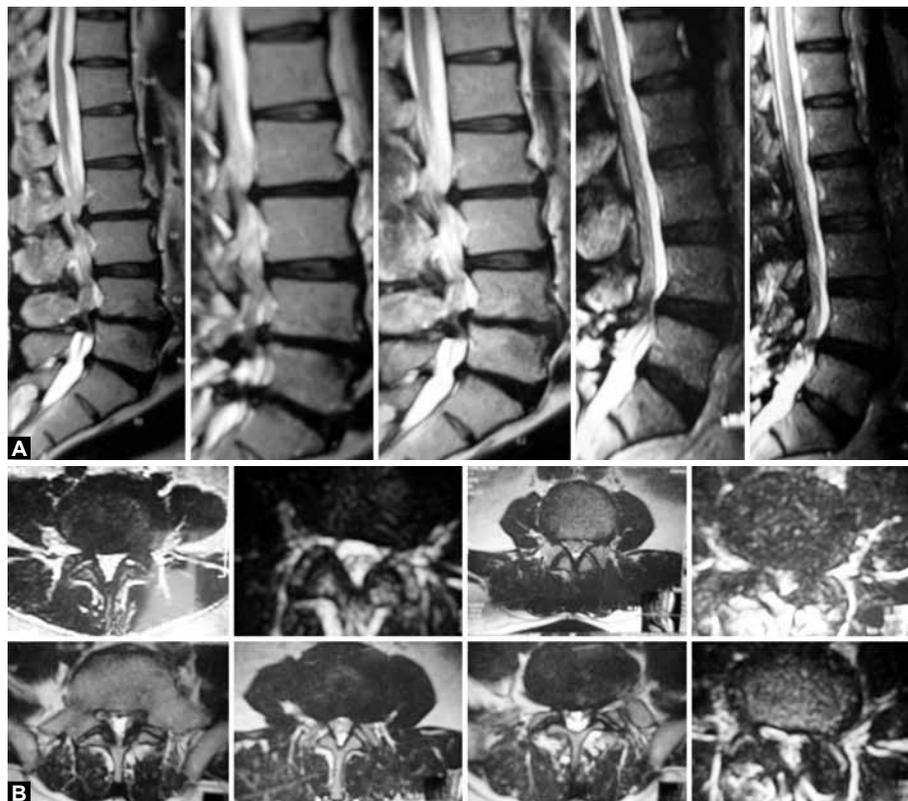
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**Fig. 1:** Degenerative lumbar canal stenosis is common in India even below the age of 60 years. The pattern on myelogram in pre MRI era



**Figs 2A and B:** Magnetic resonance imaging (MRI) pattern of degenerative lumbar canal stenosis in India

Such thoughts have compelled some to try minimally invasive instrumentation with micro decompression, transforaminal interbody fusion and percutaneous pedicle screws. It has the advantage of short incision, less morbidity, shortened bed rest and early ambulation which is so essential in older patients with comorbid conditions.<sup>27</sup>

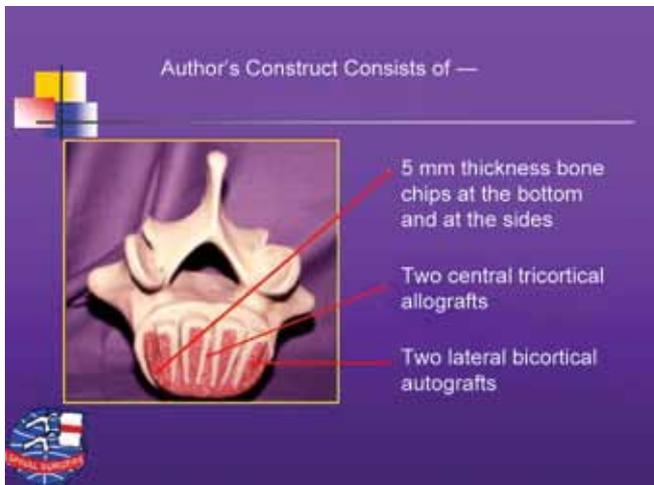
### **INSTRUMENTED PLIF**

To begin with PLIF was done using Acromed pedicle screws and variable screw placement (VSP) plates and interbody fusion with a mixture of cancellous chips at the base, two allografts (ethylene oxide gas sterilized) from the author's

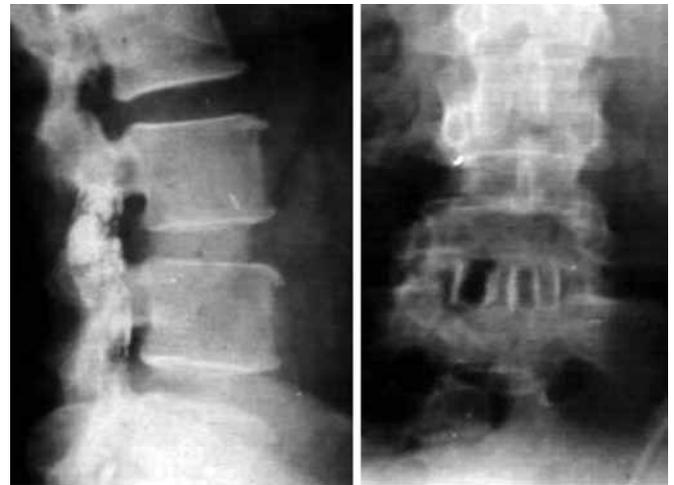
bone bank and two autografts from the patient's iliac crest in a technique described by the author.<sup>28-33</sup> A few years later Ray's round cages (Fig. 6) were used for interbody fusion. They were expensive and the author then designed round cages in India along with pedicle screws and VSP plates. Later round cages were replaced with square cages (Fig. 7).

A large number of patients with degenerative lumbar canal stenosis were operated upon using this instrumentation.

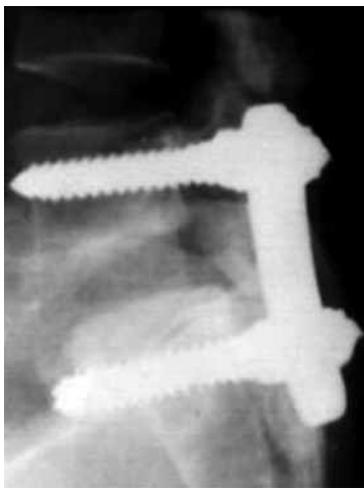
The newer version of screws followed and VSP plates were replaced with rods. The newer instrumentation which has now become popular and standard all over the world has ease of introduction with shorter learning curve but not necessarily improving the clinical outcome of the patients.



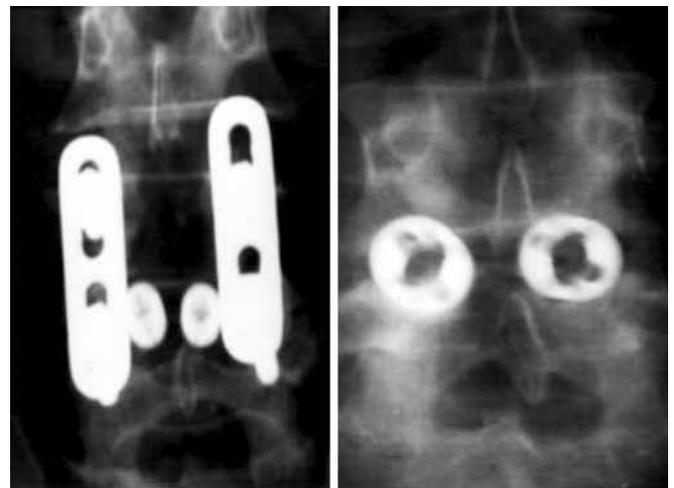
**Fig. 3:** Dr PS Ramani's construct of interbody fusion



**Fig. 4:** Interbody fusion at L4-5 level in lumbar canal stenosis with Dr Ramani's technique. The bone grafts can be clearly visualized



**Fig. 5:** Instrumented PLIF with interbody fusion with Dr PS Ramani's technique and Dr Arthur Steffee's Acromed screws and VSP plates



**Fig. 6:** Instrumented PLIF with ray cages and VSP plates with screws

### SETTLEMENT OF DISK SPACE

Settlement of the disk space is often seen in lumbar canal stenosis (Figs 8A and B). Degeneration in the lumbar spine is a dynamic process and cause relentless degeneration due to continued motion but what comes first is difficult to define. Is degeneration in the disk space and the facet joint causing abnormal motion or it is abnormal motion which causes degeneration in the intervertebral disk space to start with is difficult to define. However, when one sees patients with settlement of the disk space along with stenosis, one gets the impression that degeneration first started in the disk space.

### EARLY INSTABILITY

This is rather difficult to assess. The patient is complaining but clinical examination and standard investigations are normal. Digital Dynamic X-rays in flexion and extension solves the issue<sup>34</sup> where one can see opening out of the disk space (Figs 9A to D) suggesting mobility due to early degeneration and this is the early sign of instability. The segment needs to be stabilized to give relief from pain to the patient.

### LATERAL RECESS STENOSIS AND DISK PROLAPSE

The pathology of lumbar canal stenosis is more common in the lateral recesses,<sup>35-37</sup> which are significantly narrow along with the intervertebral foramina due to osteophytes formation, incurling of the ligamentum flavum,<sup>38</sup> coronal orientation of the facet joints<sup>39</sup> and hypertrophy of the facets. The clinical presentation of lumbar canal stenosis is essentially due to this pathology. Herniated intervertebral disk is not a part of the syndrome. However, in certain patients, (Figs 10A to C) the lumbar canal stenosis pathology can be associated with herniated intervertebral disk and need to be excised before doing instrumentation.

### MINIMALLY INVASIVE INSTRUMENTED PLIF

At the beginning of present century B-Twin cages manufactured by Disk-O-Tech Company were available (Figs 11A to C). The cages can be introduced by minimally invasive technique. The cages of different sizes come hidden in a

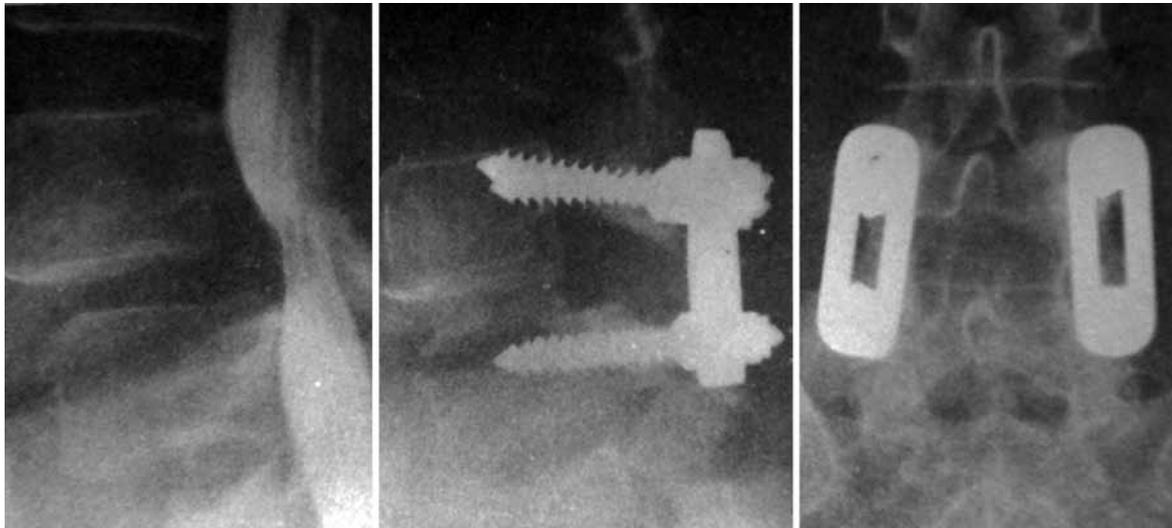
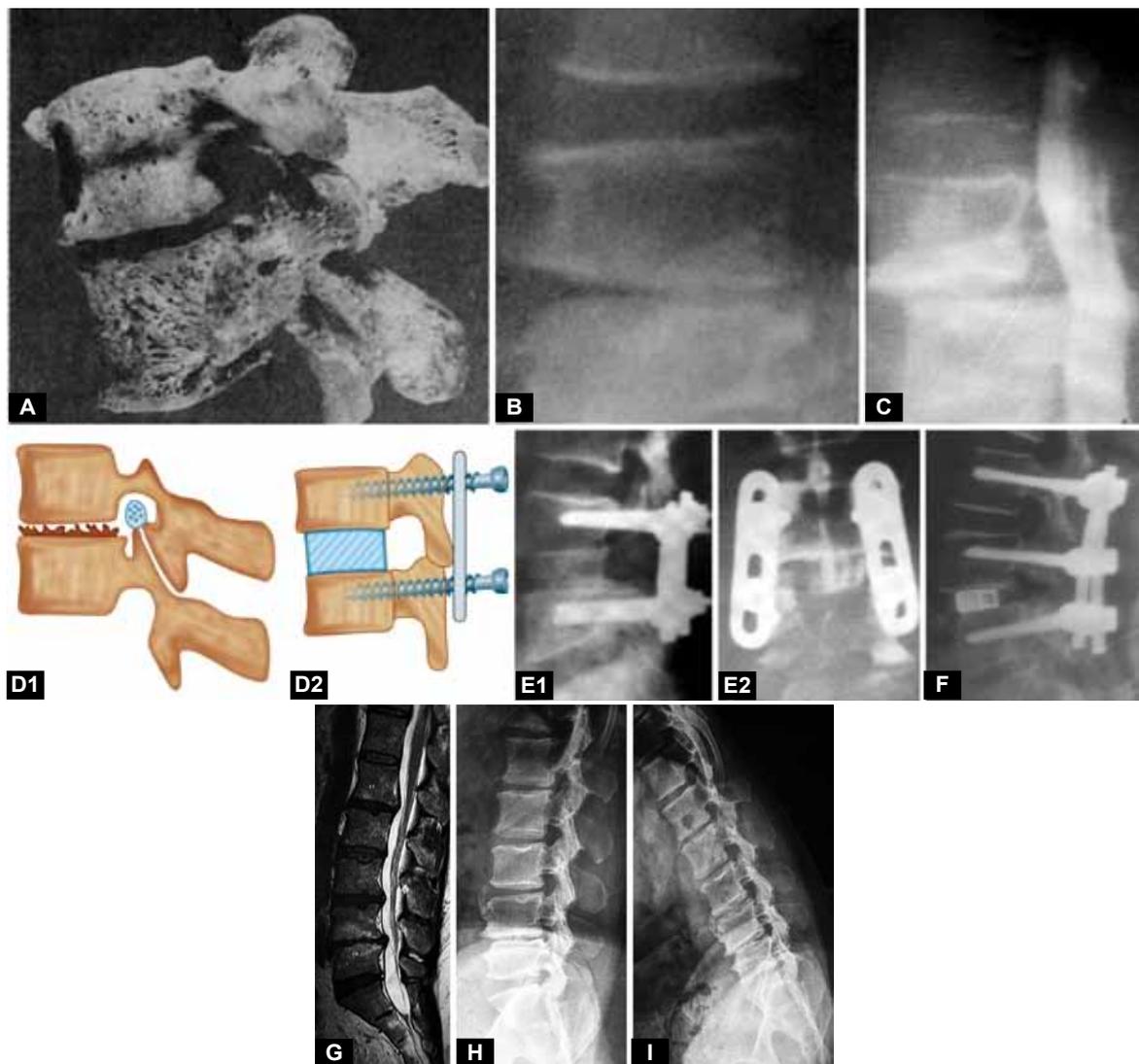
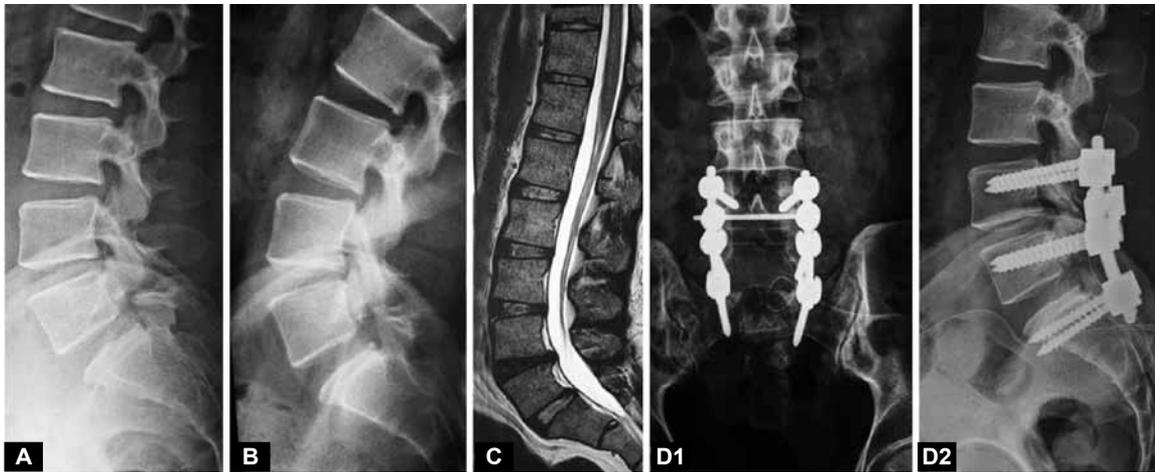


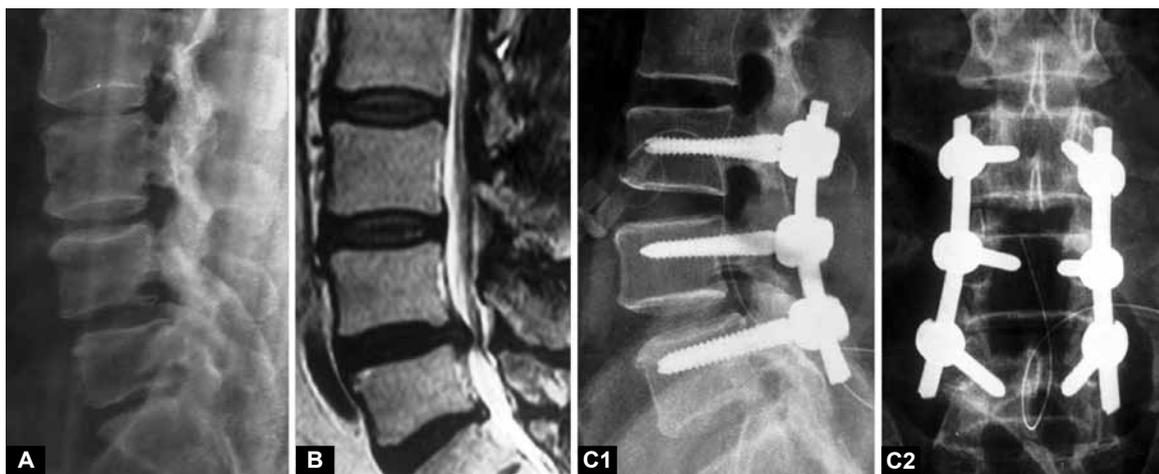
Fig. 7: Instrumented PLIF with VSP type plates and screws



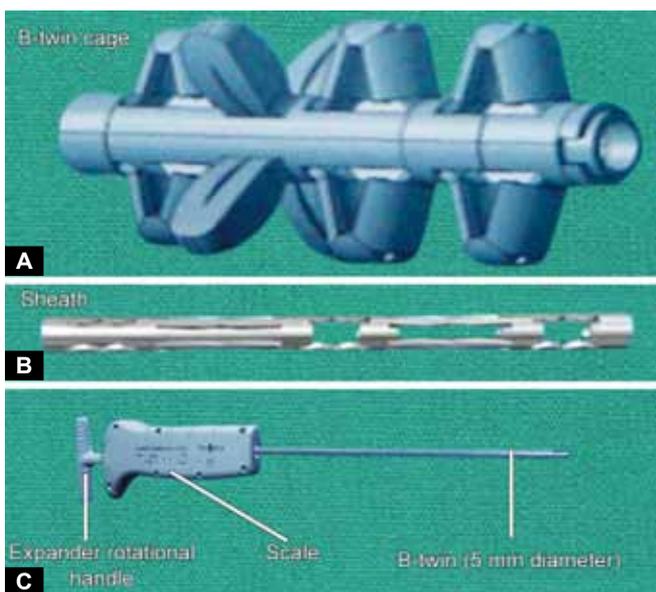
**Figs 8A to I:** (A) Specimen of spine with extensive degeneration and disk space settlement, (B) X-ray showing disk space settlement, foraminal stenosis, spondylolisthesis and osteophyte formation, (C) myelogram confirming radiological findings, (D1 and D2) pictorial presentation of settlement being corrected with instrumented PLIF, (E1 and E2) X-rays showing reconstruction and widening of the intervertebral foramen using VSP system, (F) reconstruction with cages and screws with rods (G to I) MRI and X-ray showing degenerative spondylosis of lumbar spine with L4-L5 disk space settlement



**Figs 9A to D:** Instability and opening of the disk space at L4-5 in lumbar canal stenosis with neurogenic claudication: (A) X-ray in normal position, (B) X-ray in extension position shows opening of the disk space of L4-5 due to instability, (C) MRI does not show significant canal pathology to account for neurogenic claudication, (D1 and D2) spine stabilized with instrumented PLIF using dynamic screws



**Figs 10A to C:** Lumbar canal lateral recess stenosis and disk prolapsed: (A) X-ray does not show any instability, (B) MRI showing prolapsed disk long with lateral recess stenosis at L4-5, (C1 and C2) instrumented PLIF with dynamic screws and rods

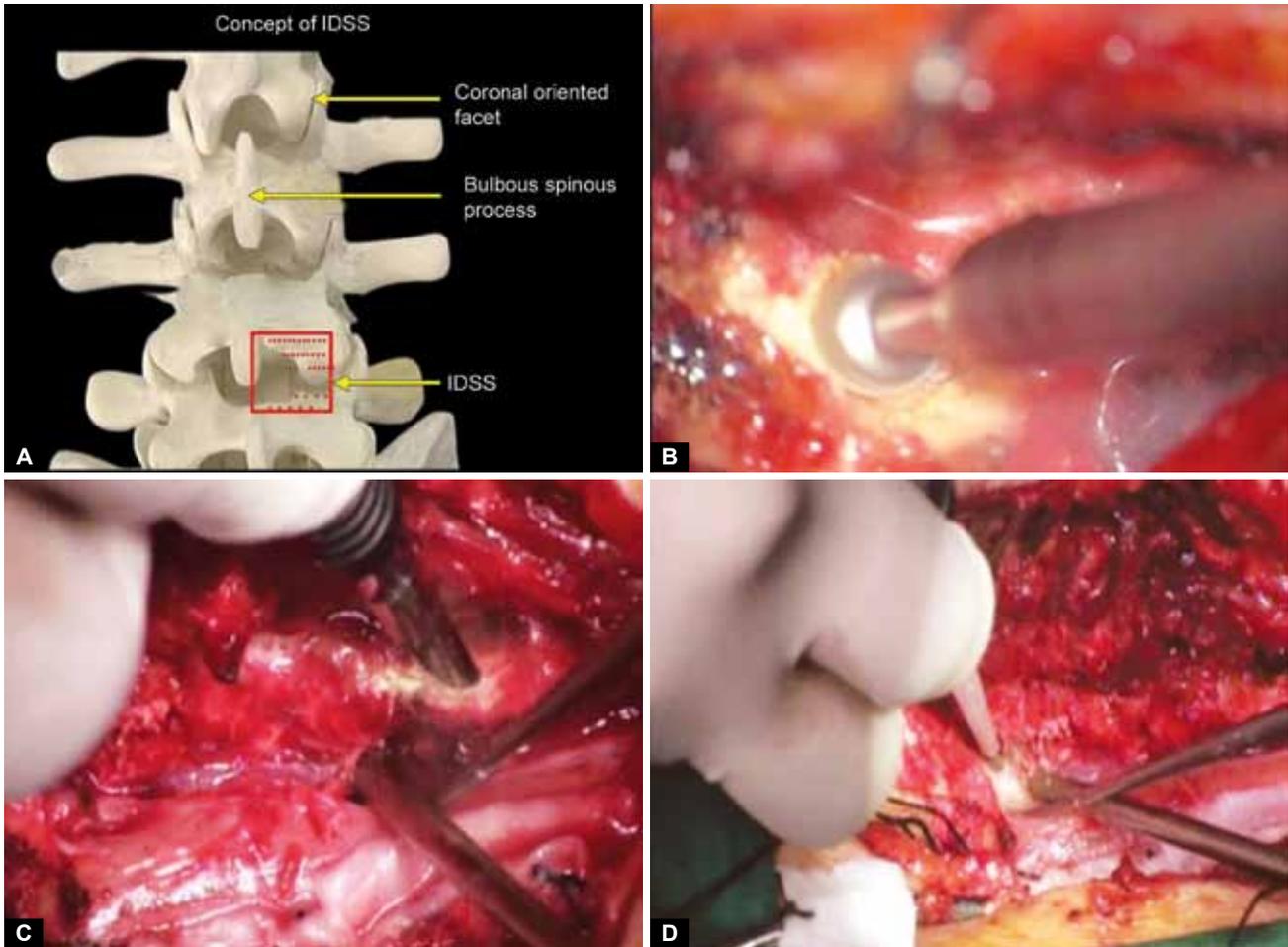


**Figs 11A to C:** (A) Showing B-twin cage after it expands in the disk space, (B) 5 mm sheath in which the cage is hidden, (C) the cage carrier with handle for rotation to eject the cage

5 mm sheath which has to be introduced into the disk space once the bed is prepared. The cage then can be ejected out to the desired depth one on each side. For a long time author has popularized internal decompression of spinal stenosis (IDSS) micro techniques to decompress the stenotic canal.

**OPERATIVE TECHNIQUE OF IDSS**

Under general anesthesia in prone position, the level of incision is marked with fluoroscopy. A 20 mm midline incision is made for bilateral IDSS. Muscles are separated subperiosteally and the author’s microlumbar retractor is used to retract the muscles and expose the interlaminar space and facet joint. The lateral part of the ligamentum flavum is excised. Approximately 3 mm of upper lamina and 2 mm of lower lamina are excised (Figs 12A to D). The facet is exposed. The medial part of the facet is either drilled away with high speed drill or cut in one piece with ultrasound blade. The nerve root is exposed, foraminotomy is done



**Figs 12A to D:** (A) Dr Ramani’s IDSS concept, (B) high speed drilling of the facet, (C) cutting the facet with ultrasonic scalpel, (D) widening the intervertebral foramina by undercutting the bone with ultrasonic swiveling reciprocating shaving tip

and the intervertebral foramen is further widened by under cutting the bone with ultrasound reciprocating swiveling tip. If the intervertebral disk is herniated, it is excised by micro approach. The nerve root is now free.

The intervertebral disk space is prepared to receive B-Twin cage. The disk space is thoroughly debrided of all soft tissue including the cartilage. The desired depth and height of the cage is evaluated. For a depth of 5 mm, the bed is filled with cancellous chips and then 5 mm broad sheath of the B-Twin assembly is inserted into the disk space. By rotating the handle of the assembly, the B-Twin cage is ejected into the disk space and the process can be visualized on continuous fluoroscopy.

The process of IDSS and placement of B-Twin cage is repeated on the opposite side.

The technique of inserting percutaneous pedicle screws is an established one being followed all over the world and hence is not described here.

**CLINICAL OUTCOME OF INSTRUMENTED PLIF<sup>28-33,40</sup>**

In a well documented and followed up for 2 years, a group of 100 patients were analyzed for clinical outcome.

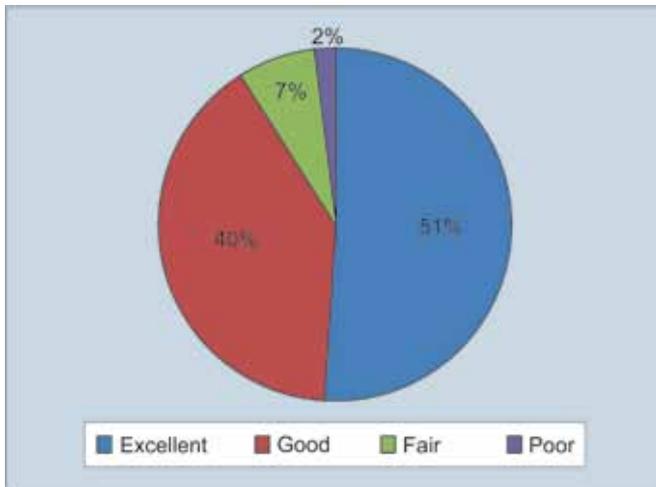
In our department, the patients are assessed with VAS and Oswestry Disability Index. Postoperatively, they are

**Table 1:** Clinical results in instrumented PLIF (2 years follow-up)

	<i>No. of patients</i>	<i>Percentage</i>
Excellent	51	51
Good	40	40
Fair	7	7
Poor	2	2
	100	100

**Table 2:** Patient satisfaction and their return back to work

<i>No. of cases</i>	<i>Occupation</i>	<i>Results</i>		
		<i>Good</i>	<i>Fair</i>	<i>Poor</i>
20	Light work (peon, attendant)	20	0	0
24	Sedentary work (office, shop attendant)	21	3	0
29	Heavy work (docks, mines, mechanical)	25	4	0
15	Heavy dock or farm labor	Advised light work for one year		
12	Sedentary work (above 60)	9	2	1



**Fig. 13:** Satisfactory results of instrumented PLIF in diagrammatic form

also assessed for patient satisfaction and return back to the original job.

Overall, 91% of the patients have show excellent and good results as shown in Table 1 and Figure 13. The satisfaction of the patients and their return back to work is outlined in Table 2.

### CLINICAL OUTCOME OF MINIMALLY INVASIVE INSTRUMENTED PLIF

In a series of 20 patients a triple technique of micro IDSS, B-Twin Interbody cages<sup>41</sup> and percutaneous or open screws through IDSS incision, pedicle screws instrumented PLIF was done for degenerative lumbar canal stenosis with instability. There were no complications. Patients with one level degeneration with instability were selected. They were relatively young with age varying from 32 to 46 years and majority of them were males (17/03). Two years follow-up has shown excellent patient satisfaction with return to normal job. None has shown adjacent segment degeneration (ASD) at two years follow-up. Unfortunately the company stopped manufacturing the B-Twin cages. The technique is rationale and in agreement with patho-anatomical concepts of stenosis where the pathology is based in the canal in and around the intervertebral disk space. Decompression can only be done with micro techniques in this region leaving posterior motion segment behind the vertebral body intact—a minimally invasive concept.<sup>42</sup>

### COMPLICATIONS

1. *Implants failure:* At 2 years follow-up, implants failure causing symptoms was seen in 7 (14%) patients (misplaced screw, early screw breakage, rod displacement, rod pointing under the skin) and required revision. Screw breakage seen on X-rays two years or more after surgery was not considered a failure or complication as by

then bone had taken over the role of instrumentation and the breakage seen on X-rays was ignored. Patients were asymptomatic.

2. *Adjacent segment degeneration:* In a well documented study of our 100 patients ASD was seen in 8 patients giving an incidence of 8%. But our study was restricted to 2 years. Perhaps the incidence would have gone higher if the study was done for 5 and 10 years or more. Revision surgery and revision instrumentation was done in 5 patients giving an incidence of 10% revision surgery for ASD at 2 years (Figs 14A to C).

We have not done a study but we have encountered cases of symptomatic ASD presenting with lumbar canal stenosis and necessitating revision surgery in patients with decompression alone for lumbar canal stenosis. In these patients, revision surgery once again involved decompression alone (Fig. 15) without answering the question if symptomatic ASD will recur. We have not done revision surgery a third time so far.

3. *Revision surgery:* During the evaluation of 100 patients it was realized that 7 patients, (14%) re-exploration was carried. In 4 of them the screw was touching the nerve root by breach in the medial pedicle cortex and reexploration was carried out while the patient was in the hospital. In the other three the screw system had failed.

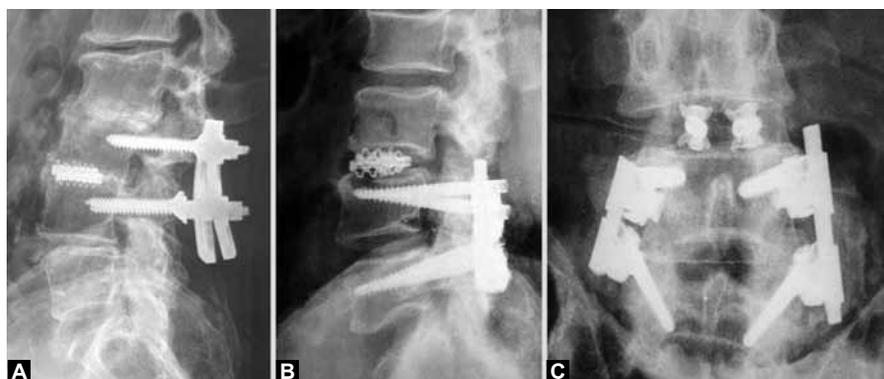
Three patients presented within 3 weeks with infection (6%). In two patients, the wound was irrigated with antibiotics following re-exploration and in the third, the bone grafts were removed as the infection was gross but the pedicle screw system was not removed. In no case, instrumentation has been removed because of infection. In the case, where bone grafts were removed the patient opted to take prolonged bed rest at home and for 18 years now he is keeping well with sedentary life style and has not opted for replacement of interbody fusion.

No screw breakage was observed within the first 2 years. Adjacent segment degeneration is described above.

Much against the wishes of spinal surgeons recurrences do happen and the spinal surgeon is obliged to do reexploration. The surgery is unpleasant because of obliterated anatomical landmarks and he canal is filled with fibrous tissue. Dura is adherent to the fibrous tissue. Even fused

**Table 3:** Complications in instrumented PLIF

Number of patients (100)	Percentage
Recurrence at a higher level	9
Iatrogenic instability	3
Implants failure	7
Infection	3
ASD	5
Inadequate decompression by previous surgery	6



**Figs 14A to C:** (A) Symptomatic ASD in a patient with instrumented PLIF developed after 9 years, (B and C) ASD in another patient with instrumented PLIF corrected by doing interbody fusion with B-twin cages



**Fig. 15:** ASD in uninstrumented PLIF corrected by doing laminectomy again

spines can present for revision surgery. Several times the recurrence is at a higher level than the previous surgery. In our department, over a period of 2 years, we were obliged to do re-exploration in the patients as shown in Table 3.

Irrespective of number of surgeries done on the spine for degeneration if the patient is suffering<sup>43</sup> and asking for treatment and the surgeon, to the best of his knowledge and expertise feels that the patient will benefit from surgery then he should be operated upon once again. It is the experience of the author that most of the times, the recurrence of symptoms is due to relentless progression of degenerative changes causing compression on the nerve roots.

Compromised canal at a higher level, failure of implants, failure of fusion, ASD, iatrogenic instability, inadequate decompression by previous surgery<sup>44</sup> and infection in our country are some of the other causes for revision surgery.

## DISCUSSION

With increased expectancy of life degenerative lumbar canal stenosis has become a most frequent ailment for which the patient is seeking the help of a spinal surgeon. Surgery on the spine for this ailment has become most frequent but truly

enough improvements in symptoms, function, quality of life and satisfaction of the patient is achieved by the surgery irrespective of the type of procedure.<sup>45</sup> However, it is observed that in older patients at one year follow-up the outcome tends to be a little less satisfactory than the younger patients.<sup>46</sup> It is interesting to note that there is significant similarity in presentation of symptoms in all patients chosen for different surgical options Age and gender was no bar.<sup>46-50</sup>

For a long time wide decompressive laminectomy, direct visualization and decompression of nerve roots, foraminotomy when necessary and discectomy when the intervertebral disk is herniated has remained the gold standard to operate patients with severe and moderate degenerative lumbar canal stenosis. However, relentless progression of degeneration causes bony ingrowths in the resected laminae causing stenosis and recurrence of symptoms.<sup>51-55</sup> When there is no convincing instability, it is believed that fusion with bone or instrumented PLIF should not be carried out as it has not produced any better results.<sup>1,3</sup> In the past, it was customary to do posterolateral fusion in presence of instability as instrumentation was not available.<sup>4</sup>

Instrumented PLIF in degenerative lumbar canal stenosis has produced good treatment outcomes in terms of patient satisfaction. The procedure is now established as a standard treatment option.

Turner et al 1992<sup>3,5</sup> felt the concern which is even felt to day that degenerative lumbar canal stenosis needs prospective controlled randomized trials to decide on a correct surgical technique which will give long-term good results. Nerve root injury, instrument induced foraminal stenosis, symptomatic epidural fibrosis, etc. are some of the avoidable but happening complications with the use of instrumented PLIF.<sup>6</sup> However, it is observed that in long term results of Instrumented PLIF in degenerative lumbar canal stenosis ASD rate is high and it is feared that the procedure may result in iatrogenic instability, postoperative spondylolisthesis or instability and epidural fibrosis causing recurrence of symptoms.

Five percent of the screws will fail.<sup>7,8</sup> Most of the times it is the small breach in the continuity of pedicle cortex medially that causes irritation of the nerve root giving rise to sciatic pain. It becomes mandatory to reposition the screw<sup>56</sup> In one paper 2% of the screws were misplaced<sup>6</sup> causing direct injury to the nerve root. The patient should be warned in advance about this consequence.<sup>57</sup> Misplaced screw can better be detected on CT scan. It also detects any lucency suggesting motion at the screw bone interface. Such thoughts have helped the evolution of minimally invasive micro endoscopic techniques to surgically manage patients of degenerative lumbar canal stenosis.

When repeat surgery becomes mandatory, it increases the rate of complications.<sup>58</sup> However, Fritzell is of the opinion<sup>59</sup> that in well-informed selected patients with severe chronic low back pain instrumented PLIF can decrease disability in a better way than conservative treatment. Rates of fusion have varied in different parts of the world suggesting poor consensus on surgical indications.<sup>60</sup> There is also the feeling that implants are overused.

Pathologically lumbar degeneration rarely occurs in the vertebral bodies or in the cross-section of the pedicle. It occurs in facet joints, the upper part of laminar junction and the edges of vertebrae near intervertebral disk. The area demanding decompression is localized on the canal near the intervertebral disk space. This concept helps to preserve posterior motion segment behind the vertebral body.<sup>12,27,61,62</sup> We have utilized this concept in our minimally invasive instrumented PLIF in the technique of IDSS, B-Twin interbody fusion and percutaneous pedicle screw fixation.<sup>42</sup> With the advent of minimally invasive surgical techniques an increasing number of spinal surgeons opt for limited, precise and more targeted techniques rather than extensive resection. Less invasive techniques maintain the stability of spine. The technique also causes minimum damage to anatomical structures by avoiding preventive resection at normal levels in the spine. At one time, the author did bilateral internal decompression by bilateral approach. Now this can satisfactorily be done through unilateral approach by micro endoscopy further minimizing the tissue damage.

Instrumentation has its own disadvantages like longer incisions, prolonged operating time, increased blood loss and instrument related complications. Instrumented PLIF can also develop pseudo arthrosis.<sup>63</sup> Noting all these disadvantages some surgeons feel that fibrous tissue formed in simple decompressive laminectomy is stiff enough to provide support and maintain stability in uninstrumented patients.

Adjacent segment degeneration does happen in PLIF surgery with or without instrumentation. But it is more common with rigid stabilization with instrumentation in PLIF. It is reported that ASD occurs in 20 to 50% of the

patients in PLIF with instrumentation and rigid stabilization.<sup>64,65</sup> The rate is high and it rises with longer follow-up beyond five years. But all patients are not symptomatic. PLIF with pedicle screws in patients with greater the number of segments fused has higher incidence of ASD.<sup>64,66,67</sup> Since all are not symptomatic Hilibrand and Robins<sup>68</sup> have made the difference between adjacent segment degeneration and adjacent segment disease. The former is shown on X-rays and the later is diagnosed clinically. Ghiselli, Wang et al<sup>69</sup> have quoted frequency of surgery for ASD at 16.5% at 5 years and 36.1% at ten years. ASD can cause instability.

Recurrent stenosis from continued abnormal motion in the dynamic lumbar spine is often used as an argument for fusion following decompression and in fact fusion percentage has markedly increased in recent times from 67 to 87%.<sup>63,70,71</sup>

Non-instrumented patients can develop instability necessitating revision surgery. Excessive removal of facets may cause instability.<sup>72</sup> Sagittal orientation of facets calls for caution on the part of surgeon. Katz<sup>73</sup> reported that in his series with non fused patients 20 to 27% developed recurrences at 7 to 10 years follow-up.

Who will need revision surgery following instrumented PLIF?

It is impossible to find predictors. One study has shown that in patients older than 65 years diabetes is the risk factor for recurrence.<sup>74</sup> Hansrai and co-workers found 6% chance of recurrence from development of instability<sup>75,76</sup> and felt that chance of revision surgery is higher with longer follow-up and in their series of 105 patients 19 patients had undergone revision at 5 years follow-up at a high percentage of 18%. Many surgeons feel that revision surgery rate is not so high and could be below 10%. But facts could be different than observations as one study<sup>77</sup> had 26 out of 88 patients subjected to revision surgery over five years and another study<sup>78</sup> commented that 23% had at least one revision surgery during 10 years follow-up.

## CONCLUSION

In well-informed selected patients with severe chronic low back pain instrumented PLIF can decrease disability in a better way than conservative treatment in patients with degenerative lumbar canal stenosis. There may be some overuse of implants but when there is instability or deformity it is mandatory to do instrumented PLIF. Elderly patients with two level degenerative stenosis with instability are suitable subjects for instrumented PLIF and they show significant improvement in symptoms, function, overall patient satisfaction and several other health related issues at least during short-term follow-up (1 year).

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