Feasibility, Risks, and Outcomes of Percutaneous Oblique Extraforaminal Lumbar Interbody Fusion Technique

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ABSTRACT

Objective: To demonstrate the feasibility, risks and outcomes of percutaneous oblique extraforaminal lumbar interbody fusion (ELIF) technique. There is a growing interest in using less invasive and less exposure surgery techniques but very little has been written on an extraformainal approach for decompression and interbody fusion through Kambin's Triangle with the advantage of sparing the facets and lamina plus dissection of the multifidus muscles.

Methods: We reviewed the medical records of 10 consecutive patients undergoing an extraforaminal approach to the lumbar disc space for placement of a cannulated and bulleted interbody cage for fusion followed by percutaneous transfacet pedicle screw fixation. The postoperative outcome scores and complications were obtained at the final follow up encounter were used to determine clinical improvement.

Results: Mean age was 47.5 years and BMI was 29.8 kg/m^2 with males comprising 10% of the patient population. Three spinal levels were operated on including L3-L4, L4-L5, and L5-S1. Patients demonstrated improved VAS scores from a mean of 7.8 to 4, p= 0.001 and ODI decreased from 53% to 24.4 %, p= 0.02 at 24 months. Complications included three patients with postoperative neuropathy, one patient had a proud cage due to over packing of the disc space, and one patient had a nonunion and a subsequent revision.

Conclusions: Results from this study show less than favorable overall outcome with 50% of patients experiencing neurological complications when using this extraforaminal approach. Operating on the L5-S1 level limits operating space and is not recommended for this approach.

Keywords: Extraforaminal approach, lumbar decompression, lumbar fusion, outcomes, degenerative disc disease, Kambin's triangle

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INTRODUCTION

Lumbar disc degeneration, facet hypertrophy, osteophyte formation, spinal and foraminal stenosis and spinal deformities are but a few of the pathological conditions encompassed within the broad term ‘degenerative disc disease’ (DDD) of the lumbar spine (1, 2). Surgical options for the treatment of DDD, is usually only indicated after failed conservative therapies (1). Surgical procedures include both non-fusion and fusion techniques, which may be open or, minimally invasive. Examples of these include a simple discectomy, laminectomy, anterior lumbar interbody fusion (ALIF), posterior lumbar interbody fusion (PLIF), transforaminal lumbar interbody fusion (TLIF) and direct/extreme lateral lumbar Interbody fusion (D/XLIF). Although each approach has its own indications, contraindications and unique set of complications, the general goal is symptomatic relief of the diseased/painful segment through interbody fusion (3).

Little is published on an approach in which the surgeon can percutaneously access the disc space through Kambin’s Triangle to perform a discectomy and/or interbody fusion (4, 5). This facet-sparing approach has the advantages of minimally invasive decompression of the exiting nerve root, preserving the facets for fusion, and placement of an interbody cage for stability and indirect decompression of the contralateral nerve root with all the benefits of decreased blood loss and preservation of the posterior elements. The focus of this paper was to look at the technical feasibility and outcomes in a single institution after lumbar interbody decompression and/or fusion via an extra- foraminal percutaneous approach to the lumbar spine for the treatment of lumbar disc degeneration.

MATERIALS AND METHODS

We reviewed the medical records of 10 consecutive patients undergoing lumbar decompression and fusion via the extraforaminal approach with supplemental posterior transfacet pedicle screw fixation by one surgeon. Data was collected from medical records and operative notes between 2010 and 2014. IRB approval was obtained for this study. Fusion was attained with polyetheretherketone (PEEK) interbody cages through a cannula, with supplemental posterior transfacet pedicle screw fixation bilaterally. Indications for surgery included chronic, disabling low back pain with leg pain secondary to stenosis from degenerative disc and facet disease with or without low-grade spondylolisthesis, central canal or foraminal stenosis as evidenced on clinical examination, provocative injections and radiologic findings, Figure 1A/B.

All patients had failed a minimum of six months of conservative therapy, which included anti-inflammatory medications, physical therapy, therapeutic steroid injections and radiofrequency rhizotomies for patients with suspected facet-mediated axial back pain. The decision to operate via an extraforaminal approach was based on a combination of informed patient preference and surgeon discretion. Patients were educated on the different surgical approaches by the surgeon.

Outcome measures included a patient numeric rating scale/Visual Analog Scale (VAS) for lower back and leg pain (0-10), the Oswestry Disability Index (ODI).

Complications were divided into neurological and non-neurological. Time to resolution of symptoms was also evaluated.Patient follow up was recorded at their first visit postoperatively within two weeks of surgery, at 3, 6, 12 months and at the final two year recorded outpatient follow up thereafter.

Summary of operative technique

The patient was placed on a Wilson frame and after induction of general anesthesia, the lumbar spine was prepped and draped in the standard sterile surgical manner. Fluoroscopy was then used in the oblique Ferguson position to allow access to the target disc space (L4-L5 or L5-S1) on the left or right, through a retroperitoneal approach. A 22 gauge spinal needle is placed to identify operative level (6). A 1.5 cm incision was made around the insertion site of the needle, which approximated to about four inches from the midline. A blunt guidewire was then placed under fluoroscopic guidance to enter the disc space while testing with neuromonitoring for nerve disturbance, Figure 2. Sequential dilation was done over the guidewire and under fluoroscopy to achieve a safe operating window while monitoring for nerve reaction, Figure 3A/B. After discectomy and endplate preparation, we measured for a PEEK cage, packed with demineralized bone matrix (DBM) and allograft cancellous bone graft anteriorly into the prepared disc space and then inserted the PEEK cage obliquely across the space under fluoroscopy, Figure 4A/B.

Once the interbody was in place and confirmed fluoroscopically, the Wilson frame was taken out of kyphosis to provide more physiological lordosis to the patient. Then, in a mini-open midline approach, bilateral transfacet pedicle screws were placed at the fusion level for additional fixation, Figures 5. Facet joints were decorticated bilaterally and DBM with allograft cancellous chips was added prior to closure.

RESULTS

Demographics

Mean age at surgery was 47.5 (range 31-67) years, with females comprising 90% of the patients. We measured mean BMI as 29.8 (range 22.6-34). Three patients had a history of smoking prior to surgery and only one ongoing at final follow up.

Functional Outcomes

Three spinal levels were operated on in total, including L3-L4 (total 1), L4-L5 (total 9) and one patient at the level of L5-S1. One patient had two levels L4-L5 and L5-S1 performed. Mean blood loss and operating time was 64.6 (range 25-115) milliliters and 1.8 (range 0.9-2.4) hours respectively. Lower back pain was reported by 100% of patients and leg pain by 100% of patients at initial presentation. Preoperative VAS lower back scores went from a mean of 7.8 (range 5-10) to 4.8 (range 1.5-6.6) at 24 months, p= 0.001. Mean preoperative ODI went from 53% (range 38-62%) to 24.4% (range 9-50%), postoperatively at 24 months, p= 0.02.

Fusion

Sagittal and Axial CT radiographs were evaluated by the authors (KRC, FJRP, and JAS) to look for graft subsidence, implant failure, and status of fusion. Fusion was defined as the absence of radiolucency's, evidence of bridging trabecular bone within the fusion area (Figure 6A/B).

Fusion was achieved in only 60% of patients.

Complications

Five of our patients (50%) had complications that could be directly attributed to the surgery. Of the five, three had nerve related symptoms following the surgeries; one patient had pain and dyesthesia due to nerve impaction at level of L5 nerve root, which worsened since the surgery. No additional surgical management was offered. One patient had a proud cage removed and decompression of the nerves with successful fusion without the need for cage replacement. One patient had further decompression of the exiting L4 nerve root because of persistent nerve symptoms postoperatively, for which a direct lateral approach was used to assess for nonunion but she was fully fused and no further surgery was performed. Patient continued to have nerve symptoms with activities possibly due to intraneural fibrosis.

DISCUSSION

This study directly assessed the feasibility and procedural outcomes of ELIF. A statistically significant improvement was demonstrated in VAS and ODI scores. There was however only a 60% fusion rate with a 50% complication rate. The high complication rate demonstrated an overall poor outcome prompting the decision to discontinue using this technique as a method to achieve interbody fusion.

Lumbar interbody arthrodesis has evolved in surgical approach over the years, from the traditional anterior and posterior open procedures, to minimally invasive, lateral and oblique approaches to the disc space (7, 8). It is suggested that most of the documented complications are attributed to the surgical approach and not the hardware or technology itself (9-12). There is a paucity of published literature to guide surgeons on the use of a percutaneous extra-foraminal facet sparing approach. The commercial instrumentation is also poorly explored. Much more has been written about traditional anterior approaches, which harbor the risks of major intra-abdominal vessel injury, visceral injury, and postoperative ileus and in some cases retrograde ejaculation (12). Direct posterior approaches involve increased risks of neural injury through retraction, arachnoiditis, epidural fibrosis and postoperative spinal instability (9, 13, 14), while lateral/transpsoas approaches are complicated by injury to the lumbosacral plexus with various postoperative lumbar plexopathies reported (15, 16).

Originally described by Phillips and Cunningham, the intertransverse lumbar interbody fusion (ILIF) technique, though technical, has some inherent advantages (9). The approach avoids the need for an anterior dissection and its inherent risks in addition to avoiding disturbance of the spinal canal or neural foramen. The recommendations were based on a small cadaver and clinical case study, which suggested that the proposed posterolateral intertransverse approach was most suitable for accessing the L3-L4 and L4-L5 disc spaces and not L5-S1 due to insufficient operating space.

The extraforaminal approach used in our patients spared the facets in 100% of patients and was associated with minimal blood loss and average incision size of 1.5 cm. We found that the surgery was much more difficult to access the disc space at L5-S1 due to the position of the iliac crest and the angle needed to access the disc for complete discectomy. It was remarkable that we did not have any recorded nerve disturbances during access to the disc space or during dilation however several patients had postoperative nerve symptoms. We therefore concluded that this was due to prolonged nerve distraction around the outside of the cannula and might be a combination of stretch and compression.

Although intraoperative neuromonitoring has not been shown to be one hundred percent sensitive, one would expect for the high proportion of postoperative de novo neurological complaints, that there would be at least one intraoperative alert to such potential injury. Secondly, the traversing nerve was fully visualized throughout the procedure, retraction kept at a minimum and operating time was on average 1.8 hours from incision to closure. In all cases, both intraoperative and postoperative imaging confirmed proper placement of interbody cages and satisfactory posterior supplemental screw fixation. Although all cage placements were confirmed fluoroscopically, a complication of proud cage was noted post operatively.

Possible explanations offered for the poor outcomes reported in this small series are likely to be approach-related as has been the recurring theme when surgery is performed extraforaminally. Firstly, the anatomy of the take-off angle of the nerve roots from the thecal sac has been described in cadaver studies as 40 degrees from L1-L5 with an acutely sharp decline to 22 +/- 4 degrees at the S1 nerve root (17) which is on reason the authors recommend against performing the procedure at this level to avoid excessive retraction of the exiting L5 nerve root. The extraforaminal region (so-called “danger zone”), including the lumbar trunk and each exiting nerve root was found in a cadaver study to be located up to 25mm more anteriorly from the intervertebral foramen in the lower lumbar segments (18).

Also of importance in this region is the anatomic location of the dorsal root ganglia (DRG); being intimately related to the inferior aspect of the vertebral pedicles and one third overlying the lateral portion of the intervertebral disc (17). Particularly concerning is excessive nerve root retraction during extraforaminal insertion of interbody cages, as well as the insertion of pedicle screws which can cause injury to the intraforaminal ganglion (17). If the ganglion is compressed against its adjacent pedicle, this may lead to irritation and inadvertent injury with long-lasting effects, which may not be detected by neuromonitoring. Multiple nerve roots contribute to the cortical Somatosensory Evoked Potentials (SSEP), so damage to one nerve root can result without a significant change in the cortical potentials. Further static mechanical forces without compression do not induce impulses in normal nerve roots (19) Additionally, incorrect placement of the pedicle screw can compromise the stability of the fixation or worse, produce a neurological deficit or radiculopathy. Two of 7 neurological deficits were believed to be related to misplaced screws in a series of 124 patients who underwent posterior spinal fusion with variable screw plate fixation (20). Physiologic animal experiments have shown that acute compression of the root or nerve produces no more than several seconds of repetitive firing. However, with acute compression of a normal DRG, repetitive firing for between 5-25 minutes was observed, with even longer durations after acute compression of chronically injured DRGs, implying significantly increased mechano-sensitivity of the DRG compared with the nerve or its root (21).

The authors acknowledge that the small patient number and retrospective nature limit this study, however, we believe that the results are worthy of sharing with surgeons practicing or considering this approach. We have examined the outcomes of 10 patients who underwent lumbar spine surgery via an extraforaminal approach and have reported less favorable patient-reported outcomes than anticipated. Although there are reports of successful outcomes using the extraforaminal approach for the treatment of isthmic spondylolisthesis (22) generally, we do not recommend this procedure be performed at the L5-S1 level and with caution at L4-L5. It is the authors' opinion that these technical limitations discussed above might be lessened at levels above L4-L5 where the nerve root exit above the disc space and Kambin's triangle is wider.

AUTHORS' NOTE

Conflicts of interest and sources of funding: We did not seek or receive any funding from the National Institutes of Health (NIH), Wellcome Trust, Howard Hughes Medical Institute (HHMI), or others for this work. KRC is a shareholder in and receives other benefits from SpineFrontier Inc.; none of the other authors (FJRP, AVC, ME, or JAS) have any potential conflicts of interest to declare for this work.

REFERENCES

1. Eliyas JK, Karahalios D. Surgery for degenerative lumbar spine disease. Dis Mon. 2011;57(10):592-606. doi: 10.1016/j.disamonth.2011.09.001. PubMed PMID: 22036115.
2. de Schepper EI, Damen J, van Meurs JB, Ginai AZ, Popham M, Hofman A, et al. The association between lumbar disc degeneration and low back pain: the influence of age, gender, and individual radiographic features. Spine (Phila Pa 1976). 2010;35(5):531-6. doi: 10.1097/BRS.0b013e3181aa5b33. PubMed PMID: 20147869.
3. Nasca RJ. Newer lumbar interbody fusion techniques. J Surg Orthop Adv. 2013;22(2):113-7. PubMed PMID: 23628562.
4. Lee S, Kim SK, Lee SH, Kim WJ, Choi WC, Choi G, et al. Percutaneous endoscopic lumbar discectomy for migrated disc herniation: classification of disc migration and surgical approaches. Eur Spine J. 2007;16(3):431-7. doi: 10.1007/s00586-006-0219-4. PubMed PMID: 16972067; PubMed Central PMCID: PMC2200706.
5. Kambin P, O'Brien E, Zhou L, Schaffer JL. Arthroscopic microdiscectomy and selective fragmentectomy. Clin Orthop Relat Res. 1998(347):150-67. PubMed PMID: 9520885.
6. Chin KR, Pencle FJR, Kubik J, Coombs AV, Seale JA, Hothem EAH, et al. Avoidance of Wrong Level Surgery in the Lumbar Spine: Report. 2015;4(5):257. doi: 10.4172/2165-7939.1000257.
7. Pradhan BB, Nassar JA, Delamarter RB, Wang JC. Single-level lumbar spine fusion: a comparison of anterior and posterior approaches. J Spinal Disord Tech. 2002;15(5):355-61. PubMed PMID: 12394658.
8. Chin KR, Pencle FJ, Coombs AV, Brown MD, Conklin KJ, O'Neill AM, et al. Lateral Lumbar Interbody Fusion in Ambulatory Surgery Centers: Patient Selection and Outcome

Measures Compared With an Inhospital Cohort. Spine (Phila Pa 1976). 2016;41(8):686-92. doi: 10.1097/BRS.0000000000001285. PubMed PMID: 27064334.

9. Phillips FM, Cunningham B. Intertransverse lumbar interbody fusion. Spine (Phila Pa 1976). 2002;27(2):E37-41. PubMed PMID: 11805678.

10. McAfee PC. Interbody fusion cages in reconstructive operations on the spine. J Bone Joint Surg Am. 1999;81(6):859-80. PubMed PMID: 10391552.

11. McAfee PC, Regan JR, Zdeblick T, Zuckerman J, Picetti GD, 3rd, Heim S, et al. The incidence of complications in endoscopic anterior thoracolumbar spinal reconstructive surgery. A prospective multicenter study comprising the first 100 consecutive cases. Spine (Phila Pa 1976). 1995;20(14):1624-32. PubMed PMID: 7570179.

12. Rajaraman V, Vingan R, Roth P, Heary RF, Conklin L, Jacobs GB. Visceral and vascular complications resulting from anterior lumbar interbody fusion. J Neurosurg. 1999;91(1 Suppl):60-4. PubMed PMID: 10419370.

13. Wetzel FT, LaRocca H. The failed posterior lumbar interbody fusion. Spine (Phila Pa 1976). 1991;16(7):839-45. PubMed PMID: 1833832.

14. Brantigan JW, Steffee AD, Lewis ML, Quinn LM, Persenaire JM. Lumbar interbody fusion using the Brantigan I/F cage for posterior lumbar interbody fusion and the variable pedicle screw placement system: two-year results from a Food and Drug Administration investigational device exemption clinical trial. Spine (Phila Pa 1976). 2000;25(11):1437-46. PubMed PMID: 10828927.

15. Houten JK, Alexandre LC, Nasser R, Wollowick AL. Nerve injury during the transpsoas approach for lumbar fusion. J Neurosurg Spine. 2011;15(3):280-4. doi: 10.3171/2011.4.SPINE1127. PubMed PMID: 21619401.

16. Ahmadian A, Deukmedjian AR, Abel N, Dakwar E, Uribe JS. Analysis of lumbar plexopathies and nerve injury after lateral retroperitoneal transpsoas approach: diagnostic standardization. J Neurosurg Spine. 2013;18(3):289-97. doi: 10.3171/2012.11.SPINE12755. PubMed PMID: 23259543.

17. Cohen MS, Wall EJ, Brown RA, Rydevik B, Garfin SR. 1990 AcroMed Award in basic science. Cauda equina anatomy. II: Extrathecal nerve roots and dorsal root ganglia. Spine (Phila Pa 1976). 1990;15(12):1248-51. PubMed PMID: 2281367.

18. Bae HG, Choi SK, Joo KS, Kim BT, Doh JW, Lee KS, et al. Morphometric aspects of extraforaminal lumbar nerve roots. Neurosurgery. 1999;44(4):841-6. Epub 1999/04/14. PubMed PMID: 10201309.

19. Rydevik B, Brown MD, Lundborg G. Pathoanatomy and pathophysiology of nerve root compression. Spine (Phila Pa 1976). 1984;9(1):7-15. PubMed PMID: 6372124.

20. West JL, 3rd, Ogilvie JW, Bradford DS. Complications of the variable screw plate pedicle screw fixation. Spine (Phila Pa 1976). 1991;16(5):576-9. PubMed PMID: 2053001.

21. Howe JF, Loeser JD, Calvin WH. Mechanosensitivity of dorsal root ganglia and chronically injured axons: a physiological basis for the radicular pain of nerve root compression. Pain. 1977;3(1):25-41. PubMed PMID: 195255.

22. Baek OK, Lee SH. Extraforaminal lumbar interbody fusion for the treatment of isthmic spondylolisthesis. J Spinal Disord Tech. 2009;22(3):219-27. doi: 10.1097/BSD.0b013e3181761528. PubMed PMID: 19412026.

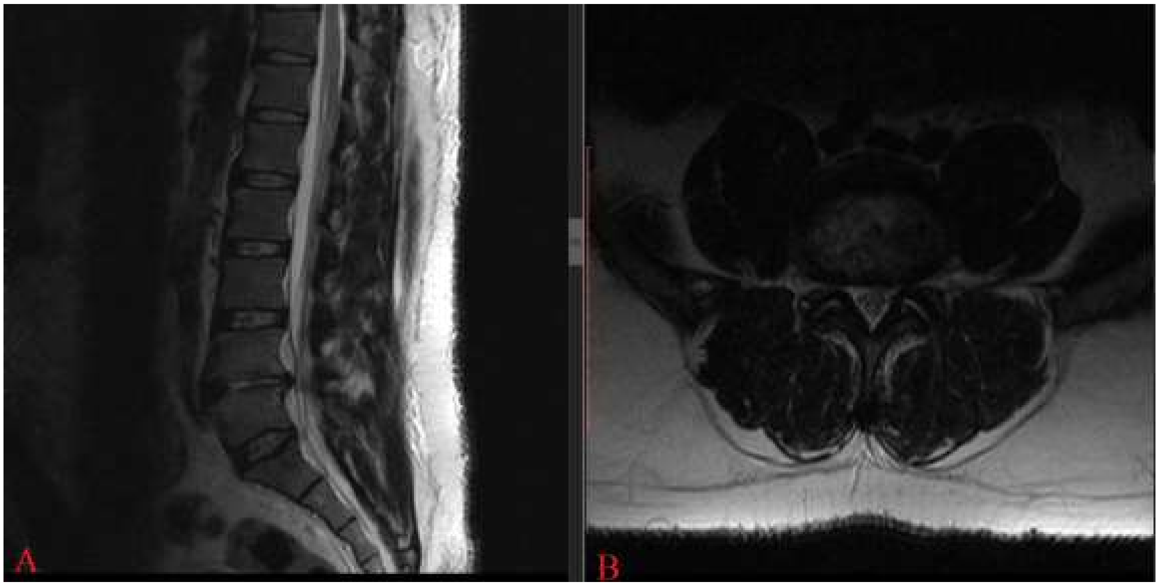

Fig. 1A/B: Sagittal & Axial MRI demonstrating herniated disc at L4-L5.

Fig 2: Lateral fluoroscopy of guidewire in L4-L5 disc space.

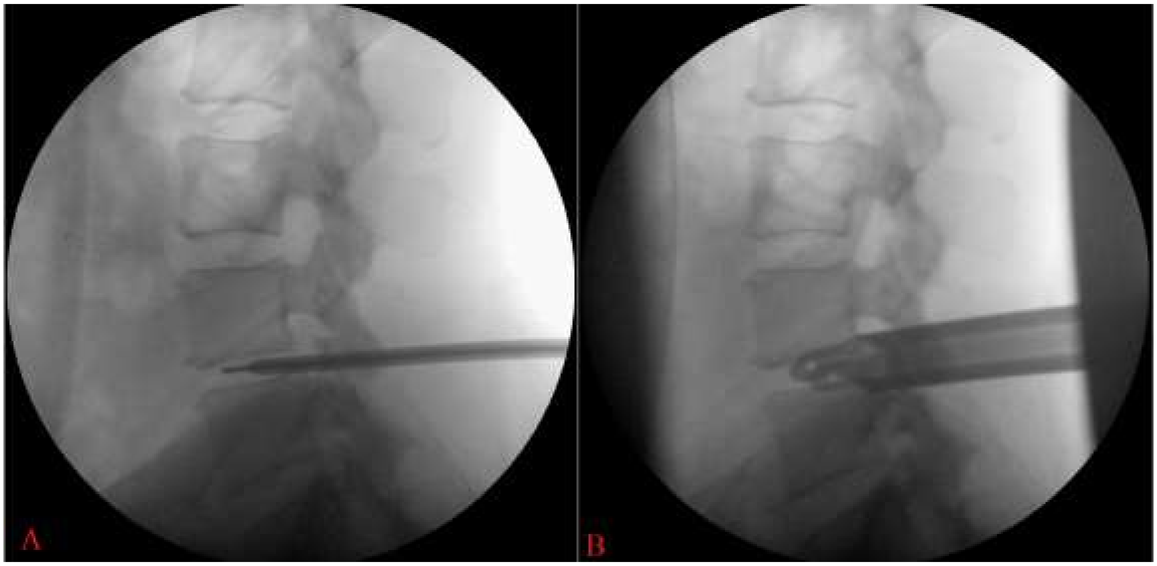

Fig 3: Lateral fluoroscopy A: guidewire and dilator at L4-L5 B: Final docking position of endoscope.

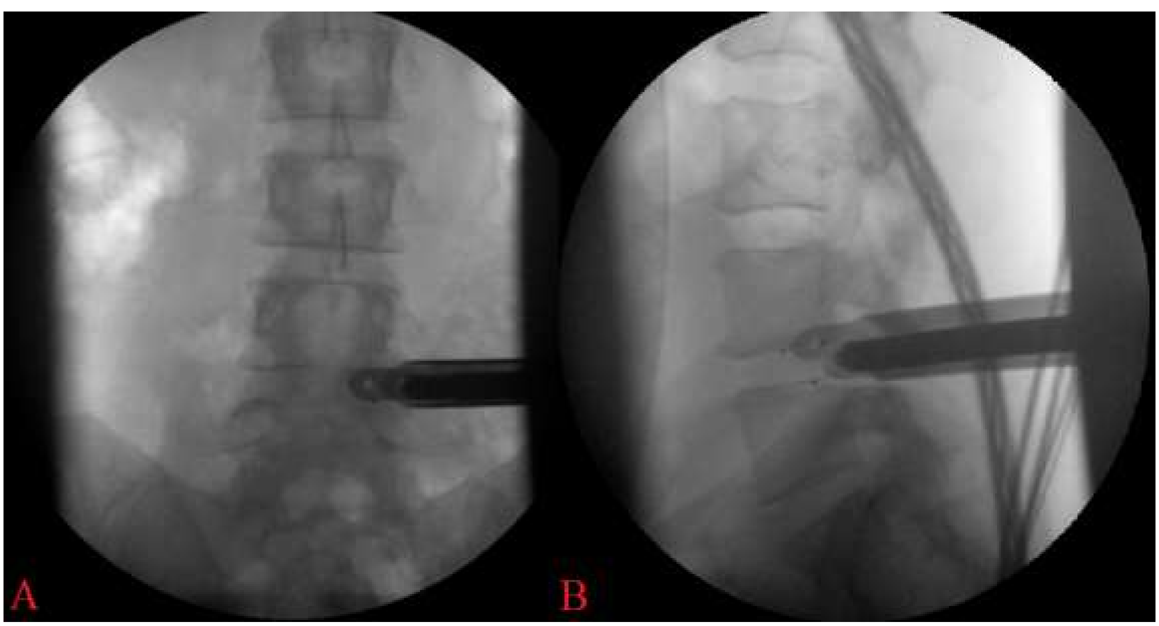

Fig 4: Fluoroscopy of PEEK cage placement A: Anteroposterior B: Lateral.

Fig 5: Lateral fluoroscopy of transfacet pedicle screw.

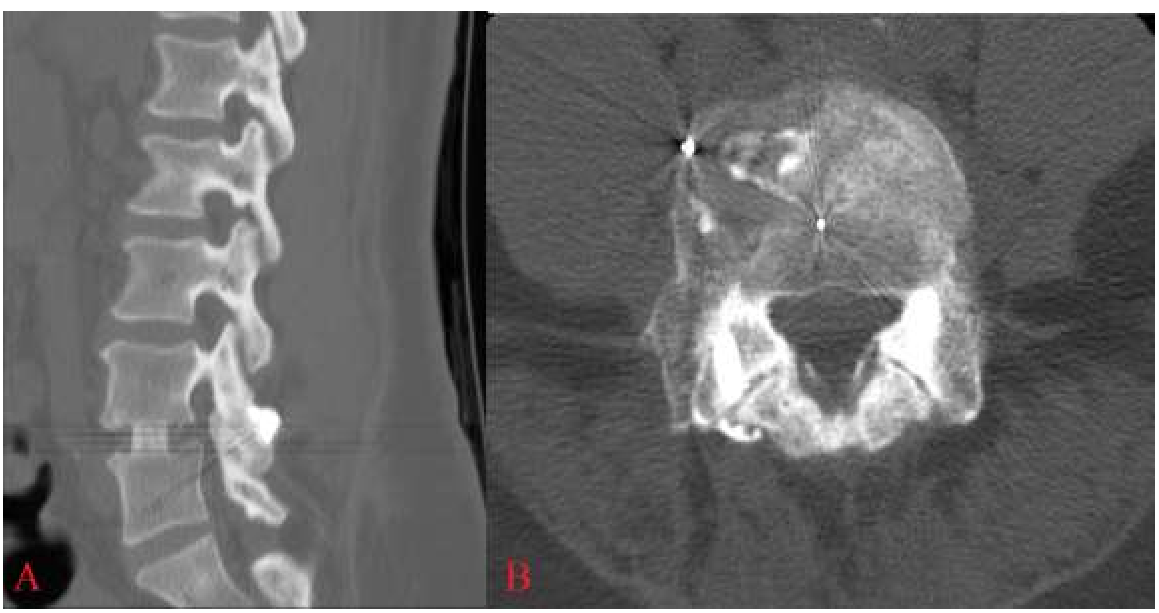

Fig 6: CT demonstrating fusion at L4-L5 A: Sagittal B: Axial.