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Original Article

Relationship between disc degeneration and facet joint arthrosis-a MRI study

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ABSTRACT

Introduction: Spinal degeneration includes degenerative changes occurring in the anteriorly located fibro-cartilaginous intervertebral discs and posteriorly placed synovial facet joints. The stability of each spinal motion segment is dependent on both these components. Thus an MRI based study on low back pain subjects was undertaken to assess the association between disc degeneration (DD) and facet joint arthrosis (FJA).
Materials & method: The study was conducted on 50 low back patients selected on the basis of predefined questionnaire and taken up for MRI assessment for grading disc degeneration and facet joint arthrosis. The severity of DD and FJA was evaluated at each motion segment and assessed with respect to gender, spinal level and the interdependence of disc and facet joint degeneration was defined.
Results: The degeneration process at the disc and facet joint was independent of gender ($p > 0.05$) but dependent on the spinal level ($p < 0.05$). Disc degeneration was seen at the caudal most level while facet joint degeneration was seen in the L4–L5 spinal level. FJA was evident even without evidences of disc degeneration and no significant association was observed between discs and the facet joints.
Discussion: The role of small facet joints should not be overlooked while defining low back pain etiology as these joints play a significant role in load transmission and rotational kinematics. This knowledge can be of help in defining appropriate treatment modality for better patient care.

1. Introduction

The intervertebral discs (IVDs) are an integral part of vertebral column and play a significant role in maintaining spinal integrity, flexibility, mobility and stability. The discs are cushions of fibro-cartilage that resist spinal compression while permitting limited movements.[1] The effects of structural changes of the discs on spinal stability and mobility have been studied extensively by earlier researchers and it has been stated that changes in disc morphology renders the spinal motion segment more flexible.[2–4,1] However these disc changes have been studied irrespective of facet joints which are also an important component of spinal motion segment.

Facet joints are the typical diarthrodial joints and bear normally 3%-25% of segmental load which increases up to 47% with the onset of disc degeneration.[5] The extensive work of Kirkaldy and Farfan provided the concept of “three joint complex” where the IVD and the two facet joints act as anterior and posterior joints respectively to stabilize each motion segment.[6,7] These three joints together bear the segmental load, dividing into two components- the compression component, borne by the IVDs, occurring in plane perpendicular to the discs and the shear or rotational component, borne by the facet joints, occurring in a plane parallel to the disc.[8] This suggests an interdependence of discs and the facet joints highlighting the fact that the degenerative changes at one joint cause similar changes to occur at the other joint, together termed as “Tripod Effect”.[7]

Each IVD is made up of peripherally arranged multilayered type I collagen fibers referred to as annulus fibrosus and the inner gelatinous material constituted mainly of type II collagen fibers called nucleus pulposus (NP). In a normal motion segment where the discs are intact, the NP bears the compressive load and consequently load is transferred to peripheral fibers of annulus fibrosus (AF).[9] During abnormal load bearing and sudden extensive rotational movements, there occur tears in the AF which may further progress to fraying and dehydration of NP with eventual

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loss of annular- nuclear distinction.[10,3,4] These pathologic alterations result in substantial changes in anatomy and physiology of the disc. In cases where the discs get degenerated, the load is distributed asymmetrically transmitting a higher load to the posterior components, potentially precipitating facet joint arthrosis. Yang and King predicted a significant rise in facet joint loading pressure with increasing segmental degeneration using a finite element model of disc degeneration.[11]

There is general acceptance that spinal pain often originates due to altered morphometry and morphology of the discs and various therapeutic interventions are directed towards the disc, for pain relief. Majority of these treatment for the painful discs have however have met with inconsistent and unpredicted outcomes, at times with persistent complaints of low back pain, referred to as Failed back surgery syndrome where the incidence has been reported to be as high as 10%–40%.[12] This generated the concept of defining degeneration of facet joints in association with disc degeneration, to help develop more specific and effective therapeutic and surgical approaches for low back pain management.

2. Materials and Method

The present study was conducted in the departments of Radiodiagnosis of Santosh Medical College, Ghaziabad and Safdarjung Hospital, New Delhi. The requisite institutional ethical clearance was obtained and the participants were chosen after a written informed consent. The participants consented and enrolled were provided by a predefined questionnaire prepared on the basis of Nordic low back pain questionnaire[13] and only subjects with definite symptoms and signs for low back pain were taken up for magnetic resonance imaging on Philips Achieva 1.5 Tesla MRI scanner. T2W images with 256×304 image matrix FOV 240 mm and slice thickness of 4 mm with 0.5 mm inter-slice gap was used. A total of 50 low back pain subjects of mean age 43.14 ± 13.84 years including 23 males and 27 females were evaluated. The lower three spinal levels were observed and the images obtained were interpreted on the image analysis software.

Disc degeneration and facet joint arthrosis were graded separately for each motion segment. Disc degeneration was graded into five grades based on Pfirrmann's criterion using T2-weighted sagittal Images[14] (Fig. 1). The criterion taken into consideration included the disc height, degenerative status of annulus fibrosus and nucleus pulposus, vertebral body and annular-nuclear distinction. Grade I represented normal whereas grade V indicated most severe form of disc degeneration.

The classification proposed by Pathria et al. was used for evaluation of facet joint arthrosis.[15] The joint space, sub chondral bone sclerosis, presence of osteophytes and bone cysts were determined. Grade 0 represented a normal facet joint whereas grade IV indicated severe facet joint arthrosis (Fig. 2). When different grades were observed for both right and left side of the same motion segment, the higher grade was used for data analysis.

Statistical analysis was performed using SPSS statistical software. The difference in age distribution between genders was evaluated using chi square test. The difference in grades of disc degeneration and facet joint arthrosis between genders was analyzed using Mann-Whitney *U* test and those among spinal segments were assessed using Kruskal-Wallis test. The association between disc degeneration and facet joint arthrosis was determined by Spearmann rank correlation.

3. Results

A total of 150 motion segments including 69(46%) male and 81 (54%) female segments were observed for degenerative changes. There was no statistical significant difference of age between genders (male: mean age = 41.91 ± 13.1 years and female: 44.19 ± 14.2 years; $p > 0.05$ at 95% CI).A total of 86 (57.33%) of motion segments were observed to have degenerated disc, which included 39(45.34%) male and 47(54.46%) female segments. The difference between genders for disc degeneration was found to be statistically non significant. Out of total 150 motion segments, 134 (89.33%) showed facet joint arthrosis, which included 65(48.51%) males and69 (51.49%) female segments with p value >0.05 (non significant for gender). The frequency of different grades of disc degeneration and facet joint arthrosis is shown in Table 1.

The severity grades of DD and FJA were statistically compared between genders and non significant ($p > 0.05$) values were obtained suggesting that severity of disease is gender independent. Though, for both the conditions the higher mean rank was observed for females suggesting that females have more severe forms of arthrosis and disc degeneration than males.

The different grades of DD and FJA were plotted with respect to spinal levels and the results are shown in Fig. 3(A) and Fig. 3(B).

There was statistically significant difference in grades of DD and FJA by spinal levels ($p = 0.036$ and 0.043; $p < 0.05$ respectively).The

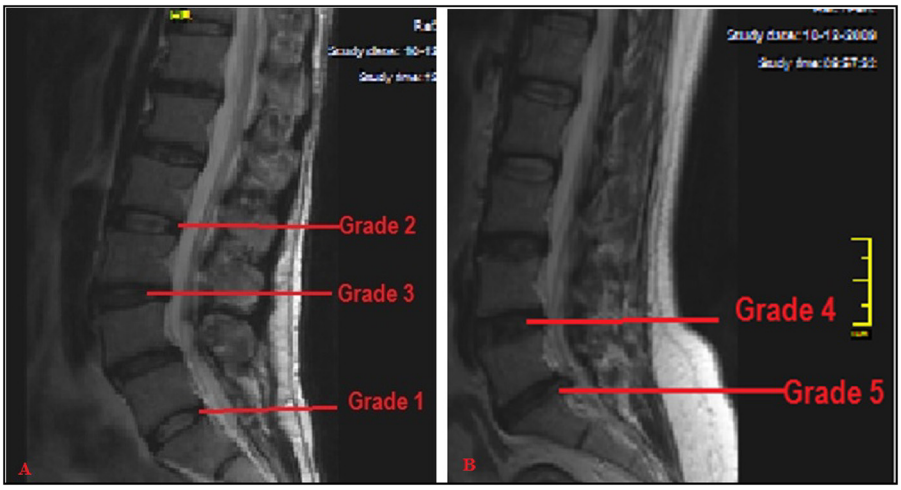

Fig. 1. Disc Degeneration grades (Grade 1–5).

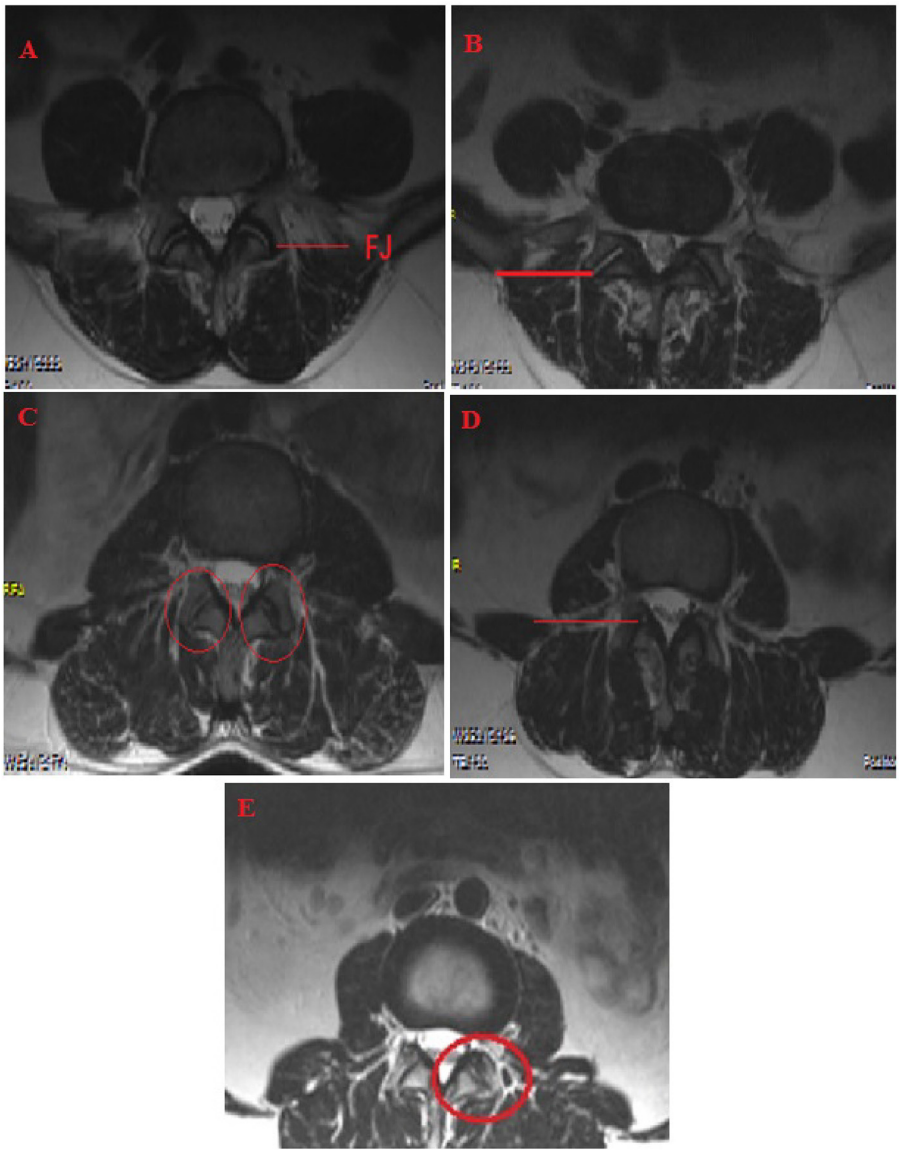

Fig. 2. Facet Joint Arthrosis grades A-Grade 0,Normal joint space; B-Grade 1,Hypersclerosis of joint margins; C-Grade 2,Decreased joint space; D-Grade 3,Small osteophytes; E-Grade 4,Complete arthrodesis.

Table 1
Gender distribution of different grades of DD and FJA.

	Gender	Grades of disease					
Disc Degeneration		Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	P value
	Male	30 (43.4%)	15 (21.7%)	6 (8.7%)	12 (17.5%)	6 (8.7%)	p-value is 0.239 NS
	Female	34 (41.9%)	17 (20.9%)	11 (13.7%)	6 (7.5%)	13 (16%)	
	Total	64 (42.6%)	32 (21.4%)	17 (11.4%)	18 (12%)	19 (12.6%)	
Facet Joint Arthrosis		Grade 0	Grade 1	Grade 2	Grade 3	Grade 4	p-value is 0.222 NS
	Male	4 (5.8%)	19 (27.5%)	27 (39.1%)	18 (26.1%)	1 (1.5%)	
	Female	12 (14.8%)	15 (18.5%)	26 (32.1%)	25 (30.9%)	3 (3.7%)	
	Total	16 (10.7%)	34 (22.7%)	53 (35.3%)	43 (28.7%)	4 (2.6%)	

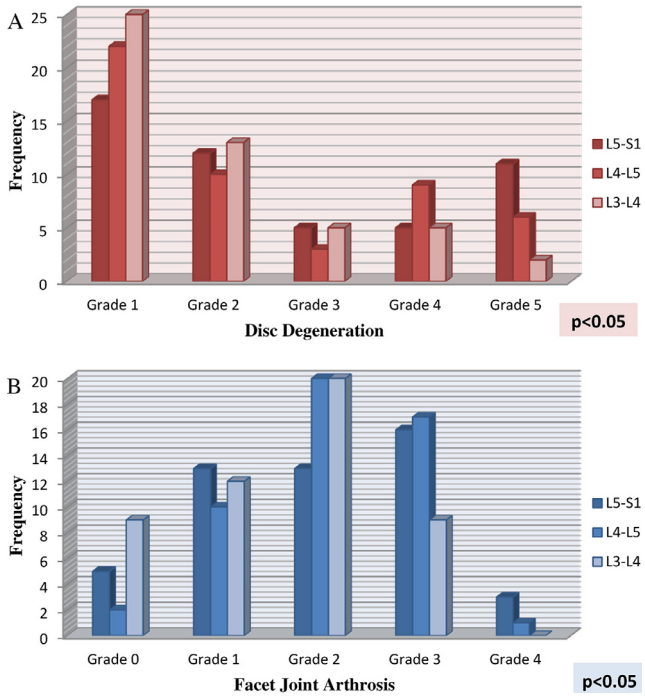

Fig. 3. Severity grades of DD and FJA and spinal levels.

Table 2
Mean rank at each spinal level for DD and FJA.

Spinal level	Mean rank for DD	Mean rank for FJA
L5-S1	85.31	80.02
L4-L5	77.09	82.94
L3-L4	64.10	63.54
P value	**<0.05 Sig**	**<0.05 Sig**

highest mean rank for DD was observed at L5-S1 spinal level while for FJA it was at L4–L5 spinal level (Table 2).

Of the total 140 diseased segments, 57.9% were with concurrent occurrence of DD and FJA, 38.7% with only FJA, 3.5% with only DD as shown in Fig. 4.

The correlation coefficient between DD and FJA was 0.09 and the association between the two variables was considered statistically non significant ($p = 0.242$; $p > 0.05$)

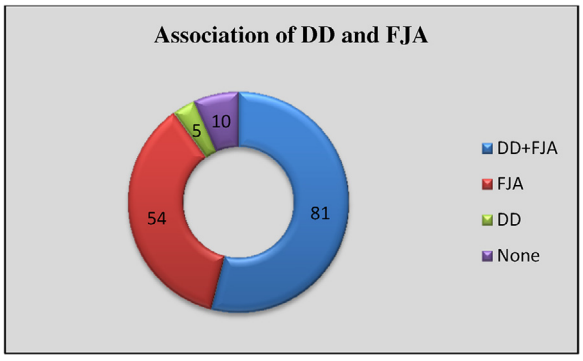

Fig. 4. Frequency representation for association of DD and FJA.

4. Discussion

Low back pain is a well known factor affecting the quality of life.[16] In recent times newer imaging modalities have provided better insight to the anatomical changes occurring in the spine that lead to morbidity and loss of functionality.[17] The MRI with its unique property of utilizing non ionizing radiations has almost replaced standard radiography and supplemented CT scanning for proper diagnosis of low back pain. Its value in assessing normal anatomy of lumbar spine viz: internal disc chemistry, architecture, features of lumbar spine degeneration, and in diagnosing herniated lumbar discs has been well documented.[18] Since this technique is efficient in diagnosing both degenerative changes in osseous and soft tissue components of spine, this technique was used in the present study to evaluate the degenerative changes of discs and the facet joints.

Low back pain is multi-factorial in origin and has been reported in higher proportion in females than in males.[19–21] The LBP prevalence in our study population confirmed this similar phenomenon of low back pain distribution where questionnaire evaluation confirmed higher prevalence in females than males (female vs male = 54% vs 46%). Disc degeneration has been documented as the main contributor of low back pain and is suggested to alter people's work and quality of life.[22] West et al. in their MRI based study on degenerative process of lumbar disc concluded that gender did not affect the presence and extent of disease.[23] Another study by Siemionow et al. on 1712 lumbar disc also stated that there was no statistical difference between males and females in degeneration grades at any lumbar level.[24] In the present study though the prevalence of DD was evident more in female subjects but the difference between genders was found to be statistically non significant ($p > 0.05$). A radiographic assessment of lumbar intervertebral discs by Evelien et al. also stated a higher prevalence of DD in females.[25] The higher prevalence in female gender could be due to the effect of female hormone on the process of degeneration. There have been various earlier studies that suggest that estrogen, the female hormone, plays a significant role in both etiology and pathophysiology of various musculoskeletal disorders.[25–27] The same possible explanation may hold true for intervertebral discs derived from the same embryological source.[28]

Apart from discs, there are evidences and studies in literature to substantiate that the facet joint is also potential cause of pain.[29–31] A similar result is evidenced in our study where LBP is experienced even in subjects with no evidence of DD. Many studies on the degenerative sequences of spine have suggested that disc degeneration is the initial step in the degeneration cascade followed by altered biomechanics causing subsequent facet joint arthrosis. Vernon-Roberts and Pirie dissected more than 100 lumbar spines and concluded that disc degeneration was the primary event leading to osteophyte formation and to facet joint changes.[32] On the other hand, Lewin concluded that disc degeneration did not seem to be the sole or dominant factor predisposing to the onset and development of osteoarthritis of the lumbar synovial joints.[33] Butler et al. used MRI to determine disc degeneration and CT scans of the same patients to determine the occurrence of facet joint osteoarthritis, and concluded that discs degenerate before facets.[34] On the other hand, Videman et al. showed that in 20% of degenerative spines, facet degeneration preceded disc degeneration.[35] The similar results were obtained in our study where about 38.7% of low back pain subjects had no evidence of disc degeneration but different severity grades of facet joint arthrosis. The correlation coefficient for severity grades of DD and FJA in our study sample also suggests no significant association between disc degeneration and facet joint arthrosis. Our study hence does not support the hypothesis that disc degeneration precedes facet joint arthrosis.

The severity of degeneration of spine varies with spinal level. The highest grade of DD was seen at L5-S1 vertebral level. This may be due to high grade of compressive forces at this vertebral level, as has been postulated by Oxland on spinal biomechanics related to L5-S1 level.[36] The increase in sacral angle also alters the anterior shear forces on the inter vertebral discs causing severe degeneration at the lumbosacral angle.[37,36] For facet joints, the process of degeneration is similar to that occurring in any other synovial joint in the body. There occurs cartilage degeneration with formation of diffuse erosions and sclerosis of joint margins.[38] A CT based study on lumbago patients suggests that the commonest vertebral level to be affected by arthrosis is L4–L5.[31] A study by Tischer et al. conclude that the most severe form of arthrosisis seen at L4-L5 level and same is seen in the present study.[39] This could be due to the fact that L5-S1 motion segment is considered a more stable joint due to presence of strong lumbosacral ligaments providing it more stability with very limited mobility.

5. Conclusion

In this MRI based study, low back pain is associated with not only DD but also FJA. There occurs no significant association between both degenerative conditions but simultaneous occurrence in 60% of study sample prompts that before planning a surgical procedure like a decompressive surgery or disc arthroplasty, the assessment of facet joint arthrosis should be taken into consideration for effective treatment and better post operative prognosis.

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