

# Feasibility of Endoscopic Transforaminal Lumbar Interbody Fusion through the Posterior Paraspinal Approach: Technical Note and Preliminary Result

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## Research article

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# Abstract

**Background:** The implement of endoscopic spinal surgery into degenerative spinal disease has minimized the requirement of fusion procedures. However, it is still necessary to develop endoscopic spine surgery in certain patients requiring fusion such as instability. We performed a full-endoscopic transforaminal lumbar interbody fusion(eTLIF) through a conventional paraspinal approach. The feasibility of procedure and early outcome were evaluated.

**Materials and Methods:** eighteen consecutive patients with degenerative lumbar disease underwent eTLIF through a conventional paraspinal approach. Their clinical outcomes were evaluated with visual analog scale(VAS) leg pain score, Oswestry Disability Index(ODI) and the MacNab's criteria; radiological outcome measured with segmental lordosis, global lumbar lordosis, disc height on plain radiograph and percentage of potential fusion mass on CT scan at pre-operative, post-operative and final follow up period. intra operative and post-operative complications noted.

**Results:** Mean age was 63. 71 years and Mean follow-up periods was 7.78 months. According to the level, L2-3 (1 case), L3-4 (4 cases), L4-5 (13 cases) and L5-S1 (2 cases). In the X-ray result, mean segmental lordosis angle(SLA) improved in pre-operative/post-operative/follow-up period  $9.87 \pm 2.74$  degree/  $11.79 \pm 3.74$  degree/  $10.56 \pm 3.69$  degree ( $p > 0.01$ ); mean lumbar lordosis angle(LLA) improved  $37.1 \pm 7.04$  degree/  $39.2 \pm 7.13$  degree/  $35.7 \pm 7.25$  degree ( $p > 0.01$ ). Mean preoperative disc height(DH) improved from  $8.97 \pm 1.49$  mm/  $12.34 \pm 1.39$  mm/  $11.44 \pm 1.98$  mm ( $p < 0.01$ ). In the CT result, Average percentage of fusion mass was 42.61%.

VAS was improved significantly, 7.67 / 3.39 / 2.5 and ODI was improved significantly, 74.9 / 34.56 / 27.76 by each preoperative / postoperative / final follow-up. In the clinical result, excellent was 5 cases and good was 13 cases.

**Conclusion:** According to the results of this study, eTLIF was competent enough to perform as open TLIF. and good results were obtained in the form of endplate preservation, disc height restoration, minimal blood loss and post-operative pain with early mobilization. In addition, the fusion volume including the cage and the bone graft material occupies 40% to 50% of disc space is expected to give sufficient fusion by using 3D printed cages which gives the high fusion rate. In conclusion, eTLIF is considered to be a viable surgical procedure.

## 1. Background

Implementation of endoscopic spine surgery in management of degenerative lumbar diseases has significantly reduced the need of fusion surgeries. [1,2] Actually, one of the principles of prof. A young's philosophy of minimally invasive spine surgery states that staged approach to the therapeutic interventions should be utilized beginning with the least invasive treatment options; while keeping salvage procedure like fusion as last resort in the pain management. [3,4] However there is some grey area like gross instability, high grade of spondylolisthesis and deformity where fusion surgery still stands

as a 1st line of management. interbody fusion procedures has evolved from open TLIF to minimal invasive MIS-TLIF. However, it gives some difficulties of visualizing the disc space, contralateral decompression and end plate preparation.

The objective of this study was to analyze the preliminary clinical and radiological outcomes of endoscopic transforaminal lumbar interbody fusion(TLIF) through paraspinal approach in patients with the degenerative lumbar spine disease using the endoscopic spine surgery.

## **2. Materials And Methods**

### ***2.1. Subjects***

This is retrospective case study was exempted from institutional review board of Nanoori Hospital, Seoul, Republic of Korea. The informed consent was obtained from all patients participated in study. We studied 18 consecutive patients with 20 levels of lumbar degenerative disease; (6 males, 12 females; Mean age 63.71 years) who underwent Endoscopic Transforaminal Lumbar Interbody Fusion(TLIF) through the Posterior Paraspinal Approach at a spine specialty hospital between august 2018 and January 2019. Inclusion criteria was degenerative grade 1 spondylolisthesis, lumbar central canal stenosis with foraminal stenosis and segmental instability confirmed on dynamic radiograph. Spondylolisthesis grade 2 and more and lumbar canal stenosis with more than 50% loss of disc height are excluded from study due to difficulty to be managed with endoscopic fusion.

### ***2.2. Surgical procedure***

Procedure done under general anaesthesia. Patient placed in prone position on radiolucent table over Wilson's frame. Entry point is located under fluoroscopy guidance. Target point is ipsilateral facet at the level and it is approached through conventional Wiltse's approach between multifidus and longissimus muscle. Usually interval located about 3cm lateral to the midline. A longitudinal skin incision of approximately 1cm in length was made 4cm lateral to the midline on affected side. It facilitates the medial trajectory of working cannula and cage into the disc space. Serial dilators introduced through the interval and finally working channel introduced along with endoscope. For initial dissection we use working cannula with outer diameter of 13.7 mm and bevelled tip, the endoscope has 15 degree viewing angle, outer diameter of 10 mm, working channel diameter of 6 mm and working length 125 mm. ILESSYS-DeltaR (Joimax GmbH, Germany).

The soft tissue over facet joint is dissected using radiofrequency ablator to expose inferior articular process(IAP) of superior vertebra. Endoscopic drill is used to hollow out the groove at IAP in inverted "L" fashion and its resected with bone cutter and forceps. IAP harvested in total to use as a autologus graft later. Underlying superior articular process(SAP) burred with drill to expose foraminal part of deep layer of ligamentum flavum. Central and contra lateral decompression can conveniently achieved though the same interval by simply tilting the endoscope. [figure 1] Haemostasis and annulotomy done with radiofrequency probe (Elliquence, New York, USA). Disc material removed with forceps. End plate

preparation is most important step of the procedure and advantage of endoscopic spine surgery is meticulous end plate preparation can be done under direct vision without damaging it. End plate cartilage is removed with dissector and curettes to prepare fusion bed in order to protect traversing root level tip of cannula is rotated from superior to medial direction and inserted into the disc space through the annulotomy site. Autologus graft mixed with allograft is tamped into the disc space under image fluoroscopy guidance. Single large 3D printed cage (GENQSS, GS Medical, Republic of Korea) with demineralised bone matrix (DBM) is inserted as oblique as possible and final position of cage is checked under both fluoroscope as well as endoscope. Working cannula is withdrawn keeping suction drain in situ. [picture 1]

After completion of interbody fusion procedure construct is stabilized with percutaneous pedicle screw fixation through same incision on ipsilateral side. Same procedure is repeated on contra lateral side through 2 separate incisions and rods are inserted with compression in routine fashion. If required pedicle screw fixation is augmented with bone cement. [video]

### **2.3 Outcome evaluation**

**a) Clinical evaluation:** Demographic data collected and all 18 patients were clinically evaluated on the basis of the Visual Analogue Scale (VAS) score for the back, Oswestry Disability Index (ODI) and MacNab's criteria preoperatively, postoperatively and final follow up (minimum 6 months). Completeness of decompression was documented with postoperative magnetic resonance imaging (MRI). Patients are also assessed for any intra or post operative complications and recurrence of symptoms.

#### **b) Radiological evaluation:**

The radiological assessment was performed by independent observer who was blinded to the patient's clinical information. Plain radiograph used to evaluate disc height (DH), lumbar lordosis angle (LLA) and segmental lordosis angle (SLA) pre and post operatively.

The fusion status was assessed using computed tomography (CT) at 6 months and 1 year as recommended by CT protocol. [5] Bony fusion was defined when there is continuous contact of trabecular bone between upper and lower endplates of fusion segments. Osteolysis at the margins of fusion devices (pedicle screw), cystic changes within endplates adjacent to the cage, linear defect in trabecular bone bridge of fusion were considered features of delayed or failed fusion.

to evaluate fusion mass, CT scan done with axial slices parallel to the end plates of fused segment. Percentage of fusion mass surface area is calculated on CT images in axial cut using software (Infinit, inc, Seoul, Korea) in following steps -

1. The surface area of fusion mass was measured at mid disc level from the region of interest (ROI) (surface area of cage is also included as we have used 3D-printed cage with osteo-integration property; surface area of osteophytes at end plate excluded)

2. the surface area of upper and lower end plates measured from the slices going through or close to the end plates
3. average of the upper and lower end plates surface area calculated

percentage of fusion mass surface area calculated with the formula:

percentage = surface area of fusion mass/average end plate surface area X 100 [figure 2]

## **2.4 Statistical analysis**

Clinical data was analyzed with SPSS version 18 statistical analysis software (IBM corporation, New York). The continuous variables were expressed as mean and standard deviation(SD). The *paired t* test is used for comparison of preoperative and postoperative VAS, ODI scores; LLA, SLA and DH values. A value of ( $p < 0.01$ ) considered significant.

## **3. Results**

### **3.1 Clinical outcomes**

Out of 18 patients, there were 10 patients with grade 1 spondylolisthesis, 4 patients with segmental instability, 3 patients with lumbar canal stenosis and 1 patient with lumbar disc herniation. 16 patients operated for single level including L2-3 (1 patient), L3-4 (3 patients), L4-5 (11 patients) and L5-S1 (1 patient) while 2 patients operated for 2 levels including 1 patient at L3-4, L4-5 and 1 patient at L4-5, L5-S1.

All patients are followed up for 6 months to 1 year with Mean follow-up periods was 7.78 months. The mean preoperative VAS score was improved significantly, 7.67 / 3.39 / 2.5 ( $p < 0.01$ ) and ODI was improved significantly, 74.9 / 34.56 / 27.76 ( $p < 0.01$ ) by each preoperative / postoperative / final follow-up. Based on MacNab's criteria, the clinical result was excellent in 5 patients and good in 13 patients. [figure 3]

### **3.2 Radiological outcomes**

In the X-ray result, mean preoperative segmental lordosis angle(SLA) 9.87+2.74 degree, immediate postoperative was 11.79+3.74 degree and at the final follow-up was 10.56+3.69 degree ( $p > 0.01$ ). Mean preoperative lumbar lordosis angle(LLA) 37.1+7.04 degree, immediate postoperative was 39.2+7.13 degree ( $p < 0.01$ ) and at the final follow-up was 35.7+7.25 degree. ( $p > 0.01$ ) Mean preoperative disc height(DH) was 8.97+1.49 mm, immediate postoperative was 12.34+1.39 mm ( $p < 0.01$ ) and at the final follow-up was 11.44+1.98 mm ( $p < 0.01$ ). We have also compared disc height between immediate post op and final follow up ( $p < 0.01$ ). In the CT result, vertebral body end-plate average surface area was

1563.7 mm<sup>2</sup> and average surface area of fusion mass was 663.7 mm<sup>2</sup>. Average percentage of fusion mass was 42.61%. [table 1]

### ***3.3 Recurrence and complications***

We noticed 2 intra operative complications in the form dural tear over traversing root sleeve which is managed conservatively using the Fibrin Sealant Patch. Both patients were asymptomatic in subsequent follow up and clinically recovered well.

We didn't experience any post-operative complication like hematoma collection, infections, implant migration, implant breakage or any other signs of non union. No patient required revision surgery.

## **4. Discussion**

Traditionally, open PLIF and TLIF are already established as gold standard treatment in the management of degenerative lumbar diseases; however, it comes with unavoidable complications like damage to the posterior ligaments complex and paraspinal muscles which ultimately leads to failed back syndrome. [6] in 2003, foley et al[7] developed MIS-TLIF technique to overcome this problem using 20-24 mm tubular retractor. However, it is difficult to observe end plate during end plate preparation and relatively difficult while decompressing the contralateral side. Lateral lumbar interbody fusion(XLIF) and oblique lumbar interbody fusion(OLIF) developed to avoid injury to back muscles and improve visualization of end plates. [8] however it is also associated with approach related serious complications like potential injury to major vessels, ureter and lumbar plexus. [9-10]

Successful clinical results in fusion surgery depends upon a high fusion rate along with maintainance of disc height and sagittal balance. Failure to achieve bony fusion may result in implant loosening, breakage and back pain in long term. Previously reported fusion rates for PLIF ranged from 56 to 100 %; [11,12] while fusion rate for open TLIF ranged from 86 to 100%. [13,14] despite of narrow operative field in MIS-TLIF; several articles have demonstrated good fusion rate ranging from 92-100%. [15,16]

In turn, successful fusion primarily depends upon surface area of fusion bed and correct placement of bone graft along with interbody cage over fusion bed. Sometimes inaccurate placement of bone graft over unprepared end plate with intact cartilage may results in pseudoarthrodesis. Potter et al[13] have reported that for obtaining firm interbody fusion, exposure of more than 30% endplate is required and clinically with transforaminal approach 56% of endplate can be prepared. At the same time, we have to be careful not to remove excess of subchondral bone. Overenthusiastic disc preparation can result into subsidence and recurrent foraminal stenosis; particularly in osteoporotic patients. As we have used 15 degree endoscope inside disc space which can be rotated 360 degree it allows access to 60-80% of the end plate. [17] we have calculated the mean percentage of surface area of fusion mass to be 42.61% which is more than sufficient to achieve interbody fusion we have used 3D-printed porous titanium interbody cage which provides osteo-conductive scaffold for new bone growth. It provides short term stability due to friction and long term stability due to osteoblast adhesion, proliferation and bone

ingrowth. Single large cage improves the construct stability and bone ingrowth decreases subsidence due to load distribution. [18] fusion rate can be further improved with the use of rh-BMP and various osteoinductive bone material.

In 2012, Said Osman [19] first reported 60 cases of endoscopic TLIF for treatment of degenerative lumbar diseases with 59.6% solid fusion and 36.2% stable fixation, but complication rate was upto 20%. Recently, Mongesterns[17] in their 30 patients operated with percutaneous TLIF with mean follow up period of 38 months reported 100% fusion rate using rigid PEEK cage and expandable titanium cage. Lee et al[20] performed percutaneous TLIF in 18 patients using titanium expandable spacer(B-Twin) under local anesthesia with conscious sedation. He achieved good clinical results with 88% fusion rate (16 out of 18) with average subsidence 2.1 mm. Subsidence of interbody disc height is expected in post operative period; however progressive subsidence can cause decrease in foraminal height which results in recurrent foraminal stenosis also destruction of sagittal balance. In present study we didn't noticed any signs of non fusion but experienced subsidence rate of 0.9 mm. However, there was significant difference between pre operative and final follow up ( $p < 0.01$ ). Significant subsidence is defined as a decrease in disc height of more than 3mm. Though our subsidence rate is low; it needs close long term follow up. Jacquet et al[21] considered procedure controversial due to technical difficulties and high complication rate(up to 36%). They also added need for technical improvements to the procedure. Certain studies also proposed feasibility of biportal endoscopic surgery for interbody fusion with significant clinical results. [22,23]

All this studies utilized classical endoscopic transforaminal approach with expansile foraminoplasty for disc space preparation and cage insertion. Majority of this studies experienced common complication of post-operative dysesthesia due to irritation of DRG while performing disc preparation and insertion of larger cage into the disc space. In our study we have utilized conventional Wiltse's approach which minimizes the need of retraction of exiting root and DRG. However, in our study we experienced complication rate of 3.6%. We noticed dural tear in 2 patients over traversing root sleeve by bevel tip due to incomplete retraction of traversing root. This complication can be minimized by carefully rotating the bevel tip and introducing it into the disc space. We didn't notice post-operative dysesthesia or neurological deficit in any patient. Interbody fusion via transforaminal approach has certain limitations like inadequate foraminoplasty may impose some difficulties while inserting cage into the disc space and obstacle of iliac crest for L5-S1 disc space. It can be comfortably overcome by paraspinous approach.

Despite of its good clinical results endoscopic TLIF have certain limitations which needs further technical development; it is not suitable for grade 2 or more spondylolisthesis due to difficulty to achieve complete reduction and sagittal balance. In patient where disc space is collapsed more than 50% it is very difficult to introduced endoscope into disc space. Said Osman [17] has advised prior pedicle screw instrumentation and distraction of disc space for the same. In our study we didn't noticed statistically significant difference between pre-operative and follow up segmental balance. Though technique of endo TLIF is similar to open TLIF its significance for restoration of segmental balance is doubtful as per present study. Further technical development in the instrumentation may require for disc space distraction, cage design in form of expandable cage or lordotic cage. Lewandrowski et al[24] tried

endoscopic TLIF with standalone lordotic cage for a single level with good clinical results(77.8%). However, he reported cage subsidence in all the cases with revision surgery rate around 8%(4 out of 48). Long term radiological studies with respect to subsidence rate, sagittal balance, effect at adjacent segment, fusion mass distribution and fusion rate will be helpful for future development of endoscopic instrumentation for fusion surgery.

This is retrospective study with small sample size and preliminary results. We need to compare study group with matched control group like open or MIS TLIF group to evaluate effectiveness of this procedure. Prospective study with large sample size will give more comprehensive results.

## **Conclusion**

According to the results of this study, endoscopic TLIF was comparable to an open TLIF with favorable results obtained in the form of endplate preservation, disc height restoration, minimal blood loss and post operative pain with early mobilization. In addition, the fusion volume including the cage and the bone graft material as measured on post-operative CT scans, occupied 40% to 50% of disc space which would be expected to give high fusion rates with the use of 3D printed cages. In conclusion, endoscopic TLIF is considered to be a viable surgical procedure.

## **Abbreviations**

SLA – Segmental lordosis angle

LLA – Lumbar lordosis angle

DH – Disc height

PLIF – Posterior lumbar interbody fusion

TLIF – Transforaminal lumbar interbody fusion

OLIF – Oblique lumbar interbody fusion

## **Declarations**

### **Ethics approval and consent to participate**

The current study is approved from institutional review board, Nannori hospital, Gangnam, Seoul, Republic of Korea.

Informed consent is obtained from all the participants in the study.

### **Consent for publication**

Not applicable.

### **Availability of data and materials**

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

### **Competing interests**

The authors declare that they have no competing interests

### **Funding**

No funds are received for the current study.

### **Author contributions**

- (1) Conception and design: HK
- (2) Administrative support: IJ
- (3) Provision of study material or patients: HK
- (4) Collection and assembly of data: HK, HR
- (5) Data analysis and interpretation: HK, HR, WP
- (6) Manuscript writing: All authors
- (7) Final approval of manuscript: All authors

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## Table

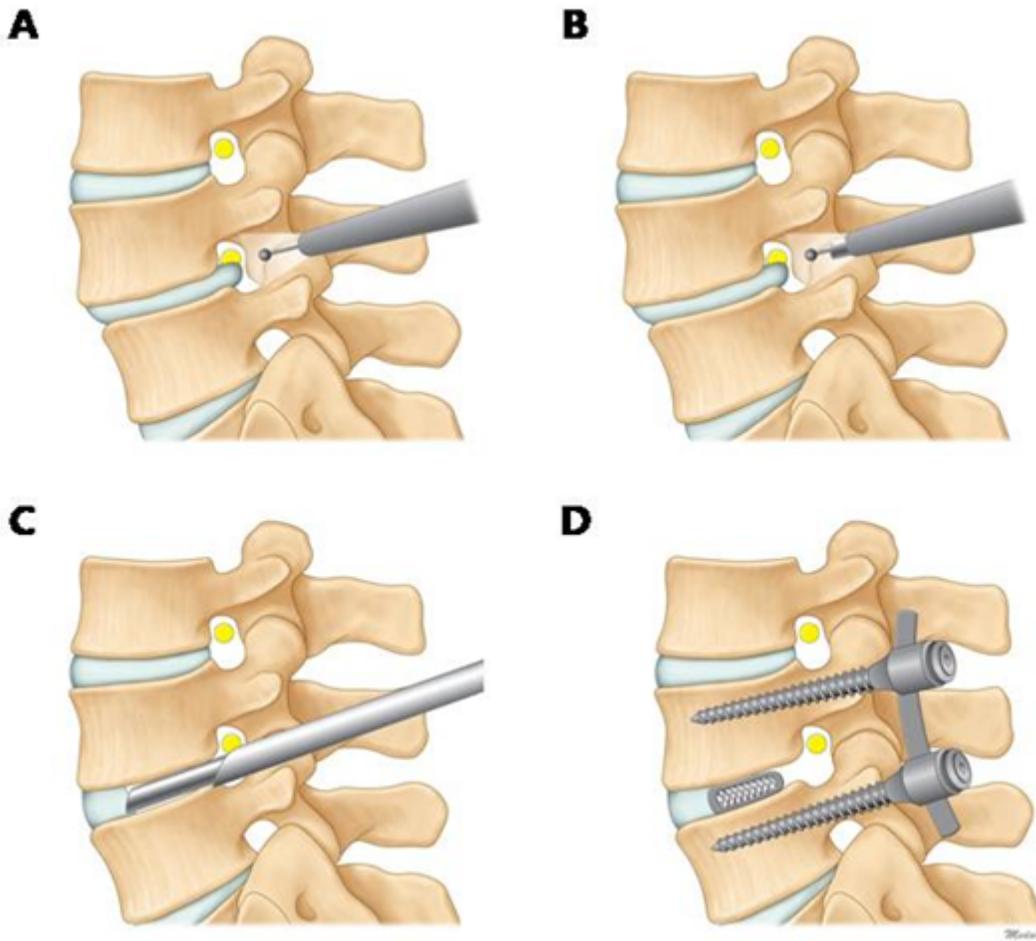
**Table 1:** Patient's radiological data pre operative post operative and final follow up period (values are presented as mean+standard deviation, p value < 0.01 considered as significant)

Radiological Data	value	P value
<b>Lumbar lordosis angle</b>		
pre operative	37.1+7.040	
post operative	39.2+7.136	( <i>p</i> < 0.01)
final follow up	35.7+7.252	
<b>Segmental lordosis angle</b>		
pre operative	9.87+2.743	
post operative	11.79+3.742	( <i>p</i> < 0.01)
final follow up	10.56+3.690	
<b>Disc height</b>		
pre operative	8.97+1.490	
post operative	12.34+1.399	( <i>p</i> < 0.01)
final follow up	11.44+1.986	( <i>p</i> < 0.01)
Mean percentage of surface area of fusion mass	42.61%.	

## Additional File Legend

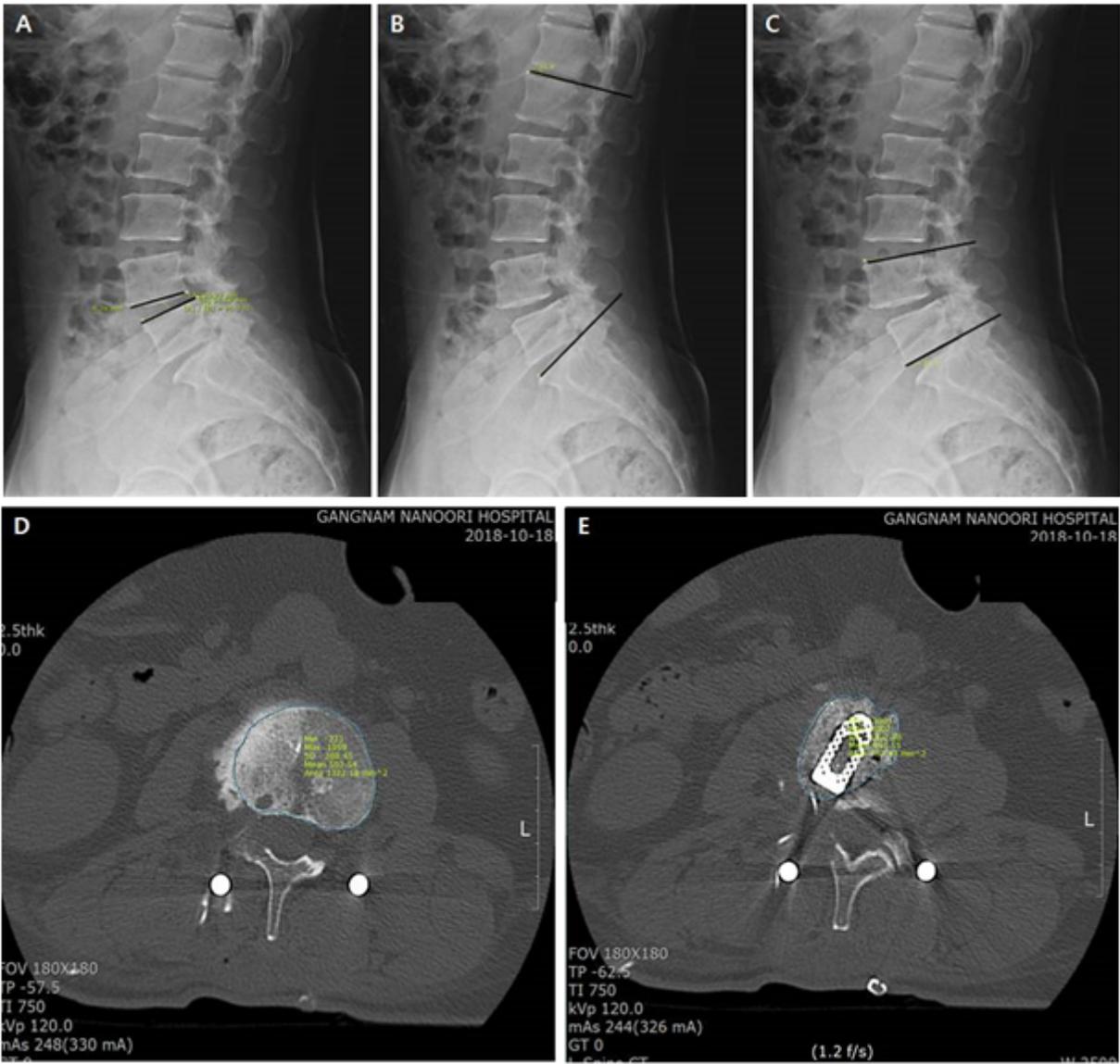
**Picture 1: A & B** beveled obturator inserted with its tip inside disc space and end plate preparation done **C & D** 3-D printed cage inserted through obturator and then it is removed **E & F** Final position of implant checked under endoscopic view and fluoroscopy guidance

## Figures



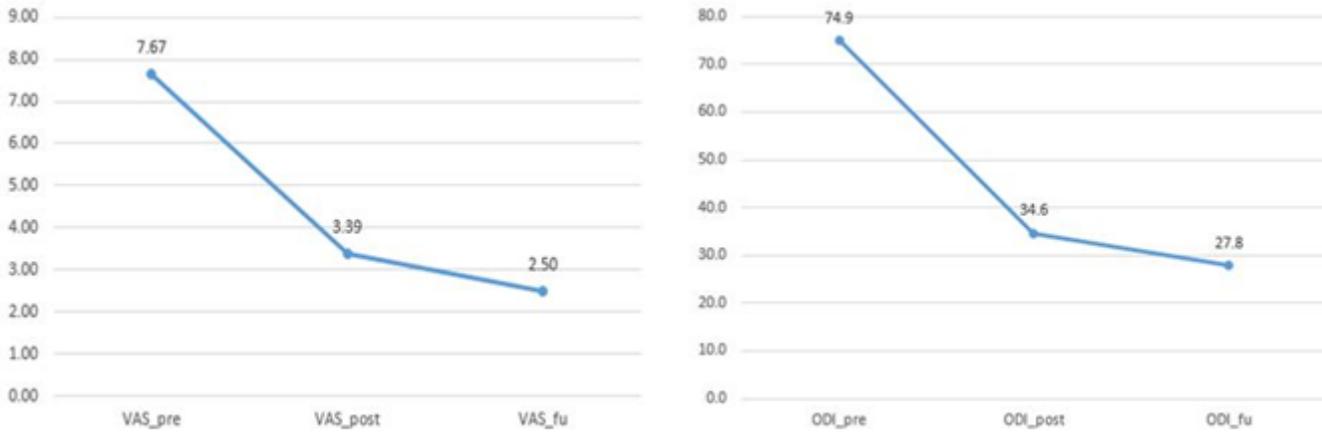
**Figure 1**

A & B Resection of superior and inferior articular process C Discectomy and end plate preparation D 3-D printed cage and percutaneous pedicle screw insertion



**Figure 2**

Radiological assessment Plain radiograph used to evaluate A. Disc height(DH) distance between upper and lower end plate, B. Lumbar lordosis angle(LLA) angle between superior end plate of L1 and S1 vertebra and C. segmental lordosis angle(SLA) angle between superior end plate of upper and inferior end plate of lower vertebra of fused segment



**Figure 3**

patients pain assessment during pre operative post operative and final follow up period



**Figure 4**

representative case - 62 years female patient operated for L5-S1 endoscopic TLIF through paraspinous approach A & B T2 weighted sagittal and axial image showing L5-S1 grade 1 spondylolisthesis with foraminal stenosis C & D Dynamic radiograph showing angular instability E Post-operative radiograph

## Supplementary Files

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- [renamed53d99.wmv](#)
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