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Comparative Study of Spino-pelvic Parameters between Scoliotic versus Non-scoliotic Patients with Multi-level Degenerative Lumbar Spondylosis

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Degenerative lumbar scoliosis is a multi-planner deformity seen in the aging spine. Important parameters in the evaluation of balance of the degenerative lumbar scoliosis include spino-pelvic parameters such as the LL, SS, PI, and PT besides the coronal Cobb´s angle. In order to minimize the energy associated with maintaining upright posture, sagittal balance is necessary. Significant sagittal abnormality or imbalance is commonly related to poor functional scores across multiple domains.

Aim: The aim of this study was to investigate the role of the spino-pelvic parameters in the development of scoliosis in multi-level degenerative lumber spondylosis disease.

Patients and Methods: This cross-sectional study was carried out in Tanta University Hospitals. It included the first 100 patients who visited the outpatient orthopedic department clinic from April 2019.

Results: There was a statistically significant ($p \le 0.05$) increase in each of the PI, PT and cobb´s angle and a significant decrease in SS in multi-level DLS with scoliosis patients in correlation to

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multi-level DLS without scoliosis patients. There were no significant differences between LL in both studied groups.
Regarding the age, sex, BMI and occupation in the two studied groups, there were no statistically significant differences. There was a significant correlation between the sex and PT in patients with multi-level DLS without scoliosis, but there was no significant correlation between sex and other parameters in both groups. There wasn´t significant correlation between the two groups by increasing the age. Manual workers in scoliotic group show higher PT and smaller SS than in non-scoliotic group, which give a significant correlation between the occupation and these spino-pelvic parameters.
Conclusion: Importance of a thorough discussion of the risks of deformity progression weighed against the anticipated benefits with patient's during clinical consultation return to the spino-pelvic parameters. Measurement of these spino-pelvic parameters can help in monitoring progression of disease in patients and allow physicians to provide better prevention, treatment and control.

Keywords: Scoliotic; non-scoliotic; lumbar spondylosis; Spino-pelvic.

1. INTRODUCTION

The spine is our body's central support structure. Lumbar degenerative disease is a frequent occurrence in older individuals who visit the spine clinic on a regular basis. It's a broad word that refers to a collection of diseases linked to the lumbar spine's ageing and degenerative processes. Low back discomfort, trouble walking, and the inability to see straight ahead when standing are all common symptoms [1]. The importance of analyzing spino-pelvic sagittal features in improving the treatment of lumbar degenerative disease has long been acknowledged [2].

The significance of sagittal spinopelvic orientation in spinal deformity as it pertains to clinical outcomes has been more acknowledged in recent years [3]. Spino-pelvic sagittal characteristics have a wide range of normal values from person to person [4]. Due to degenerative deformity, older individuals' sagittal parameters differ from those of young ones. Following the discovery of these discrepancies, a number of investigations into the relationship amongst sagittal alignment and lumbar degenerative disease were conducted. Few research, however, have looked at the differences in sagittal alignment across disease types [2].

Many studies employed healthy young people as control groups, and there is a scarcity of data on the typical range of sagittal characteristics in the elderly [5,6]. Furthermore, in degenerative scoliosis patients, the significance of preoperative and postoperative sagittal balance, as well as the strong connection between sagittal balance and health status, has been highlighted [7].

In the normal population, the sagittal balance is defined by numerous pelvis and spine characteristics and covers a broad range of variations [8]. The spinal and pelvic parameters make up the spino-pelvic sagittal parameters. Duval-Beaupere et al. defined Pelvic Incidence (PI) as a pelvic metric [9]. As an anatomic variable that reflects the morphologic characteristics of the pelvis, with a value that doesn't change with age.

Individual posture and position have no effect on the PI value, which affects pelvic orientation (expressed by sacral slope (SS) and pelvic tilt (PT), as well as the degree of lumbar lordosis (LL) [10]. The sacral slope (SS) is a posture-related metric affected by the pelvic position. The lower lumbar curvature is determined by SS, which is closely linked to LL [11].

Pelvic tilt (PT) is a posture-related measure that represents the pelvic flexion or posterior tilt angle and shows the spatial orientation of the pelvis.

Currently, there's a well-established linear relationship between pelvic incidence, sacral slope, and sagittal curves, particularly lumbar lordosis [12]. Correcting sagittal plane alignment is critical for restoring sagittal balance and achieving a better treatment result [13].

A spinal abnormality in a skeletally mature adult with a Cobb angle larger than 10o and no history of scoliosis throughout infancy and adolescence is classified as degenerative lumbar scoliosis (DLS) [14]. The asymmetrical collapse of the intervertebral disc, coupled with concomitant incompetence and hypertrophy of the facet joints, has been extensively established as a cause of DLS [15].

There was also a lack of agreement on what variables may be linked to the severity of the curve. The main goal of this prospective research was to see whether age, gender, profession, and body mass index (BMI) had any effect on the existence and development of DLS. However, only a few studies have been performed only to characterize the sagittal characteristics in DLS patients, and none of them have shown a significant connection with health-related quality of life indicators [7].

This research was carried out to look into the radiographic characteristics of DLS and to see whether there are any radiological spino-pelvic parameters that vary substantially across the patients. As a result, the spino-pelvic characteristics, which vary substantially in the sagittal plane amongst the 2 research groups, must be investigated and addressed.

2. PATIENTS AND METHODS

This cross-sectional study was done in Tanta university hospitals. It included the first 100 patients who visited the orthopedic department outpatient clinic from April 2019 and met the study selection criteria after approval of the responsible institutional ethical committee.

The patients got subdivided to 2 groups for analysis and comparison:

1. Group A had 50 patients suffering multi-level DLS with scoliosis.
2. Group B included 50 patients with multi-level DLS without scoliosis.

Inclusion criteria adults of both sex with age more than 30 years old presented with a radiological-confirmed multi-level DLS with and without scoliosis.

Exclusion criteria:

- Surgery on the spine before or trauma.
- Any previous hip or knee arthroplasty or lower extremity realignment surgery.
- Metabolic spinal pathology.
- Scoliosis or kyphosis as an adolescent.
- Spondylolisthesis.
- Osteoporotic vertebral fracture.
- Hip joint disorder.
- Ankylosing spondylitis.
- Lower limb disease.
- Pregnancy.

All participants were subjected to the following:

1) Full history taking:

- Personal history: name, age, occupation residency, sex, smoking and marital state.
- Present history, medical history, and co-morbidities.
- Any drug history.

2) Radiographic protocol:

- The same radiographic protocol was used for all patients.
- Anterior-posterior (A-P) radiographs were obtained to estimate the coronal cobb′s angle.
- Standing lateral spinal plain radiographs in a standardized fashion were obtained including the whole spine and pelvis with persistent space between the participant and the beam source with a relaxed standing position and fully extended knees while both upper limbs on opposite shoulder. The femoral heads should be visualized.
- All radiographs got evaluated and observed by 2 experienced orthopedic surgeons and the mean value was taken for final results evaluation.
- The following sagittal factors got measured in the sagittal plane radiograph:

1. Pelvic incidence
2. Pelvic tilt.
3. Sacral slope.
4. Lumbar lordosis.

Duration of the study:

The study started from April 2019.

Statistical evaluation:

The IBM SPSS software program version 20.0 was used to examine the data that was input into the computer. (IBM Corporation, Armonk, NY) Number and percent were used to describe qualitative data. The Kolmogorov-Smirnov test got performed to ensure that the distribution was normal. Range (minimum and maximum), mean, standard deviation, and median were used to characterize quantitative data. The significance of the acquired findings was assessed at a 5% level of significance [16].

3. RESULTS

Analysis of the relationships between the data within the patients of the two groups: we discovered no significant (P > 0.05) correlation among the age and spino-pelvic parameters for the 2 groups Table (1).

There was no significant (P > 0.05) effect of sex on spino-pelvic parameters in Group A. But there was significant increase (P = 0.031) of PT in females of group B Table (2).

There was no significant correlation between BMI and spino-pelvic parameters in the two groups Table (3).

We discovered significant correlation among occupations and spino-pelvic parameters in group A, as SS had significant lower result (p ≤ 0.05), and PT was significantly elevated (p ≤ 0.05) in manual worker than in farmer, housewives and office workers Table (4).

4. DISCUSSION

In the normal population, there is no such thing as a standard sagittal balance since there is such a broad range of normal values in individuals. As a result, talking about universal kyphotic or lordotic curves is illogical. The most essential thing is to have optimum congruence between pelvic and spinal characteristics in order to create a cost-effective posture that places the axis of gravity in a physiologic position [17].

Analysis of the relationships and results among each group: Using spino-pelvic radiographic data, many studies found that age and gender had an impact on spinal alignment [18-19]. Oe et al. [19] revealed that sagittal spinal alignment degradation varied by age and gender. They discovered no statistically significant relationship between age, spino-pelvic characteristics, and Cobb's angle in the two groups in our research.

There wasn´t significant correlation by increasing the age and the parameters, which was in line with what was reported by Hammerberg and Wood [18] who suggested that the SS and PT weren't linked with age. They examined patients suffering multi-level DLS and there was no relationship among increasing age and spino-pelvic parameters of balance and morphology. This was in line with what was reported by Mac-Thiong J-M et al. [20], Duval-Beaupere et al. [9] and Schwab F et al. [21] PI generally, as an anatomic parameter representing the morphologic characteristics of the pelvis, it rises throughout skeletal development before becoming a fixed, patient-specific amount at skeletal maturity. In skeletally mature individuals, PI can only be altered via sacral osteotomy or pelvic fracture. In contrast to pediatric patients, PI remained constant [22].

Regarding the LL and PT, it has been reported that increasing age is linked to an excessive lumbar lordosis loss. These age-related LL reductions may have prompted the recruitment of a compensatory mechanism in the lower limb, resulting in an increase in PT [23,24,25].

With age, PT and SS rose and reduced somewhat, suggesting an enhanced retroversion of the pelvis to adjust degenerative processes linked to decreased LL and generate a positive spinal balance, respectively (forward displacement of the spine) [18-23] Robin et al. [26] also suggested that cobb´s angle of multi-level DLS with scoliosis patients increased with more degenerative process by aging in the elderly [27].

They discovered significant positive correlation among sex and PT of group B. Females show a high PT in relative to males but There wasn't significant correlation between other parameters and sex in both groups and this was in line with what was reported by Mac-Thiong J-M et al, [28] who suggested that no differences in PI, SS, and PT when comparing adult females with males in patients with multi-level DLS. Based on older findings, PI wasn't correlated with age or gender (Roussouly P et al. [5] and Lee CS et al. [29].

These findings contradict with other results which describe gender variations on spino-pelvic parameters. Yukawa Y et al. [30] and Vialle et al. [31] discovered significant variation in SS and PI but not PT between females and males. He suggested that LL, SS, and PI were higher in females rather than males.

Liuke et al. [32] discovered that BMI>25kg/m2 could increase lumbar disc degeneration. Our present research discovered no significant correlation among the BMI and spino-pelvic parameters and cobb´s angle in the two groups. Romero-Vargas et al. [33] They looked at whether BMI was linked to changes in spino-pelvic parameters and found that the differences weren't statistically significant.

Table 1. Relation between age and different parameters in each group

	Age (years)									
	Group A			F	P	Group B			F	p
	≤50 (n = 5)	>50 – ≤60 (n = 20)	>60 (n = 25)			≤50 (n = 5)	>50 – ≤60 (n = 23)	>60 (n = 22)		
	SS									
Min. – Max.	18.20 – 36.50	17.50 – 48.50	7.80 – 60.20	0.437	0.648	28.80 – 37.70	11.10 – 55.20	11.10 – 55.20	0.376	0.689
Mean ± SD.	30.74 ± 7.51	32.88 ± 7.47	30.43 ± 10.11			33.62 ± 4.53	37.22 ± 10.74	34.90 ± 11.65		
	PT									
Min. – Max.	15.70 – 43.00	4.50 – 38.20	2.90 – 45.40	0.170	0.844	7.90 – 23.50	3.00 – 30.90	8.20 – 31.60	0.213	0.809
Mean ± SD.	25.30 ± 10.43	23.16 ± 9.69	24.89 ± 11.62			15.50 ± 6.20	17.09 ± 7.69	17.89 ± 7.83		
	PI									
Min. – Max.	51.50 – 60.50	48.40 – 71.10	35.40 – 76.50	0.071	0.932	41.20 – 51.60	30.40 – 69.20	30.40 – 69.20	0.694	0.505
Mean ± SD.	55.34 ± 3.67	55.34 ± 5.56	54.62 ± 7.94			47.38 ± 4.08	52.60 ± 8.81	51.08 ± 10.15		
	LL									
Min. – Max.	51.50 – 60.50	48.40 – 71.10	35.40 – 76.50	1.203	0.309	23.50 – 52.40	13.50 – 55.50	2.50 – 54.20	0.025	0.975
Mean ± SD.	55.34 ± 3.67	55.34 ± 5.56	54.62 ± 7.94			40.84 ± 11.87	40.76 ± 12.54	41.56 ± 12.19		
	Cobb`s angle									
Min. – Max.	14.20 – 24.0	10.90 – 46.70	11.20 – 30.0	0.234	0.792	0.80 – 4.20	0.10 – 6.20	0.30 – 7.20	0.513	0.602
Mean ± SD.	17.74 ± 4.48	19.21 ± 10.25	17.72 ± 4.98			2.04 ± 1.48	2.53 ± 1.72	2.90 ± 2.04		

F: F for ANOVA test p: p value for comparing between the different categories

Table 2. Relation between sex and different parameters in each group

	Sex							
	Group A		t	p	Group B		T	p
	Male (n = 21)	Female (n = 29)			Male (n = 22)	Female (n = 28)		
	SS							
Min. – Max.	7.80 – 48.50	18.20 – 60.20	0.953	0.345	11.10 – 55.20	11.10 – 55.20	0.787	0.435
Mean ± SD.	30.04 ± 9.76	32.45 ± 8.09			37.18 ± 11.00	34.79 ± 10.44		
	PT							
Min. – Max.	4.50 – 45.40	2.90 – 43.00	0.685	0.497	6.10 – 30.90	3.00 – 31.60	2.224*	0.031*
Mean ± SD.	25.45 ± 11.08	23.36 ± 10.34			14.72 ± 7.45	19.30 ± 7.06		
	PI							
Min. – Max.	46.50 – 76.50	35.40 – 71.10	0.166	0.869	30.40 – 69.20	40.20 – 69.20	0.852	0.398
Mean ± SD.	54.80 ± 6.27	55.11 ± 7.00			50.17 ± 9.99	52.38 ± 8.38		

	Sex							
	Group A		**t**	**p**	**Group B**		**T**	**p**
	Male (n = 21)	**Female (n = 29)**			**Male (n = 22)**	**Female (n = 28)**		
	LL							
Min. – Max.	3.50 – 54.50	1.40 – 54.50	0.874	0.387	2.50 – 55.50	13.50 – 54.50	0.195	0.846
Mean ± SD.	41.05 ± 13.95	37.47 ± 14.57			40.74 ± 13.79	41.42 ± 10.81		
	Cobb`s angle							
Min. – Max.	11.20 – 46.70	10.90 – 42.50	0.557	0.580	0.30 – 7.20	0.10 – 6.80	0.474	0.637
Mean ± SD.	17.62 ± 8.21	18.82 ± 6.90			2.78 ± 1.80	2.53 ± 1.89		

t: Student t-test p: p value for comparing between the different categories

Table 3. Relation between BMI and different parameters in each group

	BMI									
	Group A			**t**	**p**	**Group B**			**F**	**p**
	Normal (n = 1#)	**Obese (n = 33)**	**Overweight (n = 16)**			**Normal (n = 5)**	**Obese (n = 24)**	**Overweight (n = 21)**		
	SS									
Min. – Max.	35.80	18.20 – 60.20	7.80 – 39.50	1.118	0.269	25.80 – 55.20	11.10 – 55.20	11.10 – 55.20	0.773	0.467
Mean ± SD.		32.34 ± 9.07	29.32 ± 8.40			40.02 ± 14.26	34.13 ± 10.64	36.80 ± 9.90		
	PT									
Min. – Max.	19.60	2.90 – 43.00	11.00 – 45.40	0.072	0.943	6.10 – 24.60	3.00 – 31.60	7.90 – 30.90	2.819	0.070
Mean ± SD.		24.26 ± 11.37	24.49 ± 9.44			13.32 ± 6.95	19.74 ± 7.21	15.42 ± 7.36		
	PI									
Min. – Max.	54.70	35.40 – 76.50	48.50 – 60.50	1.763	0.084	30.40 – 65.30	40.20 – 69.20	30.40 – 69.20	0.190	0.828
Mean ± SD.		55.89 ± 7.74	53.11 ± 3.29			51.66 ± 14.10	52.17 ± 8.92	50.48 ± 8.35		
	LL									
Min. – Max.	51.40	1.40 – 54.50	3.50 – 53.20	0.922	0.361	35.50 – 55.50	23.50 – 54.50	2.50 – 54.20	1.156	0.324
Mean ± SD.		40.03 ± 14.37	36.01 ± 14.26			48.88 ± 8.20	40.38 ± 10.00	40.11 ± 14.58		
	Cobb`s angle									
Min. – Max.	11.80	10.90 – 46.70	11.20 – 30.00	1.354	0.182	0.80 – 2.60	0.10 – 6.80	0.10 – 7.20	1.249	0.296
Mean ± SD.		19.44 ± 8.17	16.40 ± 5.28			1.46 ± 0.87	2.67 ± 1.89	2.89 ± 1.88		

t: Student t-test F: F for ANOVA test
p: p value for comparing between the different categories.
#: Excluded from the comparing due to small number of case (n = 1)

Table 4. Relation between occupation and different parameters in each group

	Occupation											
	Group A				**F**	**p**	**Group B**				**F**	**p**
	Farmer (n= 10)	**Housewife (n= 20)**	**Manual worker (n= 12)**	**Office worker (n= 8)**			**Farmer (n= 14)**	**Housewife (n= 18)**	**Manual worker (n= 8)**	**Office worker (n= 10)**		
	SS											
Min. – Max.	25.50 – 39.50	24.30 – 60.20	7.80 – 34.00	22.10 – 48.50	8.424*	<0.001*	11.10 – 51.00	11.10 – 55.20	11.10 – 55.20	28.80 – 55.20	0.276	0.842
Mean ± SD.	32.94 ± 4.84	33.94 ± 8.38	22.44 ± 6.44	36.81 ± 8.06			34.94 ± 10.50	34.71 ± 10.62	37.23 ± 15.04	38.04 ± 7.63		
	PT											
Min. – Max.	11.00 – 28.70	2.90 – 38.20	17.10 – 45.40	4.50 – 35.70	8.297*	<0.001*	9.30 – 30.90	3.00 – 30.90	6.10 – 31.60	7.90 – 30.00	0.979	0.411
Mean ± SD.	19.02 ± 6.15	21.33 ± 9.87	35.18 ± 7.26	21.64 ± 10.68			15.96 ± 7.05	19.54 ± 7.37	17.33 ± 9.21	15.04 ± 6.98		
	PI											
Min. – Max.	46.50 – 56.50	35.40 – 71.10	50.40 – 62.50	50.60 – 76.50	1.990	0.129	30.40 – 69.20	40.20 – 69.20	30.40 – 69.20	41.20 – 65.30	0.417	0.741
Mean ± SD.	51.26 ± 2.77	54.57 ± 7.77	56.92 ± 4.23	57.75 ± 8.44			49.21 ± 8.88	52.53 ± 8.93	52.86 ± 13.02	51.31 ± 6.47		
	LL											
Min. – Max.	14.20 – 53.20	1.40 – 54.50	3.50 – 54.50	28.50 – 51.50	0.914	0.441	2.50 – 54.20	30.50 – 54.20	24.40 – 55.50	13.50 – 54.50	1.397	0.256
Mean ± SD.	41.94 ± 13.33	39.80 ± 13.19	33.23 ± 19.12	41.80 ± 8.42			36.64 ± 15.24	42.16 ± 8.06	47.19 ± 10.33	40.67 ± 13.68		
	Cobb`s angle											
Min. – Max.	10.90 – 24.00	11.20 – 42.50	10.90 – 23.00	11.20 – 46.70	1.639	0.193	0.10 – 7.20	0.10 – 6.80	0.80 – 5.10	0.80 – 6.20	0.442	0.724
Mean ± SD.	15.01 ± 4.19	20.08 ± 7.29	16.48 ± 4.46	20.79 ± 12.26			2.54 ± 2.03	2.51 ± 1.84	2.38 ± 1.53	3.24 ± 1.89		

F: F for ANOVA test p: p value for comparing between the different categories

Yet, in accordance with our results that most patients in both groups were obese, Knutsson et al. [34] reported that obesity is linked to developing scoliosis in patients suffering multi-level DLS. Additionally, Akhavanfar MH et al. [35] suggested that obese patients usually faced higher mechanical loads on the lumbar spine and thus adverse effects on spine sagittal balance.

Increased loading of the spine, on the other hand, causes the intervertebral discs to lose height and decrease their capacity to absorb gravity's force, resulting in an abnormal load around the facet joints and spinal ligaments. It may cause degenerative alterations in the spinal column by affecting the musculoskeletal system. Obese individuals with paraspinal muscular weakness, on the other hand, are weaker than healthy adults. If the muscles do not have adequate strength to maintain upright posture, degeneration and rotational deformity, which leads to scoliosis, may be accelerated.

This work revealed that higher PT and smaller SS angles in manual workers in group A than group B. There wasn't any other significant correlation between occupations and the parameters in both groups. Our findings on the relation between heavy physical work or repeated injuries with disc degeneration and scoliosis are in accordance with old studies by Lawrence JS et al. and Videman T et al. [36-37].

This gives an idea about the way by which the daily activity can lead to degenerative scoliosis if associated with multi-level DLS, as the manual workers prefer to carry heavy objects. This is gradually compensated by increase the muscle tone on the opposite side and deviation of the spine. The differences in the prevalence of the signs of disc degeneration between the disc levels may be caused by differences in physical loading [38].

This study has some limitations: First, there was no asymptomatic healthy control group in the research. All of the patients were symptomatic and had been diagnosed with lumbar degenerative degeneration. Second, all of the patients in our research were recruited from our hospital's outpatient clinic, which may have resulted in selection bias and may not accurately reflect the typical features of ADS in the general community. Third, Previous research has shown that PI, as a morphologic characteristic of the pelvis, stays constant in adulthood following bone maturation, [20-21] yet lately a few studies have documented PI changes [39,25]. As a result, further research is needed to determine if the PI difference in this study is due to illnesses or other age-related variables (e.g., degeneration of sacroiliac joint). Lastly, sitting position, and exercise are some of the other possible risk factors that weren’t evaluated in this study. As a consequence of these constraints, large sample size and multicenter investigations are required to validate findings.

5. CONCLUSION

- Pelvic incidence, which is a known morphological parameter, may be an important indicator for developing scoliotic deformity in the setting of multi-level DLS. Patients having high PI values are greatly liable to develop scoliosis after multi-level DLS.
- Differences in the functional spino-pelvic parameters, (higher PT and lower SS) in patients with multi-level DLS associated with a high risk of developing scoliosis.
- Heavy manual workers have risk to develop scoliosis when subjected to multi-level DLS. So heavy manual workers with relatively high PI and PT and small SS and LL, should take care as they are more susceptible for developing degenerative lumbar scoliosis.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

CONSENT

Written and verbal consent was taken from all included patients. All participant names in our project got hidden and changed to codes to keep the privacy. The study did not receive any fund from any institute. It did not give any compensation to the participant. It did not do any harm to the environment.

ETHICAL APPROVAL

The study started after ethical committee approval. All included patients knew about the study's goal.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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