Research Article

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Comparision of Spinopelvis Alignment with Short Segment Reduction and Fusion (Plif) In Low and High Grade Spondylolistesis

KV Shivanand Reddy1*, M Vijaya Saradhi2, Vamshidhar Arradi3 and G Bhavani Prasad4

[1]Post graduate, Department of Neurosurgery, Nizam's Institute Of Medical Sciences, Hyderabad.
[2]Professor, Department of Neurosurgery, Nizam's Institute Of Medical Sciences, Hyderabad.
[3]Post graduate, Department of Neurosurgery, Nizam's Institute Of Medical Sciences, Hyderabad.
[4]Assistant Professor, Department of Neurosurgery, Nizam's Institute Of Medical Sciences, Hyderabad

***Corresponding author**
KV Shivanand Reddy, Post graduate, Department of Neurosurgery, Nizam's Institute Of Medical Sciences, Hyderabad

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Abstract

Study Design: *A prospective clinicoradiological study of PLIF was conducted in similar types and high grades > 2 spondylolisthesis in 40 patients, with 20 patients as controls with grade < 2.*

Objective: *The objective was to assess the clinicoradiological profile of various spinopelvic parameters like pelvic incidence, pelvic version, sacrohorizontal angle, slip reduction and disc height increment using structural and standalone graft and its consequences on the post-operative outcome as assessed by Visual Analogue Score and Oswestry Disability Index.*

Methods: *Before starting the study Institutional ethical committee approval was taken and approval no 654 was given for the study and prior consents were taken by all the patients included in the study and was documented. This study involved a total number of 40 patients of spondylolisthesis >2 and 20 patients of <2 of all the age groups with progressive neurological deficits, and pain not relieved by conservative measures. All patients underwent wide laminectomy, facetectomy, complete discectomy and posterior lumbar interbody fusion with intraoperative slip reduction maneuvers, disc height maintained with interbody stand-alone graft or structured grafts made of PEEK or Titanium cages.*

Conclusions

There was no correlation between duration of symptoms and post operative pain reduction. A fusion rates of 92% were achieved with intra operative slip reduction. The results obtained in comparison with slip reduction and post operative pain reduction are directly proportional and statistically not significant. A decrease in pelvic version and increase in sacrohorizontal angle were noted following surgery. Restoration and incrementing the disc height is associated with statistically significant pain relief. Polyetheretherketone (PEEK) inter body spacer has best clinical and radiological outcome in terms of maintenance of the disc height followed by titanium cage and stand alone graft respectively. All these results had significant positive predictive value in all cases of spondylolisthesis > 2 and was statistically insignificant in patients with grade <2.

Keywords: Plif, Spondylolisthesis, Spin Pelvic Alignment

Introduction

Human bipedalism is a stable ergonomic posture. Transition to an upright posture has resulted in the pelvis becoming a key structure within the human locomotor apparatus. . Structures around the pelvis have undergone various modifications during the course of development and are prone for various degenerative changes. Spondylolisthesis is one among them, which is defined as slip of a vertebra in relation to an adjacent vertebra. Spondylolisthesis is a common cause for lower-back pain, radiculopathy and neurogenic claudication among the adult population. Based on data published by Fredrickson, et al, the rate of spondylolysis is less than 4.4% in children under the age of 6 years and approximately 6% in adults [1]. According to Roche and Rowe, the most frequent localization is L5–S1 in 82%, followed by L4–L5 in 11.3%, L3–L4 in 0.5% and L2–L3 in less than 0.5%. Based on autopsy data, Farfan3 found a 4.1% incidence for the condition [2].

The treatment of spondylolysis and spondylolisthesis can be conservative or surgical, but the therapeutic objectives remain similar. The three main treatment objectives recognized are bone fusion, pain relief and optimization of physical function.

Various surgical modalities have been described like Posterior Lumbar Interbody Fusion, Transforaminal Lumbar Interbody Fusion, Anterior Lumbar Interbody Fusion, postero-lateral insitu fusion. Posterior Lumbar Interbody Fusion is considered the best because of large surface area available for fusion through both anterior and posterior elements reconstruction, adequate disc removal, neural foraminal decompression, reduction of sagittal slip from a single posterior approach etc. Improvement in the spinal instrumentation is important to decrease operative morbidity with improving clinical outcome in the current practice of spinal surgeries.

Clinical Material and Methods

This is a prospective study conducted between October 2007 and March 2011 on 40 subjects with various types and grades of spondylolisthesis who have undergone posterior lumbar interbody fusion in Nizam's Institute of Medical Sciences by a single surgeon. (Second author).

Before starting the study Institutional ethical committee approval was taken and approval no 654 was given for the study and prior consents were taken by all the patients included in the study and was documented and also approval for publication was taken.

Clinicoradiological assessment of the patient was done preoperatively. Various clinical parameters like Age, sex, duration of symptoms, claudication distance, radiculopathy, neurological deficits and associated comorbidities like diabetes, hypertension and smoking were considered. Radiological parameters like slip percentage, disc height and spinopelvic parameters like pelvic incidence, pelvic version and sacro horizontal angles were taken into account on standing lateral X-Rays. Subjective assessment of the pain was done by Visual Analogue Score (VAS) and Oswestry Disability Index (ODI).

Pelvic Incidence [Figure 1] is defined as the angle between a line joining the centre of the upper endplate of S1 to the axis of the femoral heads and a line perpendicular to the upper end plate of S1[4,5]. The lower value of PI is approximately 35, the higher around 85 and the average being 51.9 [6]. Pelvic tilt [Figure 1] is defined as the angle between a vertical line and the line joining the middle of the sacral plate and the axis of the femoral heads [4,5]. In the standing position, the mean pelvic tilt angle, which is open at the back, is 13 ± 6 degrees.7 The sacral slope is the angle of the sacral plateau to the horizontal[Figure 1]. Disc height has been measured with various methods [8,9]. Like hurxthal methods, Farfan method, Anderson method, Dabbs method etc. Disc height in the current study was assessed by using Dabbs method, et al. calculated by the average value of the anterior and posterior disc height [Figure 2] of the intervertebral space [9].

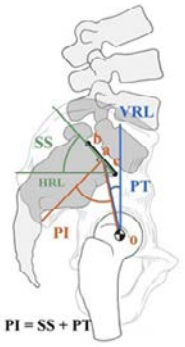

Figure 1: Measurement of pelvic parameters

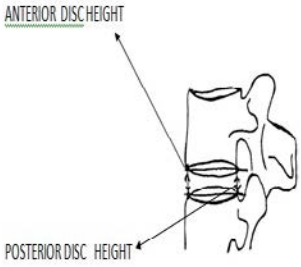

Figure 2: Dabbs method of measuring disc height

These patients were analyzed for a change over preoperative status both clinically and radiologically [Figure 3-5] in relation to above said parameters immediate postoperatively and on OPD basis on 3rd month, 6th month and after 1 year or until the radiological demonstration of fusion was achieved.

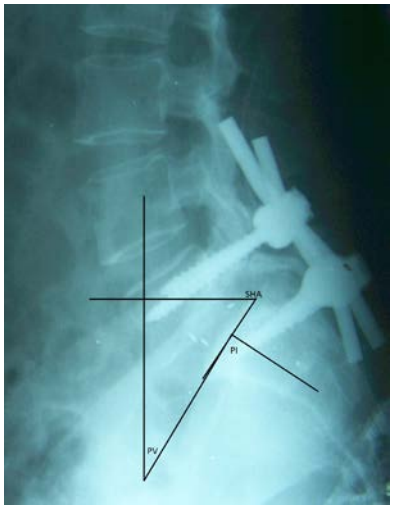

Figure 3: Post op measurement of pelvic parameters Figure

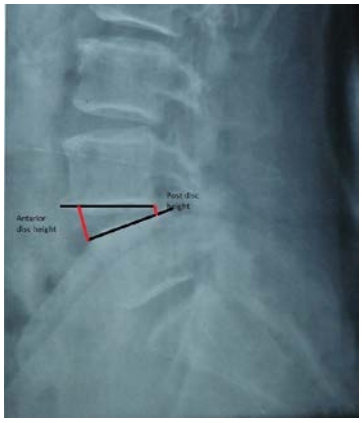

Figure 4: Pre op disc height measurement

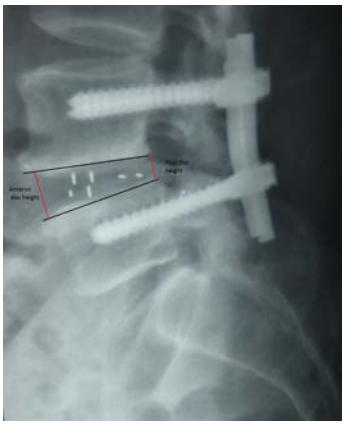

Figure 5: Post op disc height measurement

Operative Technique

Following endotracheal intubation and induction of anaesthesia, patients were positioned prone on bolsters with abdomen kept lax, padding of pressure points adequately and with urinary catheterization. All patients were administered broad spectrum antibiotics before incision and operated under adequate anaesthesia and muscle relaxation.

Lumbosacral spine is approached by midline skin incision and in internervous plane and paraspinal resection. Dissection is continued laterally, stripping the facet joint capsule from the descending and ascending facets exposing the facet joints and the transverse processes. Under fluoroscopic guidance appropriate level and size of the screw was determined. Both mono and poly axial screws were used for instrumentation. Entry points were identified under flouroscopic guidance and screws were placed through the pedicle into the body. Sacral screws were placed parallel to sacral end plate with bicortical purchase. Wide laminectomy and facetectomy performed. Complete discectomy with thorough scraping of the endplates was done. Adequate reduction is attempted after placing titanium rod and interbody titanium or PEEK cage or stand alone graft was placed in disc space. Wound closure was done in multiple layers under a negative suction drain. Median operative time was 2.5 hours with average blood loss of about 200 ml.

Results

A total of 40 patients with different types of spondylolisthesis have undergone PLIF. Of these 24 are isthmic variety, 13 cases are degenerative type and 3 are of dysplastic variety. The sex ratio between male and female being 13(32.5%) to 27(67.5%). Mean age in our study was 42.09±12.84 (Mean ± SD).Male female ratio is 32.5: 67.5, mean age at surgery being 44 years. Dysplastic type of spondylolisthesis is seen in 3 cases (7.5%), degenerative type in 13 cases (32.5%), isthmic type in 24 cases (60%).Mean age in dysplastic variety is 13 years, isthmic variety being 41 years and in degenerative type being 49 years. Control group of 20 patients was taken with listhesis < 2 grade. Among them 12 were females and 8 were males .Male :female fratio of 66.6%: 33.3%.Dysplastic type were 8,Isthmic type were 6 and degenerative variety were 6.

Average duration of symptoms are 1.2 ±0.4 years, in males being 0.9 ± 0.2 years and in females being 1.4 ± 0.4 years. Low back ache with radiculopathy was present in all cases and claudication in 25% of the cases. Of the 40 patients, 8 patients have associated comorbid conditions like diabetes mellitus in 2 cases, hypertension in 5 cases and both hypertension and diabetes in 1 case. Chronic smoking history was present in 4 patients.

Pre-operative and post-operative analysis was done at 1st month,6th month and after 1 year or till the radiological demonstration of fusion was done, in relation to changes with respect to Visual Analogue Score(VAS),Oswestry Disability Index(ODI),Slip percentage, pelvic incidence, sacrohorizontal angle, pelvic version and disc height in relation to various types of spacers.[Table 1].

Table 1: Evaluation of effect based on Outcome variables pre-op and after 6 months

Variables	Pre-op	6 months	Δ	P value	Effect size
VAS	7.42±0.84	2.15±1.38	5.27	<0.001**	4.72
ODI	37.07±3.51	12.43±6.36	25.65	<0.001**	5.19
SLIP%	36.57±20.06	15.57±17.30	21.00	<0.001**	1.12
PI	69.04±13.74	67.80±13.28	2.25	<0.001**	0.83
SHA	43.54±12.52	48.40±10.41	-4.86	<0.001**	0.62
PV	22.30±6.85	20.23±6.68	2.03	<0.001**	0.60
Disc height	8.97±0.39	10.69±0.49	1.72	<0.001**	3.86

There was a significant reduction in pre operative VAS score from 7.4 to 2.1 and ODI from 37 to 12 at the end of 6 months. A reduction in slip percentage from 36 to 15 percentage and an increment in the disc height from 8.9 to 10.6 mm was noted. Average changes in spinopelvic parameters like pelvic incidence from 690 to 670, sacrohorizontal angle from 43.50 to 48.40 and change in pelvic version from 22.30 to 20.230 was noted respectively.

Of the 40 cases PEEK cages were used in 16 cases, standalone graft in 12 cases and titanium cages were placed in 12 cases. Increment in the disc height in relation to PEEK cages, stand-alone graft and titanium cages was assessed separately and their relation to functional assessment as indicated by VAS score [Table 2] and Oswestry Disability Index (ODI) [Table 3] was assessed.

Table 2: Comparative Evaluation of VAS according to Spacer

Spacer	vas score			P value	Effect size
	Pre-op	6 months	Δ		
PEEK cages (n=16)	7.55±0.63	2.05±1.44	5.51	<0.001**	5.13
Bone graft (n=12)	7.58±0.79	2.53±1.15	5.05	<0.001**	5.41
Titanium cage (n=12)	7.08±1.08 7.08±1.08	1.83±1.59	5.25	<0.001**	3.93

Table 3: Comparative Evaluation of ODI according to Spacer

Spacer	ODI			P value	Effect size
	Pre-op	6 months	Δ		
PEEK cages (n=16)	39.37±2.60	10.75±6.51	29.63	<0.001**	5.41
Bone graft (n=12)	39.75±4.09	14.33±6.15	25.42	<0.001**	5.36
Titanium cage (n=12)	37.33±3.65	11.08±6.89	26.25	<0.001**	4.79

Statistical Methods

Descriptive statistical analysis has been carried out in the present study. Results on continuous measurements are presented on Mean ±SD (Min-Max) and results on categorical measurements are presented in Number (%). Significance was assessed at 5 % level of significance. The following assumptions on data was made:

Assumptions:

1.Dependent variables should be normally distributed.
2.Samples drawn from the population should be random.
3.Cases of the samples should be independent.

Student t test (two tailed, dependent) has been used to find the significance of study parameters on continuous scale with in each group. Effect size has been computed to find the effect. Mc Nemer browmark test for slip percentage was employed [Table 4].

Table 4: Comparision of pelvic parameters with other studies

	LABELLE ETAL10			PRESENT STUDY	
VARIABLE	PRE OP	POST OP	ROUSELLE etal17(82) PRE OP	PRE OP	POST OP
PELVIC INCIDENCE (PI)	79_ ± 11	78_ ± 11	65.53	69.04±13.74	67.80±13.28
SACRO HORIZONTAL ANGLE(-SHA	50_ ± 11	53_ ± 10	48.95	43.54±12.52	48.40±10.41
PELVIC VERSION(PV)	30_ ± 10	26_ ± 8	16.58	22.30±6.85	20.23±6.68

Statistical software: The Statistical software namely SAS 9.2, SPSS 15.0, Stata 10.1, MedCalc 9.0.1 ,Systat 12.0 and R environment ver.2.11.1 were used for the analysis of the data.

Discussion

Pedicle screw fixation with inter body fusion as a fusion procedure, provides several advantages like increase in the fusion rate compared to others, allows early mobilization of patients and obviates the need for heavy orthoses in the post operative period and is very useful in spondylolisthesis >grade 2.

Duration of Symptoms and Its Relation to Relief of Symptoms in the Post-Operative Period

Usually spondylolisthesis presents with both back symptoms and leg symptoms. Back symptoms like mechanical back pain usually gets better with fixation. Leg symptoms like radicular pain or tingling numbness due to neurogenic claudication gets better with decompressive procedures. Duration of symptoms give rough idea about the onset of instability.

Ironically the back pain of spondylolisthesis disappears once there occurs spontaneous fusion of the spondylolisthesis segment.

Leg symptoms are due to canal compromise from disc prolapse anteriorly, ligamentum flavum hypertrophy posteriorly, pars from posterolaterally. The relief of these symptoms can be achieved by wide decompression. In all our cases we have performed wide laminectomy and discectomy to achieve adequate decompression.

Irrespective of the duration of symptoms, all patients achieved symptomatic relief even on long term follow up, suggesting that solid bony fusion of the listhetic segment is the treatment of choice for symptomatic relief in terms of back and leg pains.

In a study benefits of a successful arthrodesis over pseudarthrosis was demonstrated with respect to back and lower limb symptom-

atology [10]. These results are similar to our study where there is excellent clinical outcome following bony fusion.

Comorbid Conditions and Its Influence on Post-Operative Outcome and Fusion on Long Term Follow Up

Traditionally presence of comorbidities like diabetes mellitus and smoking are associated with decreased fusion rates. Diabetes is a known inhibitor of bone healing. Comorbid conditions like diabetes mellitus, hypertension and smoking were analysed with respect to clinical and radiological outcomes [11].

There was no correlation between outcome and presence of comorbidities in our study, but our number is too small (8 cases) to arrive a categorical conclusion.

There were 3 cases of diabetes mellitus (7.5%) in which 2 cases developed superficial wound infections, which subsided after appropriate antibiotic therapy.

Change in Spino Pelvic Parameters and Their Influence on Post-Operative Outcome (VAS and ODI)

With an upright posture, a biomechanical strain occurs at the lumbosacral junction even under normal physiological conditions. The center of gravity passes through the line which falls anterior to the lumbosacral articulation. The lumbosacral disc space is normally slanted forward and downward. This leads to a shear force in the disc space and a rotational moment tending to drive the lower lumbar spine forward and to rotate in flexion contributing to spondylolisthesis. The anatomical feature that opposes these potentially harmful forces is the coronally oriented facet articulations. A defect in the pars interarticularis allows these forces to act unchecked, resulting in progression of the slippage.

Progressive geometrical changes in the lumbosacral junction are manifested clinically by compensatory postural changes seen characteristically in high-grade spondylolisthesis. There is a compensatory hyperlordosis of the upper lumbar spine and a sustained postural contraction of the hamstrings in the upright position in an attempt to rotate the pelvis backwards. As the trunk shortens with downward and forward protrusion of rib cage, the buttocks appear flattened.

Studies have suggested that normal sagittal spino-pelvic alignment is the combination of balance between spino-pelvic shape and position parameters, which are interrelated and interdependent [12,13]. The pelvic shape, best quantified by pelvic incidence determines the position of the pelvis (PI = SS + PT) and of the sacrum. [Figure 1] Duval-Beaupe`re and then Legaye coined the term 'pelvic incidence' which is the key characteristic of the pelvis [4,5].

Recent studies by Marty and Rajinics have suggested an association between a high PI and high-grade L5–S1 isthmic spondylolisthesis in adult patients [14,15]. Hanson, et al. have demonstrated association between pelvic incidence, sacral slope and between high and low-grade isthmic spondylolisthesis in adolescents and young adults [16].

In Hanson, et al. study, the mean pelvic incidence was 57° in the adult control group, 68.5° in the low-grade isthmic spondylolisthesis group, and 79.0° in the high-grade isthmic spondylolisthesis group denoting that higher the pelvic incidence more the probability of developing spondylolisthesis.

In our study there is no significant decrease in the pelvic incidence, but a change in pelvic version and sacrohorizontal angle was noted following surgery which stands comparable to other studies. These results suggest that values of the pelvic incidence are constant for the individual and are mostly unaffected by surgery [17]. Changes in the values of pelvic version and sacrohorizontal angle are noted in an inverse manner after surgical correction by the posterior lumbar interbody fusion which are comparable with other studies [18].

Low values of pelvic incidence, sacro horizontal angle and pelvic version in our study as compared to Labelle series can be explained by inclusion of relatively more number of grade 2 spondylolisthesis patients and different types operated. The post-operative increase in sacro horizontal angle and decrease in pelvic version can be explained by alteration in pelvic parameters so that the centre of gravity shifts more towards the centre of the pelvis which indirectly indicates better stabilization.

Following surgery, variation in these pelvic parameters has significant influence on the post-operative outcome as seen by statistically significant change in the Visual Analogue Score (VAS) and Oswestry Disability Index (ODI) [Table 1]. This shows that stabilization of the pelvis should be the aim, and this can be achieved by the stabilization of pelvic parameters.

Change in Slip Percentage versus Outcome (VAS)

Traditionally spondylolisthesis is recognized by its slip percentage. It is recognized that the reduction of slip reduction is mandatory for successful clinical outcome. Because of the slippage, the surface area of contact between the endplates is reduced. This may result in decreased chances of bony fusion in cases where fusion is only attempted without reduction. (Insitu fusion)

There are intraoperative maneuvers to achieve reduction. These are very technically demanding like gradual distraction and rotation method which was employed in our cases. Placement of interbody graft or cage along with attempt for reduction is useful in these circumstances to increase surface area of contact between two vertebral bodies. There is significant decrease in the slip percentage as intra operative reduction was achieved in many cases.

Earlier there were studies by Mikko Poussa, et al. and Ziad M Audat, et al. where functional outcome was assessed between posterolateral insitu fusion and posterior lumbar interbody fusion [19,20]. They demonstrated that reduction of slipped vertebral bodies is unnecessary as the ultimate outcomes are going to be similar. Yizhar, et al. have shown that there will be significant reduction in the pain following reduction and fixation [21].

Setti S. Rengachary and Raju balabandra in their review article mentioned that quality of fusion construct is better when the

deformity is corrected [22]. When reduction surgery is not performed, if lumbar interbody
Fusion (posterior or anterior) is considered, there is a smaller surface area of endplate cooptation for the placement of the graft. When the slippage is corrected, the surface area is restored.
Additionally, without reduction, the graft is placed under tension as the transverse process continues to move forward, a condition not conducive for fusion. This explains the low fusion rates with in situ arthrodesis corroborative with the study done by Hanley, et al [23].

Visual analogue score during post-operative period was assessed in relation to changed slip grade which showed a linear correlation, however the results are not statistically significant.[TABLE 5] These results are comparable to previous described results by Mikko Poussa, et al. and Ziad M Audat, et al. where functional outcome was assessed between posterolateral insitu fusion and posterior lumbar interbody fusion [19,20]. These data suggest that pain relief was equal in both posterolateral insitu fusion and posterior lumbar interbody fusion.

Yizhar Floman etal21 in a series of slip reduction on 12 adults aged 28 to 62 years (avg 47) with symptomatic lumbar or lumbosacral isthmic

Spondylolisthesis have shown that there will be significant reduction in pain following reduction which is similar to our study where it is directly proportional, but not achieving statistical significance (p value 0.27).

Post-Operative Increment in Disc Height in Relation to Different Constructs and Outcome (VAS & ODI)

Inter vertebral disc as a pain generator has very important role to play in spondylolisthesis. The disc space gradually diminishes as spondylolisthesis progresses. Disc is the source of instability, as well as pain, due to its rich neural innervations. Thus people advocate total discectomy to decrease the pain.

Reduction in the disc height is indirectly associated with narrowing of the neural foramina which in turn causes compression of the emerging nerve roots [24]. Jacking of the disk space and maintaining the disc height increases the size of the intervertebral foramen indirectly. To achieve this, we have performed total discectomy with interbody distraction in all cases and fusion attempted with various kinds of spacers.
Various interbody spacers like bone graft, titanium cage and Polyetheretherketone (PEEK) cages were used to achieve distraction and interbody fusion in our study. Placing these interbody spacers aids in preventing loss of disc height during follow up period and in avoidance of kyphotic deformity.

Advantages of placing Polyetheretherketone (PEEK) cages are radiolucency, which can radiologically demonstrate better fusion and smooth surface, which does not cause adjacent end plate sinkage.In our study the average disc height in the preoperative period was 8.97±0.39 mm.
During post-operative assessment, there is significant increase in the disc height to an average of 10.69±0.49 mm, the mean difference being 1.72 mm which is statistically significant and is comparable to results of Gopinathan24 et al in which the mean change in disc height was 4mm.
The difference in the disc height is probably due to different methodology employed in measurement of the disc heights in our study.

The individual increment in the disc heights with each spacer is separately assessed. The pre-operative disc height in graft group (n=12, 30%) being 8.84±0.41 which was increased to 10.42± 0.37 with an increment of 1.58 mm in the follow up period. In titanium cage group (n= 12, 30%) pre op values of disc height being 8.78 ±0.21 and post op 10.57±0.62 with an increment of 1.79 mm. whereas in PEEK cage group, (n=16, 40%) values in pre and post-operative periods being 8.67±0.34 and 10.73 ± 0.51 respectively with an increment of 2.06 mm.

A change in the Visual Analogue Score (VAS) and Oswestry Disability Index (ODI) was assessed separately with respect to these different inter body spacers. A change in VAS of 7.58±0.79 to 2.53±1.15 (± - 5.05) in bone graft group, 7.08±1.08 to 1.83±1.59 (± - 5.25) in titanium cage group and 7.55±0.63 to 2.05±1.44 (± - 5.31) in PEEK cage group was noted in the post-operative period. A change of ODI from 39.75±4.09 to 14.33±6.15 (±-25.42) in bone graft group, 37.33±3.65 to 11.08±6.89 (±-26.25) in titanium cage group, from 39.37±2.60 to 10.75±6.51 (±-29.63) in PEEK cage group were noted respectively.
These results suggest that, an increment in the disc height is directly proportional to improvement in clinical symptoms as assessed by the functional outcome scores (VAS & ODI).Increment in the disc height is more in cage group (PEEK > titanium) than in the bone graft group. All cases of structured grafts filled with the autologous bone grafts resulted in fusion. In two cases (8%) where there was no adequate fusion where unstructured stand alone grafts were used indicating the superiority of structured graft over stand alone grafts.

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Conflict of interest: Nil

Conclusions

There is no correlation between duration of symptoms and post-operative pain reduction as all the patients achieved symptomatic pain relief during the post-operative period irrespective of the duration of symptoms. The results obtained with respect to slip reduction and post-operative pain reduction are directly proportional to but statistically not significant, suggesting that post-operative pain reduction may not be related to slip reduction alone in patients with spondylolisthesis more than grade 2.In patient with spondylolisthesis less than grade 2 fixation is helpful but the improvement in slip angle and symptomatic improvement is not statistically significant.

The pelvic incidence is mostly unaffected by the surgery and is constant for an individual. A decrease in pelvic version and increase in

sacro horizontal angle were noted following sugery. Alteration in these pelvic parameters indicate the shift of the centre of gravity towards the centre of the pelvis which indirectly results in better stabilization of pelvis. These patients have significant improvement functionally and adequate fusion radiologically on long term follow up during post-operative period. Restoration and incrementing the disc height is associated with statistically significant pain relief.

Polyetheretherketone (PEEK) inter body spacer has best clinical and radiological outcome in terms of maintenance of disc height followed by titanium cage and stand alone graft techniques in that order. Disc height in patients with grade less than 2 has not got improvement and VAS score pain reduction has not been statistically significant.

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