Original article

Inserting pedicle screws in lumbar spondylolisthesis – The easy bone conserving way

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ABSTRACT

Background: Pedicle screw fixation in high grade lumbar listhetic vertebral body has been nightmare for Orthopaedic and spine surgeons. This is because of abnormally positioned listhetic pedicles and non-visualization of pedicle in conventional image intensifier (C-Arm). This results into increased surgical time, more blood loss, radiation exposure and more chances of infection. To overcome this problem, we have devised a new Technique of putting of pedicle screw fixation in listhetic vertebrae.

Methods: Total 20 patients of average age of 42 (25–56) were included during 2010 to 2015. Listhesis was classified according to etiology, Meyerding grading and DeWald modification of Newman criteria used for assessment of severity for spondylolisthesis on standing X-ray lumbosacral spine. Patients satisfying following criteria were considered for surgery. Age more than 20 years, with single involvement of either L4–5/L5–S1, high grade spondylolisthesis ($\geq 50\%$ Meyerding grade), unresolving radiculopathy, cauda equina syndrome or pain with and without instability not relieved by 6 months of conservative treatment. According to Meyerding radiographic grading system, 10 patients were of type II and 8 of type III and 2 of type IV. Treatment given was pedicle screw fixation, reduction of listhesis vertebra and spinal fusion with our technique. PLT was done in 10 cases and transforaminal lumbar interbody fusion (TLIF) in the other 10 cases.

Results: Mean follow up duration was 2 years (range 1.3–3.3 year). The average preoperative LBP VAS of low back pain were 6.7 and average LP VAS for leg pain 5.7. Postoperatively at final follow up there was reduction of LBP VAS to 2.2 and LP VAS to 0.5. There was rapid reduction in their LBP VAS in first two visits at 4 weeks and in LP VAS in first three visits at 8 weeks. The pain-free walking distance improved significantly. The average pre-operative ODI score was 51.4, improved to 18.6 postoperatively. There was no difference in above scores between PLT and TLIF.

Conclusion: Our surgical technique used for high grade spondylolisthesis is safe, cost-effective, bone-preserving, reliable, and reproducible for high grade Lumbar spondylolisthesis.

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1. Introduction

In our initial days of lumbar spondylolisthesis surgery, it was very difficult or almost impossible to put screw in the pedicle of displaced listhesis vertebra, as we could not visualise it by Image

Intensifier (C-arm) on the anteroposterior view (AP). So patients with listhesis were treated by putting screws in vertebra proximal and distal to listhesis, thus compromising listhesis-reduction, the stability of fixing construct and lessening chance of fusion. Later we started exposing transverse process and articular process and inserting pedicle screws in a free hand manner but pedicle visualisation on anteroposterior (AP) view was still deficient; this lead to at times to inserting one or no screw in listhesis vertebra (LV). On searching Google scholar, Pub med and Cochrane data base we found studies describing anatomical angular direction of pedicle by imaging studies or on cadaveric bones.^{1–18} There were articles that used computer-assisted image-guided navigation (IGN) for inserting the pedicle screw using 2Dimensional (2D),

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Table 1

Patient's demographic and clinical profile.

Patients	Age/ sex	Type: I/T/D	Meyerding grade	Surgery	Screw in lithesis Vbr.	Postop						
						Meyerding grade improvement	Slip angle improvement	Complications	Claudication improvement	VAS-LBP pre/post	VAS-LP pre/post	ODI pre/post
1	35/M	I	III	PLT + IF + Dm	2	0	N	None (n)	70–2000 m	8/3	N	60/
2	45/F	D	II	PLT + IF + Dm	2	0	N	None	100–3000 m	7/2	4/1	40/
3	56/M	D	II	PLT + IF + Dm	2	0	N	n	80–3000 m	8/2	6/2	35/
4	26/M	I	III	PLT + IF	2	I	50% improved	Symptomatic hardware	90–2500 m	9/2	6/2	62/
5	32/F	I	IV	PLT + IF + Dm	1	II	40%	Shy bladder, improved after 2 weeks	50–2000 m	10/2	8/2	70/
6	40/M	I	III	PLT + IF	2	0	80%	Superficial infection subsided	80 m–3 km	8/3	4/2	55/
7	55/F	D	III	PLT + IF + Dm	2	0	85%	N	50–2000 m	7/2	6/2	35/
8	37/F	I	III	PLT + IF	2	I	55%	N	100–3000 m	8/3	N	40/
9	34/F	I	III	PLT + IF	2	I	60%	N	Could not measure – 50%	6/2	N	34/
10	29/M	I	IV	PLT + IF + Dm	2	II	35%	N	70–2000 m	8/2	4/2	61/
11	51/F	D	II	PLT + IF + Dm	2	0	84%	N	100–2000 m	6/0	6/1	31/
12	28/F	I	III	PLT + IF + Dm	2	I	65%	N	50–2000 m	8/2	4/2	33/
13	33/F	I	III	PLT + IF	2	I	63%	N	Could not measure	8/2	4/2	34/
14	45/F	D	II	PLT + IF + Dm	2	0	86%	N	100–2000 m	4/0	4/1	29/
15	27/M	I	IV	PLT + IF + Dm	2	II	40%	N	50–2000 m	8/2	4/2	60/
16	55/M	I	III	TLIF + IF + Dm	2	I	85%	N	10–1000 m	8/2	8/2	65/
17	45/F	I	II	TLIF + IF + Dm	2	I	90%	Infection deep-debrided	50–2000 m	8/1	8/1	72/
18	55/F	I	III	TLIF + IF + Dm	2	I	90%	N	15–1500 m	8/2	8/2	82/
19	60/F	I	III	TLIF + IF + Dm	2	I	80%	N	25–2000 m	9/2	6/1	74/
20	48/F	D	II	PLT + IF + Dm	2	I	90%	N	30–2000 m	7/1	6/0	64/

M – male; F – female.

I – isthmic type lithesis; D – degenerative; PLT – posterolateral intertransverse fusion; IF – internal fixation by pedicle screws; Dm – decompression; N – no complication.

3Dimensional (3D), computed tomography (CT) scan preoperatively and intraoperatively whereas others used O-arm fluoroscopy and CT scan post-operatively.^{19–25} O-arm and 3D fluoroscopy IGN gave excellent results but they are expensive and may not be affordable for many facilities.¹⁹ There is no article to the best of our knowledge that describes accurate pedicle screw insertion preoperatively in an anatomical deranged spine like lumbar spondylolisthesis using conventional 2D fluoroscopic images by readily available C-arm and without exposing anteriorly displaced posterior elements (Table 1).

2. Material and methods

From May 2010 to December 2015 we conducted a prospective case series at our Hospitals. A total of twenty patients with average age of 42 (25–56) were included. Written and informed consent was obtained from all patients. Etiological classification was done. Severity of slip was estimated by Meyerding grading and DeWald modification of Newman criteria for spondylolisthesis on standing X-ray lumbosacral spine antero-posterior (AP), lateral and oblique radiographs of patients. Ten patients were of type II and 8 of type III and 2 of type IV, according to Meyerding classification; and 8 patients of Meyerding grade II were 4+0 and 2 were 4+1 respectively and 6 of Meyerding grade III were 6+1, 6+2, 6+1, 6+3, two of Meyerding grade III were 7+1 and 7+3 respectively and 2 of Meyerding grade IV were 9+2 two of 9+3 according to DeWald modification of Newman criteria. Inclusion criteria for surgery were adult patient > 20 years having focal type II L4–5/L5–S1 anterolisthesis with back pain not relieved by conservative treatment for 6 months, back pain with high grade spondylolisthesis ($\geq 50\%$ Meyerding grade), unresolving radiculopathy, cauda equina syndrome or pain with instability on flexion–extension view.

Magnetic Resonance Imaging was done in all cases preoperatively to rule out foraminal stenosis, disc desiccation, pars defect and root impingement and also to check the status of cord and vertebra. Computer tomography scan was done at 9 months post-operative period to assess the healing of the pars interarticularis defect and consolidation of posterolateral inter-transverse fusion (PLT). Treatment given was pedicle screw fixation, reduction of lithesis vertebra and spinal fusion with our technique. Posterolateral inter-transverse fusion (PLT) was done in 10 cases and transforaminal lumbar interbody fusion (TLIF) in the other 10 cases. The following functional parameters were analysed: visual analogue scale of low back pain (LBP VAS) and leg pain (LP VAS), Oswestry-Disability Index (ODI), and short form 36 (SF-36). The ODI and SF-36 were evaluated preoperatively and postoperatively at 2, 4, 6 weeks and at 12 and 24 months or till last visit of patient. Low back pain and LP VAS was evaluated preoperatively, and on postoperative at 1, 4, 8, 16 weeks, 6 months, 12 months and at 2 years or till last visit of patient. Radiological parameters of therapeutic significance, the pelvic tilt, sacral slope, pelvic incidence, slip angle and lumbosacral angle were evaluated by X-ray preoperatively and at week 1 and 6 and month 6, 12 then 24 or till last follow up visit and by CT scans at 9 month. The fusion rate and surgical complication if any were also assessed.

3. Surgical technique

All surgeries were performed under general anaesthesia. Patients were put in prone position on radiolucent table with hip and knee flexed to 90°. The spine was exposed through standard midline posterior approach to the lumbosacral spine. We prefer inserting screws before performing decompression. The following description follows for an index case of lumbar L5–sacral S1 lithesis (Fig. 1a). Initially pedicle screws were inserted in one

Fig. 1. (a) Anterior–posterior view and lateral view of grade IV, L5–S1 anterolisthesis, (b) C-arm image showing radiolucent starter inserted at base of pedicle in lateral view which is progressively angled in direction/axis of pedicle, (d) per-operative image shows manual insertion of probe on both sides of pedicle, (e) probe is angled in the line of pedicle in lateral view, (c, f) C-arm angled cephalad to make it collinear to the radiolucent probe for taking a true anterior–posterior view showing pedicle outline.

pedicle of L4 and both S1 by standard techniques. Distraction was done between L4 and S1 screw on one side to (a) increase working area between L5 and S1, (b) reduce listhesis to some extent and (c) make subsequent TLIF easier.

Now focus was shifted to inserting screws in listhesis vertebra (LV) in an atraumatic manner. Pedicle of L5 needs to be visualised in two radiographic views for safe insertion of pedicle screw in a vertebrae. In cases with listhesis in AP view, the pedicle of listhesis vertebra is not usually visualised in high grade slips. So an innovative method was devised; first the insertion point of pedicle screw was marked with a radiolucent candle point at superolateral aspect of inferior articular process (IAP) of L5 vertebra as classic landmarks of pars interarticularis, superior articular process (SAP), transverse process (TP) were anatomically displaced.^{8,26} Thereafter a lateral view of spine was taken by the C-arm, and axis of the pedicle was visualised/delineated on lateral view; and subsequently a radiolucent end-pointed marker was hammered (as a starter) aiming for the centre of pedicle (Figs. 1b, d, e and 2a). The Image Intensifier (C-arm) was then shifted into antero-posterior position and the laser mounted on C-arm (if available otherwise manually) was used to angle the C-arm cephalad in such a way that it was collinear to the previously hammered radiolucent marker (that is axis of the pedicle) (Fig. 1c and f). This angle of C-arm tilt was equal to the angle of tilt of radiolucent marker in lateral view. This shooting of X-ray beam of C-arm in the direction of pedicle axis of slipped vertebra, (as determined by lateral view) allowed us to accurately visualise the pedicle in antero-posterior (AP) view. The tip of the marker was then fine-tuned into the centre of the circle of pedicle visualised on AP view (Fig. 2b) and it was hammered directed collinear to the X-ray beam of C-arm and thus axis of pedicle in lateral view. Pedicle was probed, sounded and pedicle screws were inserted in listhetic vertebra (Fig. 2c–f). All patients with radiculopathy were subjected initially to neural decompression that is Gills type L5 laminectomy, facetectomy, discectomy and TLIF. Later we started doing L5 laminotomy and

inferior facetectomy, of L5 vertebra alone with PLT as described by Wiltse.²⁶ The reduction of listhesis was done by aforesaid (a) L4–S1 distraction, (b) hip extension, (c) sequential tightening of L5 screws, (d) reduction screw if need be. Thereafter 2-level rod – screw fixation osteosynthesis was done in a standard manoeuvre between L5–S1 screws and L4 pedicle screw was removed.

Working area in the listhesis region is often small and this can be increased for TLIF by lamina spreader put in between the two spinous process, or as above that is inserting L4 and S1 screw on one side and distracting it. In high grade slips type IV, some type III and in all cases of PLT and in osteoporotic bones 3 level fixation from L4 to S1 was done.

4. Results

The age of patients ranged from 25 to 56 years with mean age of 42 years. Twenty patients were included in the study. Most of the patients (16) were in isthmus category (Fig. 3) and other in degenerative category (Fig. 4). In isthmus spondylolisthesis there were 9 male and 7 female and in degenerative category all were females except two. In isthmus group (Fig. 5) 9 patients are young, <40 compared to degenerative group and they had active lifestyle. According to Meyerding radiographic grading system for spondylolisthesis 10 patients were of type II and 8 of type III and 2 of type IV. In degenerative group all patients were in type 2. In all isthmus spondylolisthesis patient disc degeneration was present at level of pars fracture and at the adjacent segment. There was spinal stenosis, facet overgrowth and hypertrophy of ligamentum flavum and degenerative disc desiccation at the level of listhesis in all patients of degenerative listhesis. Average duration of time between initiation of symptoms and surgery was 2.2 years with range of 9 months to 4.4 years. The average operative time was 124 min; operative time was longer in patient in which spinal decompression was done and TLIF cases. Neural decompression was done in all degenerative spondylolisthesis and 8 patients in

Fig. 2. (a) Hammering of radiolucent starter in the direction of pedicle in lateral view. (b) Pedicle probe inserted in the pedicle seen on angled AP view. (b) Arrows pointing towards the pedicle sound centred in pedicle in anterior–posterior view. (c) Pedicle sound centred in pedicle in anterior–posterior view. Anterior–posterior view of lumbosacral spine post pedicle screw insertion highlighting the efficacy of our angled AP view, (d) shows standard AP view with non-visualisation of pedicle. (e and f) Progressively angled AP view show clear demarcation of pedicle outline with screw in situ.

isthmus category. TLIF was done with polyetherether ketone (PEEK) cage and bone graft from iliac crest. In all patient PLT fusion using mixture of autogenous bone graft of iliac crest and artificial bone graft substitute was done and only PLT was done in 10 cases. In all patient post-operative AP and lateral X-ray (Fig. 6), showed screws to be centred in pedicle with no blowouts. Mean follow up of patient was 2 years (range 1.3–3.3 years). The average preoperative LBP VAS of low back pain were 6.7 and average LP VAS for leg pain 5.7. Postoperatively at final follow up there was reduction of LBP VAS to 2.2 and LP VAS to 0.5. There was rapid reduction in their LBP VAS in first two visits at 4 weeks and in LP VAS in first three visits at 8 weeks. The pain-free walking distance was estimated at an average of 80 m preoperatively and it improved to over 2 km after last visit. The average preoperative ODI values were 51.4. At 4 weeks postoperatively, the ODI value reduced significantly. Further follow up visit at 4, 6 and 8 week ODI value reduce but not as rapidly as in first follow-up visit at 4 weeks. The average mean ODI value at final visit was 18.6. The SF-36 score improved from 36.5 preoperatively to 59.3 at the last follow-up. SF-36 score significantly improved at 4 weeks, after that at further follow up it did not reduce as rapidly as in first two visits. There was no difference in above scores between PLT and TLIF.

Slip percent as measured by Meyerding method improved from an average of 65% preoperatively to 25% at final follow up as measured by X-ray at week 1, 6 and 6, 12 then 24 month or till last follow up visit and by CT scans at 9 months. Slip angle (Fig. 6B) improved from an average of 19° to 7° postoperatively at final follow up as measured by X-ray at week 1, 6 and 6, 12 then 24 month or till last follow up visit and by CT scans at 9 months.

We encountered superficial infection in one patient which was managed with dressing and appropriate antibiotics, deep infection

in one who responded to surgical debridement and antibiotics, and prominent hardware in one thin male patient with grade IV slip and in one female patient of grade III for which they were counselled. In all patients there were no progression of slip at 2 years (Fig. 7a and b) and consolidation of posterolateral fusion mass was confirmed on postoperative CT scan except in five patient of isthmus spondylolisthetic vertebra but they were stable on flexion–extension dynamic lateral X-ray of spine (75% fusion rates). All patients were clinically satisfied and low back pain significantly improved with no progression of slip (Fig. 8).

5. Discussion

Pedicle morphometric analysis for entire lumbar spine was described by Zindrick et al.²⁷ and Weinstein.⁴ Transverse pedicle angles from L1 to L5 progressively increase to a maximum of almost 30° in L5 while sagittal pedicle angle remains almost 90° from L1 to L4, but at L5 the pedicle is caudally directed 18° approximately and L5 has the largest transverse pedicular width. Pedicle morphology in degenerative (DS) and spondylolytic spondylolisthesis (SS) is changed in that there are no significant differences in the mean transverse diameter or axial length in degenerative spondylolisthesis but the mean axial angle was significantly smaller in the DS. In the DS, the pedicles were more sagittally oriented. Such difference in the axial angle of the pedicles in DS should be taken into consideration when placing at the insertion of pedicle screws.²⁸ In spondylolytic spondylolisthesis (SS) the pedicle is elongated and the angle of the pedicle is wider in cases of L5–S1. Vertebral body shape was more posteriorly wedged in SS. Pedicles were more narrow and shorter in L5–S1 SS (20). In L5–S1 SS, a longer screw is suitable for insertion of L5 pedicle and

Fig. 3. (a and b) Anterior–posterior and lateral view of grade III L5–S1 isthmic spondylolisthesis pre-operatively. (c and d) Anterior–posterior view and lateral view of anterolisthesis showing almost full correction of the slip post-operatively. Sacral screws were inserted by two described techniques one in divergent and the other convergent manner. (e) Anterior–posterior X-ray view and flexion–extension lateral view showing increase slip in a case of grade II degenerative listhesis, (f) sagittal MRI section of spondylolisthesis, (g) axial section MRI of degenerative L4 L5 spondylolisthesis, (h) anterior–posterior and lateral view of degenerative spondylolisthesis post operatively.

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Fig. 4. (a) Preoperative X-ray of grade IV isthmic spondylolisthesis – 80% (b and c) postoperative X-ray showing reduction to grade II – 25%.

Fig. 5. (a) Post-operative CT scan sagittal formulation and axial section of above grade IV isthmic spondylolisthesis. Sagittal CT sections show reduction of anterolisthesis to Meyerding grade II and neural foramina free from any impingement; axial CT sections shows no pedicle breach and spinal canal free from any impingement. (b) CT section shows slip angle 7.2° ; CT section shows slip reduced to Meyerding grade I, measurement of slip angle, sacral inclination 35.9° , pelvic incidence 61° , sacral slope, 41° , pelvic tilt 20° (1 year post op).

Fig. 6. (a and b) Anterior–posterior and lateral view of anterolisthesis post-operatively after 18 months showing PLT graft (autologous and artificial) compared to preoperative X-ray films. (c–f) Line diagram of our technique in clockwise direction-localise pedicle axis on lateral view with a starter – tilt the C-arm cephalad in line with the for a true angled AP view of pedicle – insert screws.

Fig. 7. TLIF series (a) L 5–S1 listhesis Grade II. (b) L4–L5 listhesis.

Fig. 8. TLIF series (a) degenerative listhesis grade II preoperative MRI. (b) Flexion–extension view show listhesis increasing to high grade II with measurements of pelvic incidence, sacral slope and pelvic tilt preoperatively. (c) Postop X-ray with 2level fixation and TLIF.

the screw should be inserted more medially compared to patients without SS.

In spinal surgery pedicle screw insertion by computer-assisted navigation gives excellent result.¹⁹ Various studies on free hand technique using 2D fluoroscopy and computer assisted pedicle screw insertion in listhesis concluded, that pedicular screws were inserted more accurately with image-guided computer navigation than conventional methods. There was decreased incidence of pedicle breach and clinical events in computer assisted technique than free hand technique.^{22–24} O-arm-based navigation, which uses intraoperative acquisition and registration of navigated images,

may overcome many of the disadvantages of registration-based method as seen in preoperative computed tomography imaging, 2D fluoroscopy, and 3D fluoroscopy.²⁵ However, these image-guided system and O-arm based system are expensive and may not be affordable for many facilities¹⁹ and also not fool proof because O-arm navigation is tracker dependent and as distance increases from tracker more pedicle screw violation occurs. Lateral perforations are more common due to instability at time of pedicle screw insertion due to translation and rotation of vertebral body. However, O-arm navigation does not provide any significant advantage over conventional free hand pedicle screw insertion technique.²¹

Our technique is (Fig. 4C) biomechanically sound as we first determine the direction of pedicle axis on lateral view and mark it with a radiolucent marker tapped lightly at pedicle screw insertion point. The C-arm beam is then turned for an a-p view of spine in which the pedicle outline is not visualised in cases of high grade slips; so to solve this problem the C-arm is tilted accordingly in a cephalo-caudal direction, and X-ray beam is shot collinear to the radiolucent marker (elucidating pedicle axis) placed before on lateral view. This usually demarcates the pedicle outline in AP view for safe screw insertion. Hence a pedicle not seen on standard a-p views is visualised on this angled antero-posterior view. We comprehend that fixation before decompression is safe and avoids neural injury, as instrumentation with duramater exposed can be jeopardising. Our technique is different from Sethi et al.,²⁹ they rely on a proper AP view in which c arm beam is shot through superior endplate of deranged vertebra which shows the index vertebra as a rectangle with a sharp superior border. They contend that taking of this true AP view is in itself problematic and requires some practice as accepted by authors; whereas our technique is simple and biomechanically sound. This is because our technique relies on finding the pedicle tube axis in lateral view first and marking it with a hammered radiolucent marker. This mathematically determines the angle by which the C-arm needs to be tilted in cephalo-caudal direction while taking AP view of LS spine, so that X-ray beam is shot collinear to the above placed marker and thus through pedicle axis (Fig. 7e and f). Further in listhesis not only is the vertebra with its superior endplate displaced, but also tilted caudally, and in these cases taking a true AP view as discussed by authors (Sethi et al.) may be difficult.⁴ It is like a Ferguson X-ray view but we calculate the angle by which C-arm is to be tilted for a true AP view scientifically and easily on a prior lateral view. Not only is it easy and reliable but also less damaging to bone and soft tissues as no overzealous dissection of anatomical landmarks for pedicle entry points is necessary.

In high grade (IV) slips space between cephalic and caudal vertebrae to listhesis decreases and working area for insertion of pedicle screw is less (Fig. 4D). In such cases even tilting of C-arm as in our technique may not be enough to clearly visualise the vertebra. So, a slight modification is done; hence in these cases we insert caudal and cephalad screws first, attach rod to screws on one side of spine and distract it just enough to avoid any coronal malalignment. This not only increases the working area but also reduces the listhesis a little indirectly; and allows our described technique to be followed for pedicle visualisation and screw insertion in to listhesis vertebra on one side. The rod is removed and same step is repeated and pedicle screw inserted in listhesis vertebra on the other side.

This technique is simple and easy to learn, fault free and avoids many surgical disasters and blemishes. It allows us to insert pedicle screw in listhesis vertebra even in very high grade slips. The advantage of inserting screws in LV is that it helps us to reduce the listhesis vertebra and reap the advantages of reduction of listhesis. The main benefit of reduction of high-grade slips is decreased back pain, correction of the lumbosacral kyphosis and improvement of the overall sagittal alignment and balance, patient's ability to stand upright and decrease shear forces which increase ability of fusion. Decrease in slip angle improves the lumbo-sacral kyphosis which makes it to appear better cosmetically.^{30,32}

We did decompression in only patients with symptoms or signs of clinic-radiological correlating radiculopathy. All patient had improvement in anterolisthesis, showed improvement in lumbo-sacral kyphosis (slip angle) and Meyerding percentage slip as in other studies.^{30,31}

We did X-ray and CT scan postoperatively to see consolidation of postero-lateral fusion (PLT) mass. We did PLT and TLIF in

10 cases each with same clinical scores.³² Our technique is also bone conserving and PLT only with posterior element sparing decompression like laminotomy, reposition laminoplasty and foraminotomy suffices in our method for most of grade II slips.³³ All patient had consolidation of PLT except five of isthmic type, but they were stable on flexion–extension views. No motor weakness or permanent deficits were documented in any patient. Correction of deformity did not have any neurological complications except in one female (type IV isthmic) patient who developed a shy bladder type of symptoms. She had normal sacral sensation and urge to pass urine but was not able to do so. She was given bladder kinetic drugs and it recovered in 16 days. No patient developed adjacent segmental displacement in follow up visit.

6. Conclusion

This innovative technique of putting pedicle screw in deranged spine like listhesis is safe, easy to do, carries less radiation exposure and is cost-effective and reduces surgical time. It is reliable as in it the angle by which the C-arm needs to be angled cephalo-caudally is mathematically measured on lateral view. This technique involves using C-arm present almost universally in Orthopaedic O.T and avoids the use of costly intraoperative O-arm and navigation system. The technique is bone conserving also. This technique can be extrapolated to other anatomically deranged spine like sagittally deformed (Kyphotic) spines for safe insertion of pedicle screws. The limitation in our study was limited size but it is scientifically sound and can be recommended.

Conflicts of interest

The authors have none to declare.

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