The Egyptian Journal of Hospital Medicine (April 2018) Vol. 71(1), Page 2365-2369

# Assessment of Pelvic Parameters before and after Postero-lateral Interbody Fusion Surgery in Patient with Lumbo-sacral Instability

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## ABSTRACT

**Background:** pelvic incidence (PI) is a fundamental pelvic anatomic parameter that is specific and constant for each individual and determines pelvic orientation as well as the size of lumbar lordosis (LL). Pelvic incidence (PI) is a descriptor of pelvic morphology and not of pelvic orientation: therefore, its angular value is unaffected by changes in human posture. The pelvic tilt (PT) and the sacral slope (SS) are position-dependent variables and are very useful to characterize the spatial orientation of the pelvis. Pelvic incidence, sacral slope and pelvic tilt are particularly useful because it can be demonstrated that pelvic incidence (PI) is the arithmetic sum of the sacral slope (SS) + pelvic tilt (PT). **Objective:** this study aimed to determine the effect of Postero-Lateral Inter Body Fusion Surgery (PLIF) in 25 patients with Lumbo-Sacral instability by measuring these three pelvic parameters by plain x- ray before and after surgery. **Patients and Methods:** when compared to normal populations, pelvic incidence (PI) is significantly higher in spondylolisthesis and the difference in PI tends to increase in a direct linear fashion as severity of the spondylolisthesis increases. The cause effect relationship between pelvic morphology and spondylolisthesis remains to be clarified. Taking into consideration the pelvic parameters stimulated a renewed interest for the radiological evaluation and classification of spino-pelvic alignment in L5-S1 spondylolisthesis. **Results:** we found that Postero-Lateral Inter Body Fusion Surgery (PLIF) is sucssessful operation for treatment of lumbo sacral instability such as degenerative spondylolisthesis, isthmic spondylolisthesis and post laminectomy instability. In comparison with lateral view x-ray before and after the operation, the pelvic incidence increased and pelvic tilt decreased. **Conclusion:** PLIF is successfully used to treat degenerative and isthmic spondylolisthesis. PLIF is successful regardless of age, sex and concomitant morbidities such as diabetes mellitus, hypertension and ischemic heart disease.

**Keywords:** antero-posterior, lateral, pelvic incidence, posterior lumbar interbody fusion.

## INTRODUCTION

Spinal instability was defined as an abnormal response to applied loads, characterized by movement in the motion segment beyond normal constraints [1]. Lumbar spinal instability may be caused by: degenerative disease, post operative status, trauma to spine or its surrounding structures, developmental disorders, like scoliosis and other congenital spine lesions and infection and tumors. Instability of the lumbar spine occurs often and mostly affects the region of L4-L5 or L5-S1 [2]. The clinical symptoms and signs are non-specific and can be described as 'low back pain with or without radiculair pain'[3] .

The stabilizing system can be represented by means of three subsystems. The passive subsystem consisting of vertebrae, facet joints, inter vertebral discs, spinal ligaments, joint capsules and passive muscle support. The neural feedback system is containing force and motion transducers and the neural control centers. The third system is the active subsystem including the muscles and tendons surrounding the spinal column.

Thus, the spine needs the integrated function of the three subsystems, mentioned above, to control stability and movement. Instability is found when one of the systems fails to fulfill his task and disturbs the balance[3] .The important thing is to consider that all the lumbar muscles contribute to stability of the lumbar spine[4,5]. The high mobility of the hip joint affects pelvic positioning, so that, with bipedalism, the sacral plateau began to act as a base to support the weight of the spine. Degenerative diseases of the spine are influenced by its spatial positioning during the lifetime of the individual[6] .There is concern about analyzing the sagittal alignment of the spine. It is now known that sagittal alignment directly influences an individual's energy expenditure[7]. The C7-sacrum plumb line, thoracic kyphosis, and lumbar lordosis serve as parameters for evaluating sagittal alignment. The shape of the pelvis and the sacral slope influence the lumbar lordosis of each individual [8].There are some parameters that are used as references for the evaluation of pelvic alignment.

The pelvic incidence (PI) is defined as the angle between a line perpendicular to the midpoint of the sacral plateau and a line from this point to the center of the femoral head. This angle most reliably represents the transmission of load by the sacral plateau. The average value of the angle of incidence was $55°\pm10$[7,9-12].

## AIM OF THE WORK

The aim of this study was to assess pelvic parameters before and after postero- lateral inter



Received: 22/1/20178 DOI: 10.12816/0045313
Accepted: 3/2/2018

body fusion (PLIF) surgery in patient with lumbo sacral instability.

## PATIENTS and METHODS

This retrospective study included 25 patients who underwent PLIF surgery with lumbosacral instability as:degenerative spondylolisthesis (DS), isthmic spondylolisthesis (IS) and Post-laminectomy instability (PLI).

All patients had been treated in Department of Orthopedic Surgery, Said Galal Hospital and Shark El Madina Hospital in Alexandria.

**Inclusion criteria:** age between 18 and 60 years, patient with lumber instability, post operative postero-lateral inter body fusion and changes in pelvic parameters preoperative and post operative.

**Exclusion criteria:** pregnant or nursing women, psychosocial instability, comorbidity that prevents participation or transportation, patients with inflammatory arthritis, tumors, or neuromuscular diseases.

**Radiographic protocol:** on each lateral radiograph, three pelvic parameters were measured, the sacral slope (SS), the pelvic title (PT), the pelvic incidence (PI), all measurements were performed manually, a free software GEOGEBRA [146] was used to increase the accuracy of our measurements.

**Provision to maintain privacy:** all participant names were hidden and were replaced by code number to maintain privacy of patients

**Patients:** age ranged from a minimum of 35 years old to a maximum of 60 years old. **Sex:** we had 15 female patients and 10 male patients. **Occupation:** 11 of them were house wives, 6 of them were worked in office, 8 of them were manual labor. **Comorbidities:** 13 of them had no comorbidities, 4 patients were hypertensive, 2 patients were diabetic, 2 patients were suffered from diabetes millitus and hypertension, 2 patients were suffered from ischemic heart disease and hypertension and 2 patients were suffered from ischemic heart disease, diabetes millitus and hypertension. **Levels:** according to the level of pathology we had 12 patients with L5-S1 and 12 patients with L4-L5 and 1 patient with L3-L4. **Pathology:** the concomitant pathology of instability were isthmic spondylolisthesis in 8 patients, degenerative spondylolisthesis in 13 patients and post laminectomy instability in 4 patients.

**The study was approved by the Ethics Board of Al-Azhar University.**

## RESULTS

**Table 1:** distribution of the studied cases according to sex (n = 25).

| Sex | No. | % |
|---|---|---|
| Male | 10 | 40.0 |
| Female | 15 | 60.0 |

**Table 2:** distribution of the studied cases according to age (n = 25)

| Age (years) | No. | % |
|---|---|---|
| ≤50 | 12 | 48.0 |
| >50 | 13 | 52.0 |
| Min. – Max. | 35.0 – 60.0 | |
| Mean ± SD. | 48.56 ± 8.75 | |
| Median | 52.0 | |

**Table 3:** distribution of the studied cases according to pathology (n=25).

| Pathology | No. | % |
|---|---|---|
| Isthmic spondylolisthesis | 8 | 32.0 |
| Degenerative spondylolisthesis | 13 | 52.0 |
| Post laminectomy instability | 4 | 16.0 |

**Table 4:** distribution of the studied cases according to level (n = 25).

| Level | No. | % |
|---|---|---|
| L5 – S1 | 12 | 48.0 |
| L4 – L5 | 10 | 40.0 |
| L3 – L4 | 3 | 12.0 |

**Table 5:** distribution of the studied cases according to PLIF (n = 25)

| PLIF | No. | % |
|---|---|---|
| Without cage | 18 | 72.0 |
| With cage | 7 | 28.0 |

**Table 6:** distribution of the studied cases according to symptoms (n = 25)

| Symptoms | No. | % |
|---|---|---|
| Low Back Pain | 25 | 100.0 |
| Bilateral sciatica | 4 | 16.0 |
| Left sciatica | 13 | 52 |
| Right sciatica | 8 | 32 |
| Neurogenic claudication | 8 | 32 |

**Table 7:** distribution of the studied cases according to occupation (n = 25)

| Occupation | No. | % |
|---|---|---|
| House wife | 11 | 44.0 |
| Worked in office | 6 | 24.0 |
| Manual labor | 8 | 32.0 |

**Table 8:** distribution of the studied cases according to comorbidities (n = 25)

| Comorbidities | No. | % |
|---|---|---|
| Negative | 14 | 56.0 |
| **Positive** | 11 | 44.0 |
| Hypertension | 9 | 36.0 |
| Diabetes | 4 | 16.0 |
| Cardiac | 4 | 16.0 |

**Table 9:** distribution of the studied cases according to comorbidities (n = 25)

| Comorbidities | No. | % |
|---|---|---|
| Negative | 14 | 56.0 |
| **Positive** | 11 | 44.0 |
| Hypertension only | 5 | 20.0 |
| Hypertension + Others | 4 | 16.0 |
| Diabetes only | 2 | 8.0 |
| Diabetes + Others | 2 | 8.0 |
| Cardiac + Others | 4 | 16.0 |

**Table 10:** comparison between pre-operative and post-operative according to pelvic incidence (n = 25).

| Pelvic incidence | Preoperative | Postoperative | t | p |
|---|---|---|---|---|
| Min. – Max. | 17.20 – 41.10 | 24.40 – 47.70 | | |
| Mean ± SD. | 33.26 ± 6.89 | 37.37 ±6.79 | .977 | .001 |
| Median | 33.60 | 40.0 | | |

**Table 11:** comparison between preoperative and postoperative according to pelvic tilt (n = 25)

| Pelvic tilt | Preoperative | Postoperative | Z | p |
|---|---|---|---|---|
| Min. – Max. | 8.80 – 45.0 | 5.40 – 35.10 | | |
| Mean ± SD. | 21.35 ±9.27 | 16.47 ±9.57 | 3.835 | <0.00 1 |
| Median | 17.60 | 10.90 | | |

**Table 11:** comparison between preoperative and postoperative according to sacral slope (n = 25)

| Sacral slope | Preoperative | Postoperative | t | p |
|---|---|---|---|---|
| Min. – Max. | 37.90 – 71.0 | 34.80 – 76.0 | | |
| Mean ± SD. | 54.61± 9.42 | 54.54 ±11.2 | .064 | .950 |
| Median | 54.50 | 54.0 | | |

## DISCUSSION

It has been recognized that the orientation of the lumbosacral pelvic junction plays a critical role in the overall alignment of the spine, and that sagittal spinopelvic balance is made from spinal and pelvic parameters[13]. A study reported spinopelvic parameters in normal and low back pain populations [14]. PI is an important anatomic parameter that describes the anatomic configuration of the pelvis and greatly influences the sagittal configuration of the spine [14]. It is relatively constant during childhood. Thereafter, PI increases significantly during adolescence until reaching its maximum value in adulthood. It is not affected by posture or the pelvic position, and is considered to be invariable at the end of growth [15] . PI represents the algebraic sum of the SS and the PT : PI=SS+PT. Thus, if we consider the PI of any subject, when the sacral slope increases, the pelvic tilt decreases [15].It is commonly reported as a compensatory mechanism: when the trunk inclines anteriorly (e.g., age related change, sagittal imbalance, loss of lordosis, increase of kyphosis) a subject will try his/her best to maintain an economic posture and keep the spine balanced [15] .Also, the morphology of the pelvis as quantified by PI is a strong determinant of the spatial position of the pelvis in a standing position: as the PI increases, so does the SS, PT or both [15]. Values and correlations of spinopelvic parameters for the normal population have been well established [15].

In this study, we found that pelvic incidence increased about 4 degrees after PLIF and pelvic tilt decreased about 5 degrees after PLIF. According to pelvic incidence we found that it ranged from 17.20 to 41.10 with mean 33.26 ± 6.89 pre operatively and pelvic incidence from 24.40 to 47.70 with mean 37.37±6.79 post operatively which was statistically significant. According to pelvic tilt we found that it ranged from 8.80 to 45.0 with mean 21.35 ±9.27 pre operatively and pelvic tilt from 5.40 to 35.10 with mean 16.47 ±9.57 post operatively, which was statistically significant.

According to sacral slope we found that ranged from 37.90 to 71.0 with mean 54.61± 9.42 pre operatively and sacral slope from 34.80 to 76.0 with mean 54.54 ±11.2 post operatively, which was statistically not significant.

**Kong *et al.*** [16] reported that postoperative change in spinopelvic parameters, the SS increased from 38.8±7.1 to 43.6±7.2 degrees, the PT decreased from 20.2±8.3 to 15.3±7.8 degrees. Surgical correction of degenerative spondylolisthesis using posterior lumbar interbody fusion and posterior instrumentation resulted in significant changes in spinopelvic parameters.

**Lim *et al.*** [17] reported that the PI was significantly greater for patients with degenerative spondylolisthesis (59±9°) and isthmic spondylolisthesis (59±13°) compared to a normal people (49±9°). The SS was significantly lower for patients with degenerative spondylolisthesis (34±7°) than that of the normal people (38±7°). The PT of degenerative spondylolisthesis was 24±7° and isthmic spondylolisthesis was 21±7° was significantly greater than that of the normal people (11±6°). **Hanson *et al.*** [18] reported that as the degree of spondylolisthesis increased, the LL, PI and PT increased as well.

**Park *et al.*** [19] reported that surgical correction of adult isthmic spondylolisthesis with posterior lumbar interbody fusion and posterior instrumentation resulted in improvement of sacral slope, pelvic tilt, lumber lordosis, and sagittal balance Pelvic parameters and sagittal balance changed subsequently. Sacral slope was increased by 4.4 degrees and pelvic tilt was decreased by 4.4 degrees and sagittal balance was displaced 5.6 mm posteriorly.**Feng *et al.*** [20] reported that no significant difference can be found between the parameters of the posterolateral fusion and posterior lumbar interbody fusion. The two different operations can reduce the PT of the patients with spondylolisthesis. The PT of the PLIF group decreased 4.92 degrees after the operation in the PLF group, the PT improved 3.89 degrees. In correspondence with the PT, after the surgical treatment, the SS increased 4.64 degrees in PLIF group and 3.98degrees in PLF group.

**Labelle *et al.*** [21] reported that pelvic shape is unaffected by attempts at surgical reduction, proper repositioning of L5 over S1 significantly improved pelvic balance and lumbar shape in L5–S1 developmental spondylolisthesis. Changes in pelvic balance can only be detected if sub grouping into balanced and unbalanced pelvis was done. These results support the rationale of sub-dividing subjects

with high grade spondylolisthesis into unbalanced and balanced pelvis groups to analyze the results of surgery and further support the contention that reduction techniques might be considered for the unbalanced retroverted pelvis sub-group. Sacral slope increased slightly, but significantly following surgery. However, the direction and magnitude of change were significantly different by SS/PT group. For the balanced pelvis group (high SS, low PT) and sacral slope decreased. For the unbalanced retroverted pelvis group, sacral slope increased. But, pelvic tilt decreased slightly, but significantly following surgery. As for SS, the direction and magnitude of change were significantly different by SS/PT group. For the balanced pelvis group, pelvic tilt increased slightly. For the unbalanced pelvis group, pelvic tilt decreased significantly.

## CONCLUSION

Different compensatory mechanisms may contribute to the maintenance of spinopelvic sagittal alignment in isthmic spodylolisthesis. The pelvis and lumbar spine adapt in accordance with the degree of pelvic tilt and sacral slope. It is found that pelvic incidence regulates both sacral slope and pelvic tilt. PLIF is the gold standard to which all other fusion methods should be compared.

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