International Surgery Journal
Sawant N et al. Int Surg J. 2021 Jan;8(1):232-237
http://www.ijsurgery.com
pISSN 2349-3305 | eISSN 2349-2902

DOI: https://dx.doi.org/10.18203/2349-2902.isj20205886

Original Research Article

Clinical, functional and radiological spinopelvic balance parameters assessment after transforaminal lumbar interbody fusion in grade 1 spondylolisthesis

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Received: 15 October 2020
Revised: 22 November 2020
Accepted: 02 December 2020

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ABSTRACT

Background: The aim was to study effectiveness of TLIF procedure by assessing clinical and radiological spinal sagittal parameters pre and postoperatively.
Methods: 8 patients who underwent TLIF procedure after diagnosis of spondylolisthesis studied prospectively. After recording general information, symptomatology, functional parameters were evaluated using visual analogue scale (VAS), Oswestry disability index (ODI), short form 12 (SF 12) and radiological sagittal balance parameters were assessed by calculating sagittal vertical axis (SVA), lumbar lordosis (LL), pelvic incidence (PI), pelvic tilt (PT), sacral slope (SS), preoperatively and postoperatively during follow up at 1 and 3 months.
Results: We operated 4 (50%) patients at L4-L5 level of degenerative spondylolisthesis, 1 (12.5%) patient of degenerative spondylolisthesis at L5-S1 level and 3 (12.5%) patients of isthmic spondylolisthesis at L5-S1 level. All patients were grade 1 spondylolisthesis according Meyerding classification. After surgery all sagittal spinal balance parameters were not found to be statistically changed from the baseline, although there was minimum improvement. Regarding the clinical outcome measures, both VAS (<0.0001), ODI (<0.0001), and SF12 (<0.0001) improved after surgery significantly.
Conclusions: In most case of grade 1 spondylolisthesis, there was only a minimal imbalance of the sagittal spinal balance parameters and so in situ fusion can be done. Even if a complete reduction of spondylolisthesis was not achieved during surgery, there was correction of a few of the parameters of spinal balance which were deranged preoperatively. Overall TLIF is very good procedure in terms of improvement in clinical and functional parameters in grade 1 spondylolisthesis.

Keywords: Grade 1 spondylolisthesis, Lumbar lordosis, Pelvic incidence, Sacral slope, Transforaminal lumbar interbody fusion

INTRODUCTION

One of the most common factors to missed time at work is low backache and also it is most common reason of work related disability.[1] Low back pain may aggravated by activity and which lead to minimizing activity and it further leads to disability. One of the most expensive burdens on the system of health care is low backache. It is one of the common medical problem. In lifetime, there is 50-70% chance of a person getting low backache.[2] Spondylolisthesis is one of the common cause of lumbar spinal instability. Lumbar fusion is commonly done procedure for spondylolisthesis. In low grade spondylolisthesis, lumbar fusion can be considered if there is no response to adequate conservative management that is persistent pain and neurological deficit. Now a days, interbody fusion supported by transpedicular screw fixation is

most common treatment for low grade spondylolisthesis.[3,4] There are many types of procedures available for interbody fusion like transforaminal lumbar interbody fusion (TLIF), lateral lumbar interbody fusion (LLIF), anterior lumbar interbody fusion (ALIF), posterior lumbar interbody fusion (PLIF), extreme lateral interbody fusion (XLIF). There are specific disadvantages and advantages of each procedure.[5] TLIF is most commonly done procedure. Maintenance of spinopelvic sagittal balance parameters is crucial for good radiological and clinical as well as functional outcome.[6]

Our aim was to study effectiveness of TLIF in the treatment of disabling low backache resulting from spondylolisthesis, discogenic pain syndrome or post discectomy syndromes unresponsive to conservative management by assessing use of clinical and radiological parameters. Clinical parameters; overall pain relief and quality of life using a combination of visual analogue scale (VAS), Oswestry disability index (ODI) and short form 12 (SF 12) questionnaire which shall be assessed both pre and post operatively. Radiological parameters; spinal sagittal balance and its parameters i.e. sagittal vertical axis, lumbar lordosis, pelvic incidence, pelvic tilt, sacral slope which shall also be measured pre and postoperatively. All these parameters are expected to improve postoperatively ultimately improving quality of life.

METHODS

We made a prospective non-randomized study of patients with lumbar spine instability. A total of 8 patients were evaluated and assessed during the period from 1st February 2019 to 31 July 2020.

The study was conducted in Department of Neurosurgery, Sree Chitra Tirunal Institute for Medical Sciences and Technology (SCTIMST) Thiruvananthpuram.

The indication for surgery was instability, as defined by the criteria for which instrumentation was needed to restore spine stability. The indications for fusion were in cases with combined severe low backache and radicular pain, after failure of conservative treatment.

All patients were initially assessed in the outpatient department and underwent a detail evaluation of neurological status; radiographs were taken and underwent treatment as per specific treatment plan.

Inclusion criteria

Consenting adult patients with age ≥18 years; pathology evidenced by CT, MRI LS spine, radiographs; Symptomatic backache; Able to verbalize pain score; Glasgow Coma Scale (GCS)- 14,15

Exclusion criteria

Non consenting patients; <18 years age; pregnancy/lactation; ASA (American Society of Anaesthesiology) grade 3, 4 and 5; patients who have other pathological problems such as traumatic vertebral fractures, tumours or infectious disease.

When a patient meeting broad inclusion criteria was admitted, the principal investigator was informed by the admitting team.

Preoperative work up

Informed written consent was taken for all patients. Current intensity and distribution of pain and neurological examination was conducted. Local and systemic examination also was done to assess cause of instability. Pain and instability was graded clinically and radiologically using visual analogue scale (VAS) (0 as no pain to 10 as maximal pain) and Oswestry disability index (ODI) of backache (ranging from 0 to 100 with higher scores indicating more disability related to pain) and SF 12 was obtained after brief instruction at least 24 hour before the surgery.

Radiological examination was done using X-ray lumbar spine (AP, lateral and F-E radiographs), X-ray whole spine 36 inch lateral view (including C1 and femoral head), CT scan of LS spine plain and MRI LS spine plain. Also spinal sagittal balance and its parameters like sagittal vertical axis, lumbar lordosis, pelvic incidence, pelvic tilt, sacral slope which were measured preoperatively.

Other investigations- Baseline blood investigations for anaesthesia fitness.

Post void residual urine was calculated for each patient by doing ultrasound of kidney and urinary bladder. Post void residual urine more than 30 ml was considered significant.

Surgery- Open transforaminal lumbar interbody fusion.

Criteria to select cage was at the discretion of surgeon.

Patients were posted for surgery electively after preanesthetic checkup. Surgeries involved single or multilevel fusion.

Spinopelvic sagittal balance parameters measurement

Preoperative SVA was 28.9 mm and postoperatively reduced to 23.3 mm. SVA was measured as offset between the C7 plumb line and posterior superior corner of S1 endplate.

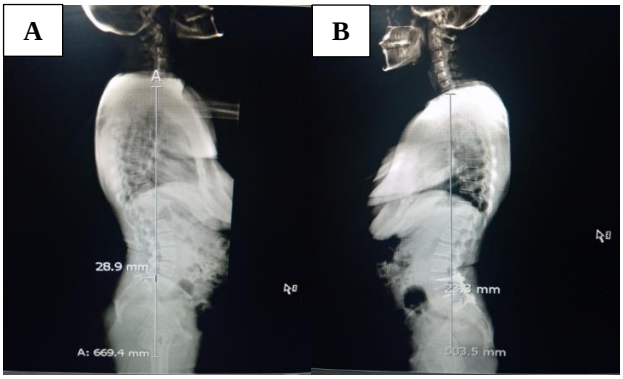

Figure 1: A) Pre and B) postoperative radiographic measurement sagittal vertical axis (SVA).

Preoperative LL was 66.80 and postoperatively it was 66.00. LL was measured as an angle between the upper endplate of S1 and L1.

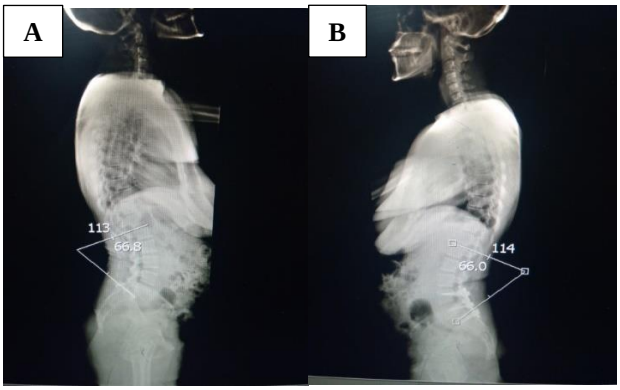

Figure 2: A) Pre and B) postoperative radiographic measurement of lumbar lordosis (LL).

Preoperative PI, PT and SS was 670, 18.50 and 49.60 respectively and post operatively PI, PT and SS was 62.5, 22.9 and 39.5 respectively.

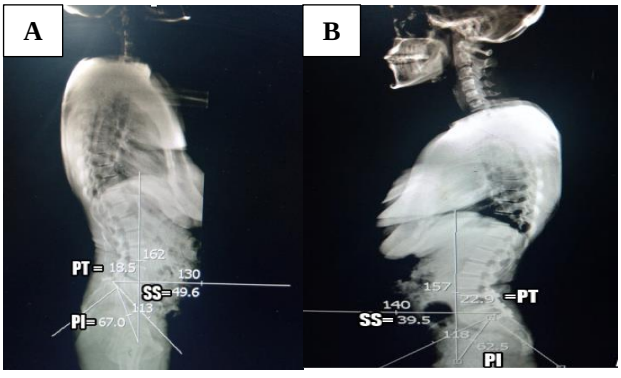

Figure 3: Pre and postoperative radiographic measurement of PI (pelvic incidence), SS (sacral slope), PT (pelvic tilt).

Pelvic incidence (PI) was measured as angle between bicoxo-femoral axis and line perpendicular to upper endplate of first sacral vertebra and a line joining centre of the upper endplate of first sacral vertebra. PT was measured as angle between line joining middle of first sacral vertebra endplate and bicoxo-femoral axis and a vertical line. Sacral slope (SS) was measured as angle formed by a horizontal line and endplate of S1.

Surgical technique

In general anaesthesia patient was placed in prone position. The posterior elements of spine were exposed to base of transverse process. After pedicle screw insertion inferior and superior articular processes of one facet joint was resected and disc is exposed in neural foramen. Care was taken to coagulate the epidural veins running superior to the pedicle into the neural foramen before incising the disc. The disc was subtotally resected using rongeurs, shavers and curettes. After discectomy, disc space was progressively distracted via contralateral side. After scraping of the endplates the anterior part of the disc space was filled with autologous bone chips harvested locally. A curved bullet cage was filled with bone graft and inserted into the central or posterior part of the disc space. The 40° angle of the introducer and shape of the cage enable controlled cage positioning. Then rods were mounted with slight compression bilaterally. Decortication of remaining posterior elements was done and bone graft was placed to achieve a posterior fusion. Decompression of the spinal canal was done before discectomy. Resection of the facet joint was done on the same side in cases of unilateral nerve root compression. In cases of isthmic type of spondylolisthesis with nerve root compression on both sides, complete laminectomy was performed to permit adequate nerve root decompression. Resected lamina was used as bone graft. C-arm fluoroscopy confirmation of cage position was done before final tightening of screws and also confirmed that cage was at least 5 mm from the posterior cortical margin. To achieve firm contact between graft material and end plates, gentle compression force was applied over adjacent screws after proper position was obtained. Pedicle screw fixation was carried out to improve the bony union and to obtain the stability immediately after surgery. Wound closure was done on layers after confirming haemostasis.

Postoperative management

Overnight observation in neurosurgery ICU. Routine antibiotics and analgesics/anti-inflammatory were used during preoperative, immediate and late postoperative period. Post operatively patients were ambulated with a lumbar corset generally on the second day after surgery.

Post operatively, spinal sagittal balance and its parameters i.e. sagittal vertical axis, lumbar lordosis, pelvic incidence, pelvic tilt, sacral slope were measured and compared both preoperatively and postoperatively. ODI, SF12, VAS were also measured postoperatively and compared to look for any improvement.

Clinical follow-up was done at 1 month and 3 months:

Evaluation of functionaloutcome in terms all parameters of spinal sagittal balance were calculated by repeating 36 inches x-ray whole spine before each follow up. ODI, SF12, VAS were measured during each follow up.

Statistical analysis

Qualitative data were presented using frequency, percentage and quantitative data using descriptive statistics i.e. Mean±SD. Shapiro-Wilk's test was used to test whether the data is following normal distribution. Means were compared between the different time points using the repeated measures ANOVA test or paired t-test. Spearman or Pearson's correlation coefficient was performed to assess correlation between parameters. Statistical significance was set at 0.05. Results were represented graphically. Descriptive statistics were used for parameters which did not need statistical analysis. MS Excel and GraphPad softwares (SPSS Inc., Chicago, IL, USA) were used for data entry and analysis.

RESULTS

In our study, 8 patients were included, 1 (12.50%) was male and 7 (87.50%) were females. Overall sex ratio was male:female was 1:7. Average age of patients were 51.40 with range of 38-67. The youngest patient was aged 38 years and the oldest was 67 years old. The mean body mass index of our patients was 30.08±3.59 kg/m^2 (range: 24.22-35.10 kg/m^2). Out of the 8 patients included, 62.5%, i.e. 5 patients had degenerative spondylolisthesis, while 37.5%, i.e. 3 patients had isthmic spondylolisthesis. Of the 8 patients included in our study, the level of spondylolisthesis (degenerative spondylolisthesis) was L4-L5 in 50% (4/8) patients and L5-S1 in the remaining 50% (4/8) patients (degenerative spondylolisthesis, 12.5%, 1/8; isthmic spondylolisthesis, 37.5%, 3/8). All patients in our study were of grade 1 spondylolisthesis according to Meyerding classification.[7] Out of 8 patients, 50% (4/8) patients had hypertension, 37.5% (3/8) patients had diabetes mellitus, 25% (2/8) patients had dyslipidaemia, and 12.5% (1/8) patients had hypothyroidism. Most common symptom experienced by our patients was low back ache (100%; 8/8), followed by lower limb pain in 75% of patients and paresthesia in 37.5% patients. Post void was significant in 50% (4/8) patients and non-significant in the remaining 50% (4/8) patients.

Titanium cage filled with bone graft and mixed with MASTERGRAFT (resorbable ceramic granules made of hydroxyapatite and b-tricalcium phosphate) was used in all of our patients during surgery. Half the patients in our study underwent TLIF at L4-L5 level and the other half at L5-S1 level. Average operative time was 147.5±22.5 minutes. In this study, blood transfusion was not needed in any patient. The average intraoperative blood loss of our study patients was 437.5 (range: 300-550 ml).

Table 1: Clinical evaluation using VAS ODI and SF12.

Parameter	Pre-operative	Post-operative (at 3 months)	P value*
VAS	8.0±0.76	1.75±0.71	<0.0001
ODI	49.38±4.44	22.50±2.62	<0.0001
SF-12	28.13±2.23	20.0±1.51	<0.0001

*Calculated using the pairedt-test. P<0.05 considered statistically significant.

In this study, the average VAS score prior to surgery was 8.0±0.76 (range: 7-9), which reduced to 4.63±0.74 (range: 4-6) immediately post-surgery, 3.25±0.71 (range: 2-4) after 1 month of surgery, which further decreased to 1.75±0.71 (range: 1-3) 3 months postoperatively. The one-way ANOVA test revealed a statistically significant difference in the VAS score among the different time points. The average ODI before surgery was 49.38±4.44 (range: 42-55); it reduced to 34.38±4.31 (range: 29-42) one month after surgery, which further decreased to 22.50±2.62 (range: 19-27) three months post-surgery. The one-way ANOVA test demonstrated a statistically significant difference (p<0.0001) in the ODI at various points in time. The average SF-12 score before surgery was 28.13±2.23 (range: 23-30) that decreased to 23.88±1.55 (range: 21-26) one month after surgery, which further reduced to 20.0±1.51 (range: 17-22) three months post-surgery. The one-way ANOVA test demonstrated a statistically significant difference (p<0.0001) in the SF-12 scores at various points in time.

Table 2: Comparison of all spinal balance parameters.

Parameter	Pre-operative	Post-operative (at 3 months)	P value*
PT	19.19º±6.33º	18.33º±2.82º	0.5762
SS	42.68º±9.43º	39.21º±4.82º	0.3244
PI	60.51º±10.36º	58.06º±5.10º	0.4456
LL	56.63º±9.87º	52.30º±8.83º	0.1866
SVA	4.07º±3.56º	1.33º±1.37º	0.1244

*Calculated using the pairedt-test. P<0.05 considered statistically significant.

There was no significant difference of any of the spinopelvic sagittal balance parameters postoperatively as compare to preoperatively.

Table 3: PI-LL difference.

PI-LL difference	Mean±SD	Range	P value*
Before surgery	10.64±6.84	1.4-19.8	0.7386
Immediately after surgery	9.08±4.45	1.8-15.3	
After 1 month	8.86±2.72	6.1-14.5	
After 3 months	8.19±2.71	3.6-12.5	

*Calculated using the One-Way ANOVA Test. P<0.05 considered statistically significant.

In our study, the average PI-LL difference before surgery was 10.64º±6.84º (range: 1.4º-19.8º), 9.08º±4.45º (range: 1.8º-15.3º) immediately after surgery, 8.86º±2.72º (range: 6.1º-14.5º) one month after surgery, and 8.19º±2.71º (range: 3.6º-12.5º) three months after surgery.

The average hospital stay of our study patients was 9.25±2.49 ml, and ranged between 6 days and 14 days. There were no complications during or immediate after surgery and also during 1 month and 3 months follow up period. None of our patients (100%; 8/8) needed any revision surgery.

DISCUSSION

Various techniques for fusion of lumbar spine have been reported over the past 90 years. The trend has been changed from fusion without instrumentation to the use of one of following viz. metallic cages, carbon fibre cage, autograft, allograft, bone morphogenic protein and supplemental instrumentation. Lumbar fusion is generally offered after a trial of conservative treatment or failure of non-surgical treatment. TLIF is a commonly done operative procedure for lumbar fusion especially patients suffering from unilateral symptoms.

Many studies looked for spinopelvic balance parameters pre and post operatively and also during follow up with various spondylolisthesis grades after TLIF procedure.[8-10] In our study, there was no significant change in the spinopelvic parameters postoperatively at 3 months compared to preoperative measurements. In study by Ould-Slimane et al only PT and LL significantly improved post operatively while SVA, PI and SS did not significantly change postoperatively.[11] In study by Eghbal et al, only lumbar lordosis changed significantly, all other parameters not significantly changed.[12] Mean PI-LL (difference of pelvic incidence and lumbar lordosis) in our study was 10.64 preoperatively which decreased to 8.19 postoperatively. Aoki et al studied influence of PI-LL mismatch on surgical outcomes of short-segment transforaminal lumbar interbody fusion and suggested that efforts should be made to reduce PI-LL to 10° or less whenever feasible.[13] In study by Schwab et al advised simple formula of "LL=PI±9°" based on study of lumbar lordosis and pelvic incidence relationship.[14] In our study mean PI-LL was 8.19 in follow up which is comparable with these studies.

In this study, blood transfusion was not needed in any patient. The average intraoperative blood loss of our study patients was 437.5 (range: 300-550 ml). In prospective study by Yang et al average blood loss in TLIF procedure was 432.5 ml and there was no requirement of blood transfusion in most of the patients which is similar to our study.[15] In the study by Ould-Slimane et al, average blood loss was 570±360 ml and no blood transfusion was necessary.[11] These results are comparable with our study.

Average operative time in our study was 147.5 minutes which is comparable with other studies. In studies by Ould-Slimane et al and Yang et al, average operative time was 124±37 minutes and 90-160 minutes respectively.[11,15]

In our study, the average hospital stay was 9.25 days which is comparable with a study by Hey et al where range of hospital stay was 5-11 days.[16] In a meta-analysis by Hammad et al the hospital stay in open TLIF ranged from 3-19 days with a mean of 6.92 days in 25 different studies, which is comparable to our study.[17]

Leg and back pain measured by VAS along with ODI and SF 12 were significantly improved in our study. This findings correlates with others studies. In study done by Eghbal et al, there was decrease in VAS and ODI with significant p value like in our study.[12] Also in comparative study done by Parker et al, there was decrease in VAS, ODI and SF12 with significant p value (<0.001).[18] Also in meta analysis by Hammad et al mean VAS score at follow up was 2.88 and mean ODI at follow up was 20.62 which is also comparable with our study findings.[17]

In spite of no significant change in spinal balance parameters there was clinical and quality of life parameters. This would be due to subtle changes in spinopelvic parameters. We found pelvic tilt in our patients largely unchanged after surgery. Interestingly in our patients there was minimal improvement the SS postoperatively which then translated into an incremental improvement in pelvic incidence. This reduction in pelvic incidence lead to a further reduction in the SVA. While the SVA in our patient subset was normal to begin with, the final SVA was only within 1.33 cm. We believe that in addition to the intraspinal space created by decompression, discectomy, foraminotomy and amenable increase in disc height due to insertion of a cage, decrease in SVA too has contributed to improvement in overall quality of life parameters.

CONCLUSION

Significant improvement was seen clinically in terms of VAS for back and leg pain and functionally in terms of ODI and SF12 scores after TLIF procedures for spondylolisthesis. Measurement of sagittal spinal balance parameters is mandatory before any fusion procedure preoperatively and postoperatively to predict outcome and decide management plan according to that. In most case of grade 1 spondylolisthesis, there is only a minimal imbalance of the sagittal spinal balance parameters and so in situ fusion can be done.

Even if a complete reduction of spondylolisthesis was not achieved during surgery, there was correction of a few of the parameters of spinal balance which were deranged preoperatively. Improvement in Quality of life could be due to both improvement in spinal balance and reduced

abnormal mobility at respective level. Overall TLIF is very good procedure in terms of improvement in clinical and functional parameters in grade 1 spondylolisthesis.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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Cite this article as: Sawant N, Abraham M, George T, Easwer HV, Divakar G. Clinical, functional and radiological spinopelvic balance parameters assessment after transforaminal lumbar interbody fusion in grade 1 spondylolisthesis. Int Surg J 2021;8:232-7.