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ORIGINAL ARTICLE

Evaluation of Potential Segmental Instability with Lumbar Degenerative Disease

Ahmed El Shabrawy Sweilam [I*], Magdy El Sayed Hassan Rashed [I], Mahmoud Mostafa Taha [I], Magdy Omar El Sheikh [I]

Neurosurgery Department, Faculty of Medicine, Zagazig University, Zagazig, Egypt

* Corresponding author:
Ahmed El Shabrawy Sweilam
Neurosurgery Resident,
Neurosurgery Department, Faculty of Medicine, Zagazig University, Zagazig, Egypt
E-mail:
drahmedshabrawy23@hotmail.com

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ABSTRACT

Background: Lumbar degenerative disease (LDD) is a chronic condition of the lumbar spine affecting the vertebrae, facet joints and intervertebral discs and commonly causing low back pain (LBP) which may be due to instability of the motion segment. The aim of this work is to evaluate the relation between lumbar degenerative disease and lumbar instability. **Methods:** Sixty patients (20 females and 40 males) complained of LBP and/or sciatica. They were studied in 4 groups categorized according to magnetic resonance imaging (MRI) grading using Modified Pfirmann Disc Degeneration Scale: Group I (19 patients grade IV), Group II (16 patients grade V), Group III (14 patients grade VI) and group IV (11 patients grade VII). In addition to full history taking, all of them were subjected to thorough clinical examination including pain visual analogue scale (PVAS) to assess pain severity, Routine lab. investigations and Radiological examination (X-Ray: Static and dynamic, CT and MRI). **Results:** No significant differences between four groups regarding clinical data (LBP, sciatica, full motor power or SLR) were found but straight leg raising (SLR) angles were lower than normal within all groups, while PVAS showed significant difference between four groups ($P<0.05$). X-ray findings showed significant differences ($P<0.05$) among different degenerative grades. By correlating PVAS with disc height (DH) ratio and CT facet grading there were positive correlation, while Angle difference were negatively significantly correlated to DH ratio and correlated to CT grading positively. **Conclusion:** severity of LBP is directly correlated with the grade of disc degeneration found in MRI and both are directly correlated with the DH ratio and angle difference measured in X-ray and the degree of facet arthropathy seen in C.T.

Key words: Disc height; Pain visual analogue scale

INTRODUCTION

Degenerative disc disease is a common condition that may affect both sexes despite it is more prevalent in men **[1]**.

Lumber disc degeneration is related to progressive alteration in the disc tissue composition and morphology as disc dehydration, decreased disc height osteophyte formation and endplate calcification **[2]**.

Low back pain related to degenerative disc disease is quite common and the relation of pain provocation to lumbar disc degeneration was reported **[3]**.

Degenerative instability has been described as a transitional stage in the degenerative cascade, lying between initial dysfunction stage and subsequent restabilization stage **[2]**.

Pfirrmann introduced Pfirrmann disc degeneration grading scale using the signal intensity on T2-weighted MR images to estimate water content with morphological parameters on a scale from I to V **[4]**.

Dynamic radiography is a simple and reliable method to determine motion segment instability by observing the sagittal translation

and segmental angulation of the vertebrae on each other **[5]**.

This study aimed to evaluate the relation between lumbar degenerative disease and lumbar instability.

METHODS

The study included 60 patients (20 females and 40 males) whom ages ranged from 40-60 years (mean±SD = 50.1±6.65 years). They were complaining of low back pain (LBP) and/or sciatica.

Exclusion criteria:

1) Evident instability.
2) Trauma.
3) Discitis or other spine infection.

Based on MRI findings (Using Modified Pfirrman disc degeneration scale) the included patients belonged to grades IV, V, VI, VII and retrospectively categorized into 4 groups:

Group I (MRI grade IV): Included 19 patients (5 female and 14 males) with age range 40-60 years (mean±SD = 50±6.9).

Group II (MRI grade V): Included 16 patients (9 female and 7 males) with age range 40-60 years (mean±SD = 48.1±5.5).

Group III (MRI grade VI): Included 14 patients (3 female and 11 males) with age range 40-60 years (mean±SD = 51.0±7.0).

Group IV (MRI grade VII): Included 11 patients (3 female and 8 males) with age range 40-60 years (mean±SD = 51.1±6.8).

All studied patients were subjected to:

1- Full history taking.

2- Thorough clinical examination with pain assessment using Pain Visual Analogue Scale (PVAS) (which is self completed by the respondent) as the following:

- The respondent is asked to place a line perpendicular to the VAS line at the point that represents his pain intensity.
- Using a ruler, the score is determined by measuring the distance (mm) on the 10-cm line between the "no pain" anchor and the patient's mark, providing a range of scores from 0-100 mm (0-10 cm).
- A higher score indicates greater pain intensity. Based on the distribution of pain VAS scores in pre and post surgical patients who described their pain intensity as none, mild, moderate or severe. The following cut points on the pain VAS have been recommended: No pain (0-4 mm), mild pain (5-44 mm), moderate pain (45-74 mm) and severe pain (75-100 mm).

3- Routine laboratory investigations:

- Complete blood count (CBC).
- Liver and kidney functions.
- PT, PTT and INR.

4- Radiological examination:

1- X-ray:

1- Static: To measure the anterior disc height and posterior disc height then finding the ratio between them.

2- Dynamic: To measure the angle between each two adjacent vertebrae included in the study in flexion and extension then finding the difference between them.

2- Computerized tomography (CT) scan: to assess facet joint degenerative changes.

2- Magnetic Resonance Imaging (MRI) of the lumbar spine: to assess the morphology of the intervertebral disc using "**Modified Pfirrmann disc degeneration scale**" **[6]**:

Grade	Signal From Nucleus and Inner Fibers of Anulus	Distinction Between Inner and Outer Fibers of Anulus at Posterior Aspect of Disc	Height of Disc
1	Uniformly hyperintense, equal to CSF	Distinct	Normal
2	Hyperintense (>presacral fat and <CSF) +/- hypointense intranuclear cleft	Distinct	Normal
3	Hyperintense though <presacral fat	Distinct	Normal
4	Mildly hyperintense (slightly >outer fibers of anulus)	Indistinct	Normal
5	Hypointense (= outer fibers of anulus)	Indistinct	Normal
6	Hypointense	Indistinct	<30% reduction in disc height
7	Hypointense	Indistinct	30%–60% reduction in disc height
8	Hypointense	Indistinct	>60% reduction in disc height

5- Written informed consent was obtained from all participants and the study was approved by the research ethical committee of Faculty of Medicine, Zagazig University. The work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Statistical Analysis

The following statistical methods were used for analysis of results of the present study. Data were checked, entered and analyzed using SPSS version 19 (SPSS Inc., Chicago, IL) used in Windows 7 for data processing and statistic.

A- Descriptive statistics:

Data were expressed as number and percentage for qualitative variables and mean±standard deviation for quantitative ones.

Data were summarized using:

1- The arithmetic mean ($\overline{X}$) as an average describing the central tendency of observations:

$$\overline{X} = \frac{\Sigma X}{n}$$

Where:

Σ = Sum of

X = Individual data

n = Number of individual data.

2- The standard deviation (SD) as a measure of depression of the results around the mean:

$$SD = \sqrt{\frac{\Sigma(X-\overline{X})^2}{n}}$$

B-Inferential statistics:

1- The students "t" test for comparison of means of two independent groups.

$$"t" = \frac{\overline{x}_1 - \overline{x}_2}{\sqrt{\frac{SD_1^2 + SD_2^2}{n_1 + n_2}}}$$

Where

$\bar{x}_1$, $\bar{x}_2$ = the mean of the first and second groups respectively.

n_1 ,n_2 = number of the first and second groups respectively.

SD_1, SD_2 = the standard deviation of the first and second groups respectively.

The results of the "t" value was then checked using student "t" table at degree of freedom (df = $n_1 + n_2 - 2$) to find out the level of significance (P-value).

2- Chi-squared test (χ^2):

Used to find the association between row and column variables.

$$\chi^2 = \frac{\sum (O - E)^2}{E}$$

Where:

O = observed value

E = expected value = $\frac{\text{row total x column total}}{\text{Grand total}}$

df = degree of freedom

r = row

c = column

Mann-Whitney U test: was used for non-normally distributed data.

McNemar's test: for paired nominal data

P <0.05 was considered statistically significant (S).

P < 0.001 was considered highly statistically significant (HS).

P≥0.05 was considered non statistically significant (NS).

RESULTS

Results were collected, summarized, analyzed and tabulated in tables from (1) to (5).

Table (1) shows no statistical significant difference between the 4 groups regarding the demographic data.

No significant statistical difference between the four groups regarding LBP frequencies, sciatica distribution full motor power or SLR. Neurological examination findings and PVAS scores showed significant statistical differences (P = 0.01, 0.0001) respectively among four groups (Table 2).

Table (3) shows the differences between the 4 groups regarding disc height (DH) ratio and angle difference which were statistically significant with P = 0.001 and 0.04 respectively, while there were significant statistical difference regarding facet degeneration grades except for grade 0 and III between group I (MRI grade IV) and group III (MRI grade VI).

By correlating PVAS to disc height ratio (DHR) and CT facet arthropathy grade, it was found that the correlations were positive, highly significant with P=0.001 (Table 4).

Regarding the relation between Angle difference and DHR there was negative significant correlation (r = -0.17, P<0.05) while the correlation with CT facet grades was significant positive (r = 0.24, P = 0.008) as shown in Table (5).

Table 1. Demographic data of the studied patients in the included MRI grades.

	Group I (Grade IV) n = 19		Group II (Grade V) n = 16		Group III (Grade VI) n = 14		Group IV (Grade VII) n = 11		F	P
Age (years)										
X̄±SD	50.5±6.9		48.1±5.5		51.0±7		51.1±6.8		0.5	0.7
Range	40-60		40-60		41-60		40-60			NS
	N	%	N	%	N	%	N	%	X^2	P
Sex										
Female	5	26.3	9	56.2	3	21.4	3	27.3	5.28	0.15
Male	14	73.7	7	43.8	11	78.6	8	72.7		NS

SD: Standard deviation X^2: Chi square test NS: Non significant P>0.05

Table 2. Relation between clinical data and MRI grades.

	Group I (Grade IV)		Group II (Grade V)		Group III (Grade VI)		Group IV (Grade VII)		X^2	P
	N	%	N	%	N	%	N	%		
LBP										
No	3	15.8	2	12.5	0	0.0	0	0.0	4.02	0.25
Yes	16	84.2	14	87.5	14	100.0	11	100.0		
Sciatica										
RT	2	10.5	4	25.0	2	14.3	0	0.0		
LT	4	21.1	1	6.3	1	7.1	1	9.1	5.96	0.4
Bilateral	13	68.4	11	68.8	11	78.6	10	90.9		
Neurological exam										
Full power	19	100.0	16	100.0*	11	78.6	7	63.6		
Ankle dorsi flexion										
Grade 3	0	0.0	0	0.0	1	7.1	0	0.0	16.95	0.01
Grade 4	0	0.0	0	0.0	1	7.1	3	27.3*		**
Ankle planter flexion grade 4	0	0.0	0	0.0	1	7.1	1	9.1		
SLR										
X̄±SD	36.3±7.6		36.6±7.7		38.6±7.7		36.9±7.8		0.26	0.85
Range	30-45		30-45		30-45		30-45			NS
PVAS										
X̄±SD	4.9±1.7		6.0±1.0		7.2±0.9		9.3±1.0		30.1	<0.0001
Range	2-7		4-7		6-9		7-10			**

LBP: Low back pain SLR: Straight leg raising PVAS: Pain visual analogue scale

Table 3. Radiological (X-ray and CT) findings of studied patients in the included MRI grades.

	Group I (Grade IV)		Group II (Grade V)		Group III (Grade VI)		Group IV (Grade VII)		F	P
X-ray:										
1-DH ratio										
$\bar{X}$±SD	1.1±0.13		1.76±.3		2.8±0.4		4.5±0.7		54.8	<0.001
Range	1-1.42		1.3-2.1		2.1-3.5		3.7-5.52			**
2-Angle Diff.										
$\bar{X}$±SD	10.3±4.88		9.4±5.2		10.7±7.3		6.76±3.6		2.82	0.04*
Range	1.12-21.62		1.67-21.22		0.94-24.04		0.17-17.11			
CT:										
Facet arthrophy grade	N	%	N	%	N	%	N	%	X^2	P
0	5	26.3*	2	12.5	0	0.0	0	0.0	31.78	0.001
I	9	47.4	9	56.3	2	14.3	0	0.0		
II	5	26.3	5	31.3	7	50.0	6	54.5		
III	0	0.0	0	0.0	5	35.7*	5	45.5		

DH: Disc height Angle Diff.: Angle difference

Table 4. Correlation between PVAS and DH ratio/CT findings.

	PVAS		
	r	**P**	**Sig.**
DH ratio	0.76	<0.001**	HS
CT grade	0.63	<0.001**	HS

Table 5. Correlation between angle differences and both DH ratio and CT facet grades.

Variable	Angle difference		
	N	**r**	**P**
DH ratio	122	-0.17	0.04
CT facet grades	122	0.24	0.008

DISCUSSION

Disc degeneration-Aging relationship is a matter of natural course. Disc degeneration may be attributed to longstanding upright position that is thought to produce huge mechanical stresses on the vertebral column**[7]**.

Lumbar spine instability can be defined as an abnormal motion to physiologic loads leading to wider than normal motion range which may be a result of degenerative processes of the disc and facet joint**[8]**.

Disc degeneration may be a leading cause of low back pain [LBP] which is a prevalent medical problem with a significant proportion being of mechanical origin and is often referred to as instability**[9,10]**.

Certain movement associating pain i.e. a mechanical component to the back pain may indicate instability or degenerative fracture**[11]**.

This study was designed in a trial to investigate and evaluate the relation between lumbar degenerative disease [LDD] and lumbar instability in patients complaining of LBP and/or sciatica.

Sixty patients [20 females and 40 males] with ages ranged from 40-60 years [mean±SD = 50.1±6.65] were included. They were complaining of LBP and/or sciatica. As MRI is considered as mainstay in lumbar spine degenerative disease and LBP assessment**[12]**, all sixty patients underwent lumber spine MRI to assess the morphology of the intervertebral discs.

Using modified Pfirrmann disc degeneration scale**[13]** the studied patients were categorized into 4 groups based on the MRI grading. **Group I [Grade IV]:** 19 patients [5 females and 14 males] with age mean±SD = 50.5±6.9. **Group II [Grade V]:** 16 patients [9 females and 7 males] with age mean±SD = 48.1±5.5. **Group III [Grade VI]:** 14 patients [3 females and 11 males] with age mean±SD = 50.0±7. **Group IV [Grade VII]:** 11 patients [3 females and 8 males] with age mean±SD = 51.1±6.8.

By analyzing the demographic data [sex and age] among the 4 groups, it was found that sex distribution had no statistical significant difference [P>0.05] [Table I] which is almost agreeing **[14]** who reported that no significant difference in disc degeneration in all spine level between sexes with some exception of the level of C2-3, T6-7 and L4-5. In a different manner, **Martinez et al. [15]** reported that although men likely start degeneration process ten years earlier than women, surprisingly, women are almost more susceptible to the degeneration effects such as malalignment or instability which was agreed by **Abi-Hanna et al. [16]**. In contrast **Elena et al. [1]** recorded that degenerative disc disease [DDD] is more prevalent in men which may be explained by the heavy works of males than females.

Also, there was no significant statistical difference between 4 groups regarding age in this study [P>0.05] differing from **Oh and Yoon [7]** who considered aging is the main pathogenetic factor of disc degeneration, they divided their studied patients according to the one's decades of life and Pfirrmann disc grades in all the spine levels and showed that grade III was in 2nd and 3rd decades while grade IV was more common in over 6th decade. Collectively, they concluded that sex difference, linked to age, affecting disc degeneration was considered to the motion segments as C3/4, L4/5 and L5/S1 until 5th decades, and thoracic segments after 6th decades. The difference between these results and the current study results may be due to difference in the studied numbers of patients and the scale of age decades.

Low back pain [LBP] and sciatica frequencies were compared among different grades of disc degeneration [DD] of this study groups, the percents were 84.2%, 87.5%, 100% and 100% in groups I, II, III, IV, respectively while sciatica percents were 68.4%, 68.8%, 78.6% and 90.9%, respectively and was predominantly bilateral [TableII] the findings which are in concordance with that of **Majid et al. [17]** who recorded LBP in their studied lumber stenosis patients with degenerative instability with a percent of 97.6% and radicular pain of 93.1% which was mostly bilateral. **Katariina et al. [18]** in a cross-sectional magnetic resonance imaging [MRI] study recorded an increased risk of LBP in relation to all signs of disc degeneration.

The straight leg raising [SLR] test is a clinical method used commonly to examine lumbasacral region and demonstrate lumbosacral radicular irritation **[19]**. In this method, the patient lies supine having his fully extended leg passively stretched from 0 : 80°. It is considered positive when pain is elicited when the angle to which the leg is raised is ≤ 45°.

By neurological examination, full motor power frequencies and [means ± SD of SLR] were 100%, 36.3±7.6, 100% and 36.6±7.7, 78.6% and 38.6±7.7 and 63.6% with 36.9±7.8 in the four groups, respectively with no statistically significant difference between the different disc degeneration grades of these groups regarding either of the two items [P>0.05] [Table II], but the angles' mean in all groups indicates sciatica associated with all grades of LDD as these values were lower than that of patients without sciatica or nerve root irritation which , as recorded by **Dan [20]** was 70°-90° of hip flexion.

To study pain as a complaint of most of the included patients, Pain Visual Analogue Scale [PVAS] **[21]** was applied to all groups to evaluate pain intensity. PVAS is self completed by the respondent who is asked to place a line perpendicular to the VAS line at the point that represents the pain intensity.

The means of VAS scores of the studied groups were present in the mild pain area which cutoff range is 5-44 cm, group I [grade

IV] had the lowest mean [4.9±1.7] and group IV [grade VII] had the highest one [9.3±1.0] with statistically significant difference between them [P=0.0001], the results which may indicate positive correlation between pain intensity and disc degeneration [Table II]. These results are not in agreement with **Yasuchika et al. [22]** as it was reported in their study for evaluation of non specific LBP that disc degeneration is commonly observed in patients with no LBP, suggesting that the correlation between disc degeneration and back pain is an area of debate.

Spinal stability depends on three functionally interdependent subsystems; Active: including muscles and tendons, Passive: including vertebral bodies, facet joints and their capsules and spinal ligaments and the third is the Neural control subsystem: including the various transducers and neural control centers. Spinal stability is maintained both in neutral or extreme positions by these three subsystems **[23]**.

The complex anatomical structures of the intervertebral discs are important for vertebral column mobility, and they are strong participant in anchoring vertebrae to each other, also distributing the pressure that results from the entire trunk movement **[24]**.

Degenerative process passes through three phases: Dysfunction, Instability and Restabilization **[5]**. Disc height change is one of the radiological findings indicating instability **[Jang et al., 2009]**. Disc height diminution is one of the criteria of transformation of the degenerative process from the first phase [temporary dysfunction] to the unstable phase, as this diminution with laxity of ligaments and joint capsule and facet joint cartilage degeneration are the causative pathogenetic factors of abnormal mobility and unstability of the affected motion segment **[25]**.

In the current study disc heights [anterior and posterior] were measured using X-ray and disc height ratios were calculated and compared between the studied groups representing 4 of MRI degenerative grades. The means±SD of disc height ratio among groups I, II, III, IV were 1.1±0.13, 1.76±0.3, 2.8±0.4 and 4.5±0.7, respectively showing significant difference between them [P<0.05] [Table III]. These results suggest a correlative association between the disc height ratio and the degenerative process. In a study carried out by **Tesuhiro et al. [26]** to investigate the relationship between spinal degeneration and instability, they measured the disc heights among 637 outpatients complained of LBP and/or leg pain, their results indicated that disc height was intimately related to instability factors, with correlating disc height with DD grading they recorded that grade II had the heighest one followed by grade I then III, IV finally V with significant diminution of disc height among grade V than other grades. These results are almost agreeing the results of the current study inspite of using disc height ratio instead of absolute disc height. **Kong et al. [27]** insisted that there is a close correlation between the disc degeneration and instability while **Mc Gregor et al. [28]** and **Soini et al. [29]** disputed this. These differences of researchs' results and the controversy about the degeneration of the motion segment and instability may be attributed to different numbers of studied patients and different ages of them.

CONCLUSION

Low back pain and/or sciatica are prominent complaints resulting from lumbar degenerative disease. Determining whether these manifestations are related to instability or not remains challenging.

It was found that the severity of low back pain is directly correlated with the grade of disc degeneration found in MRI and both are directly correlated with the disc height ratio and angle difference measured in X-ray and the degree of facet arthropathy seen in C.T.

Recommendations

MRI grade of disc degeneration, disc height ratio and angle difference in X-ray and facet arthropathy grade in C.T. can be used as indicators of instability in patients complaining of low back pain.

Conflict of Interest: Nothing to declare.
Financial Disclosures: Nothing to declare.

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