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ROLE OF MAGNETIC RESONANCE IMAGING IN EVALUATING DEGENERATIVE LUMBAR SPINE INSTABILITY

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Abstract

Background: Lower back pain, it is one of the 10 most frequent reasons for visiting a family doctor, and at least 85% of the population will experience low back pain at some point in their lives. Instability here means the absence of stability in a mobile vertebral segment. This disorder represents the most common cause of work-related disability and state disability services costs among individuals aged less than 45. Low back pain is a common clinical condition, and lumbar instability plays an important role in the decision for surgery, such as vertebral fusion with decompression. **Purpose:** The purpose of this study is to determine the magnetic resonance imaging findings suggestive for instability in the lumbar vertebrae.

Patients and methods: We reviewed the MRI studies of the lumbar spine of 48 patients with backache who had functional dynamic radiographs proved that they have lumbar spinal instability. In each study, we classify grade of facet arthropathy, Modic changes, spondylolisthesis, disc degeneration, and presence of osteophytes and annular tear, and we correlated between them

Results: We review 48 MRI studies of patients with lumbar instability, 28 (58%) patients was female and 20 (42%) was male. We found most patients had grades II and III facet arthropthy (81.2%), grade I Spondylolisthesis (77.1%), Modic changes type II (41.7%), grade IV and V disc degeneration (75%), annular tear (79.2%), and osteophytes (66.7%). We found that facet arthropathy has a correlation with the disc degeneration degree ($p < 0.05$), with the presence of osteophytes ($p < 0.0325$) and with the most affected segment ($p < 0.001$). Likewise, disc degeneration was correlated significantly with the Modic changes ($p < 0.01$) and with marginal osteophytes ($p = < 0.01$), while no significant correlation between osteophytes and Modic changes ($p > 0.19$).

Conclusion: MRI can accurately assess the structures that maintain lumbar stability.

1. INTRODUCTION

Lower back pain, it is one of the 10 most frequent reasons for visiting a family doctor. It is considered that it occupies the second cause of consultation in orthopedics, the fifth of hospitalization and the third of surgical interventions. An 85% of people at some time in their life are affected and it presents itself in both sexes equally, with a peak of predominance between 30 and 40 years of age. Regarding to the duration of symptoms, low back pain may be acute (< 6 weeks), subacute (6 to 12 weeks), and chronic(> 12 weeks)[(1)]. In 5-25% it appears acute back pain, of which 90% remits in 6 weeks and 10% becomes chronic; is the most competitive and expensive reason of work-related disability under 45 years[(2)]. Medical direct costs have been estimated between 12.2 and 90.6 billion in the US per year[(3,4)].The elements of the vertebral column should be relatively rigid and incompressible to support the trunk and limbs, strong enough to protect the spinal cord and cauda equinaas well as, to have some flexibility to allow movements in different directions. These features either isolated or in combination, can lead to many problems, mainly in the lumbar region. Low back pain have been associated with innervation spectrum : the anterior vertebral elements formed by the disc and the annulus fibrosus, the anterior longitudinal ligament, the posterior longitudinal ligament, the vertebral body, the epidural plexus and the dura; and the posterior vertebral elements that involve the facet joints, the spinous process, the ligamentum flavum, and the posterior muscles[(5)].There are four types of problems that can produce low back pain: pain from the affected vertebral segment, compression of nerve roots, instability, and disk involvement. Unstable lumbar segment is a major factor in chronic low back pain and often it plays the role to decide surgical indication for spinal fusion and decompression[6].

The spine is can be divided into segments, which are described as "segments of movements or mobility" composed of 2 vertebrae and the soft tissue structures between them (the disc, ligaments and muscles). Vertebral stability is the ability of the vertebrae to keep their relationships and minimize or inhibit their movements through posture activities and physiological stresses, so that premature mechanical and biological aging of its parts should be prevented. Lumbar spine stability It is retained by the interactions among discs, joints, ligaments and muscles.

Vertebral stability is defined as the extent of a vertebra's ability to keep its relationship with fellow vertebra and control relative movements at it during these postures and physiological stresses, so it is crucial to prevent premature mechanical' as well as biological breakdown in the components of this unit. The stability of the entire lumbar spine is ensured by an interaction between discs, joints, ligaments and muscles ([7]. The movement segment stability is impaired due to degenerative changes of disk and facet joints. Even though Segmental instability is often. used as parallel to degenerative spondylolisthesis, and it is obvious that there are a number of other pathologies which can be unstable (acute. trauma, surgery, spondylolysis, tumors or infection)[8].According to the specialist, there are different interpretations; one of them suggests as an acceptable model for a loss of stability of the mobile column followed by an abnormal movement with greater displacement than in a normal segment and abnormalities (pain and deformity) resulting from force being placed on this level. These abnormal movements are explainable by the disruption in the support structures (Facet joints, disc, ligaments and muscle), if they are damaged or have more laxity than they alter balance and merit instability. Biomechanically, the term "stability" is established in relation to the load acting on a structure and its response in terms of motion. This load can be from posture and body mass (preload) or different physical or physiological charges. The mobile segment of the spine may be regarded as the minimal functional unit of the spine. It has fluid properties (viscosity), and solid properties (elasticity), these allowing deformation and gradual recovery, respectively loading and unloading from which it energy absorbs of six degrees of freedom movements[9].Diagnosis of vertebral instability is frequently based on the identification of images depicting abnormal movement of vertebrae. May be associated with x, y and z axis abnormal translation or rotation according to the 3D systems coordinate system proposed by Panjabi et al. where(the x axis is horizontal, lying from left to right within the coronal plane; the y-axis is vertical or cranial-caudal; and the sagittal z -axis is horizontal from front to back). The instability is usually multidirectional. The displacements are in sagittal direction (front to back, z-axis) and coronal direction (side-to-side, x axis), with the axial plane displacements[10]. They are evaluated in images by computerized tomography or magnetic resonance imaging (MRI). In the neutral radiography projection. Several findings have been proposed, such as a vacuum phenomenon, degeneration of the disc, osteosclerosis, traction osteophytes with the appearance of spurs or claws, translation vertebral $\geq$ 4.5 mm, short transverse processes of L5 and an intercrestal line thatgoes to level L5 or lower. At present, MRI is the most beneficial diagnostic toolf or degeneration abnormalities. In our study we focused more on discogenic origins,as an annular tear or formation of marginal osteophytes, as well as changeson the terminal platforms of the vertebral bodies (Modic types) and arthropathy of the facet joints[11,12].

The aim of current study is to determine the magnetic resonance findings of lumbar vertebral instability.

2. MATERIAL AND METHODS

It is a descriptive prospective observational study. We reviewed the MRI studies of the lumbar spine of 48 patients with backache who had functional dynamic radiographs proved that they have lumbar spinal instability. Study was done in Imam Hussein teaching hospital in Nasiriya city/Iraq. Patients were referred from different departments including orthopedics, rheumatology, neurology, and neurosurgery departments. We use a 1.5T MRI scanner (Philips, Achieva) with a spinal array surface coil. Sagittal, coronal, and axial Tl and T2 weighted imaging of the lumbar spine were acquired by using a fast spin-echo sequence. We excluded patients with history of previous surgery to the spine, those with other spine disease (like trauma or infection), and patients with history of tumor affecting the spine. Osteoarthritis or lumbar facet arthropathy was classified, according to the degrees of Pathriainto0, I, II and III (Table 1 and Fig. 1); The changes inthe terminal platforms were classified, agreement with Modic, in types I, II and III (Table 2and Fig. 2,3); and disc changes due to degenerative diseasethey were classified, according to Pfirrmann,in five degrees (Table 3). The spondylolisthesis was classified, according to Meyerding, in grade 1 that is less than 25%,grade 2 that is 25-50%, grade 3 that goes from 50 to 75%, grade 4 which is considered75-100%, and grade 5 that is complete (spondyloptosis)(Fig. 4,5). All the variables are studies in SPSS statistical program using Chi square test and Pearson correlation, a p-value <0.05 was considered statistically significant.

Table (1): Classification of lumbar facet arthropathy according to Pathria

GRADE	CRITERIA
0	**Normal intervertebral foramen: The normal dorso-lateral edge of the vertebral disc and the foramina epidural fat (oval or inverted pear-shape)**
1	**Mild foramina stenosis, and deformation of epidural fat and the remnant of fat completely encircling the normal nerve root.**
2	**Marked foraminal stenosis, the epidural fat just partially surrounding the nerve root.**
3	**Advanced stenosis with the whole epidural fat obliterated.**

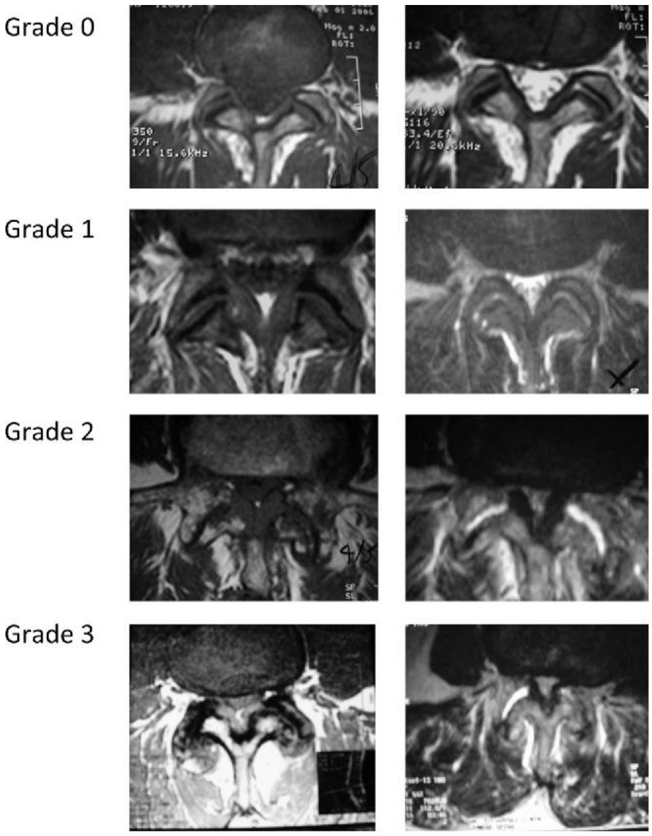

Figure (1): MRI appearance of each grade of lumbar facet arthropathy according to Pathria classification

Table (2): Modic classification of degenerative changes of vertebral end plates.

Types	CRITERIA
I	**Hypointensity in T1 and hyperintensity in T2. This correlates with microfracture, edema and tissue vascularized fibrogranulose**
II	**Hyperintensity in T1 and isointensity or hyperintensity in T2. Indicates fat infiltration and demineralization bone of the subchondral spongy bone**

III	**Hypointense in T1 and T2. Represents bone sclerosis changes with regeneration and remodeling of the subchondral bone**

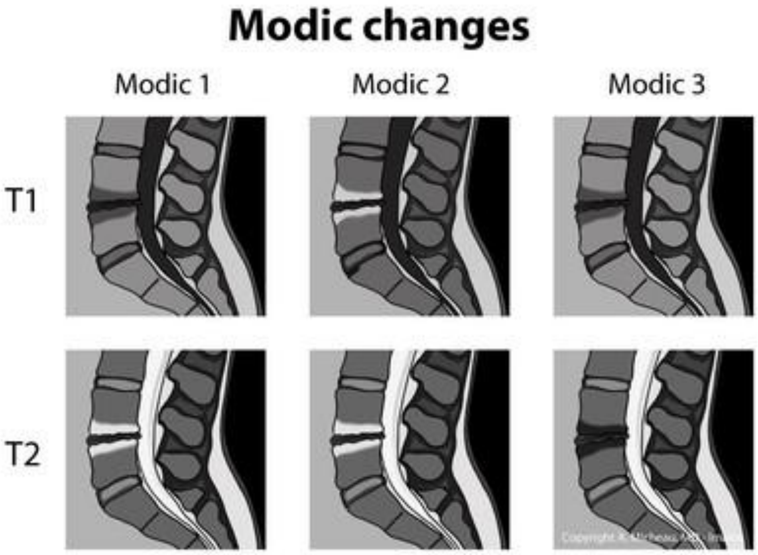

Figure (2): T1 and T2 MRI appearance of each type of Modic changes

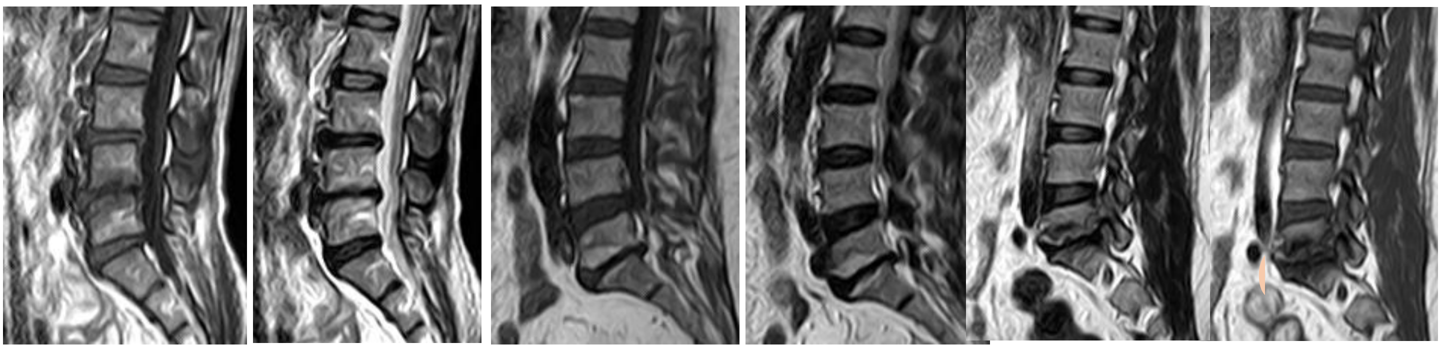

Figure (3): shows types of Modic- changes, A: type- I, B: type- II, C: type- III

Table (3): Pfirrmann classification for the degree of disc degeneration

Grade	Structure	Distinction between the nucleus and the fibrous ring	T2 signal	Disc height
I	Homogeneous	Respected	Hyperintense	Normal
II	Horizontal Band	Respected	Hyperintense with a band hypointense	Normal
III	Gray	Blurred, not clear	Intermediate	Slightly diminished
IV	From gray toblack,inhomogeneous	Loss of intensity differentiation	Intermediate to hypointense	Diminished
V	Black	Complete loss of	Complete hypointensity	Collapse and deformed

		differentiation		

Type I **Type II** **Type III** **Type IV** **Type V**

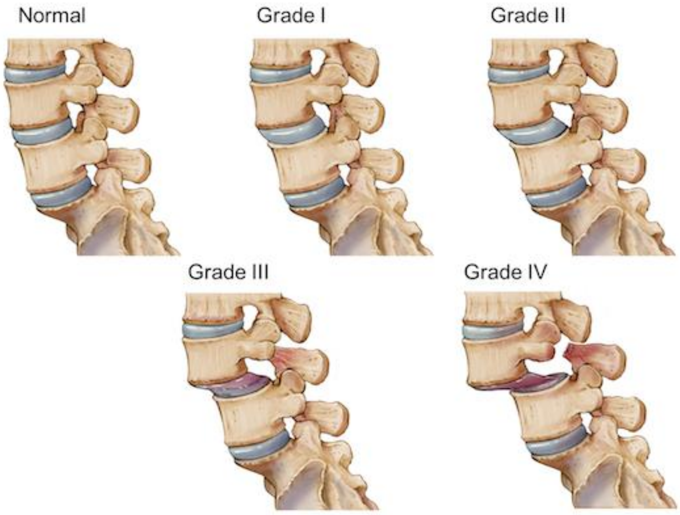

Figure (4): Grading of spondylolisthesis is done according to the Meyerding classification

Figure (5): shows grades of spondylolisthesis, A: grade-I, B: grade-II, C: grade-III

3. RESULTS

We review 48 MRI studies of patients with lumbar instability, 28 (58%) patients was female and 20 (42%) was male; range of patient`s age is (32-88 years) with median age of 59 ± 5.3. (Figure 6,7).

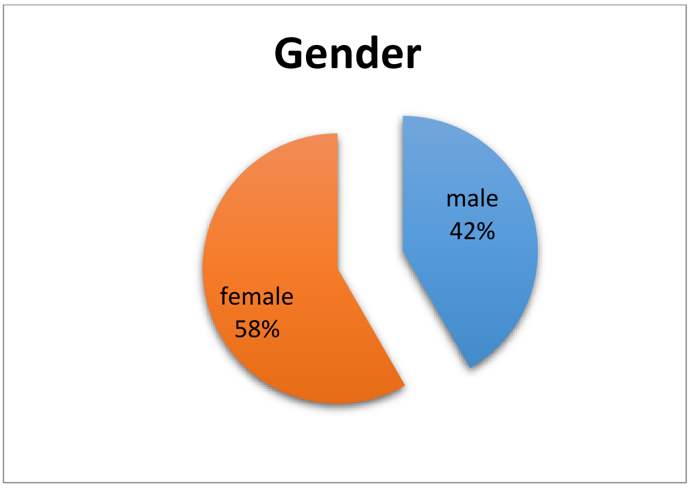

Figure (6): shows percentage of male and female in the study

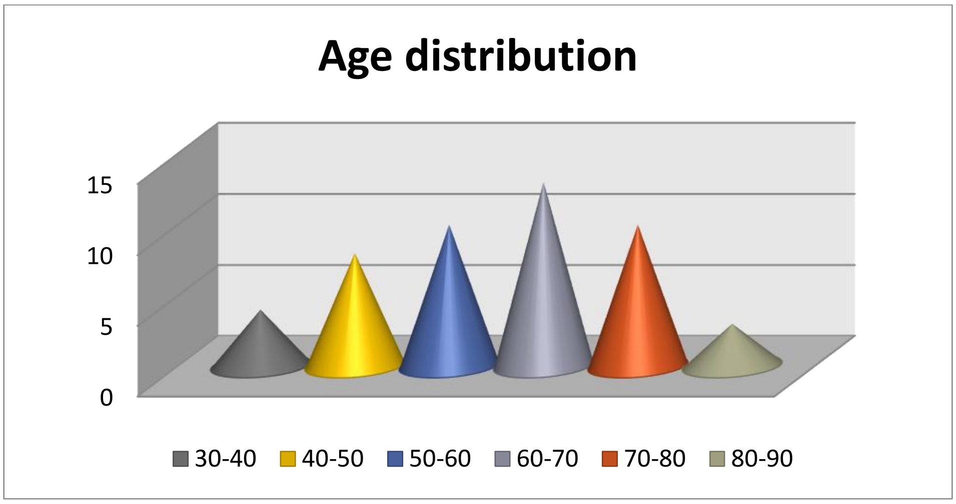

Figure (7): shows distribution of patient`s age

In the assessment of MRI findings, we found that all patients presented with facet arthropathy with a distribution of 9 patients in grade I,17 patients in grade II and 22 patients in grade III, which means that the most frequent are grades II and III, with significant-difference (p value = 0.004). Regarding the spondylolisthesis, it was observed that 37 patients (77.1%) showed grade I listhesis, 9 patients (18.8%) of grade II, and 2 patients (4.1%) of grade III; we did not find grade IV, there is no significant difference between them (p-value =0.06). With regard to Modic type changes, it was presented a distribution of 12patients (25%) type I,20 patients (41.7%) of type II, 6 patients (12.5%) of type III and 10 patients (20.8%) without changes; patients with type II had the larger number of Modic changes, with a significant difference (p value = 0.035). Regarding to disc degeneration:12 patients (25%) showed a grade III, 18 patients (37.5.%) exhibited an IV degree and 18 patients (37.5) were assigned a degree V; there was none with degree I or II; with non significant differences (p value = 0.2) (table 4).In 38 patients(79.2%)had annular tear and in 10 patients (20.8%)had not. Last parameter we obtained was that 32 patients (66.7%) had osteophytes and 16 patients (33.3%) had not. No significant difference between the two last parameters (annular tear and osteophytes) (table 5).

Table (4): shows the percentage of each studied variable

Variable	Facet arthropathy			Spondylolisthesis			Modic changes				Disc degeneration		
Grade/type	I	II	III	I	II	III	0	I	II	III	III	IV	V
Number	9	17	22	37	9	2	10	12	20	6	12	18	18
Percentage	18.8	35.4	45.8	77.1	18.8	4.1	20.8	25	41.7	12.5	25	37.5	37.5
p-value	0.004			0.06				0.035			0.2		

Table (5): shows the percentage of annular tear and osteophytes

Variable	Annular tear		Osteophytes	
	Present	No	Present	No
Number	38	10	32	16
Percentage	79.2	20.8	66.7	33.3
p-value	0.125		0.08	

We found that the segment most affected is L5-S1, with a totalof 22 patients (45.8%); the second segment involved is L4-L5, with 20 patients (41.7%); and inthird place we find L3-L4, with 6 patients(12.5 %) (Fig. 8). The evaluation of the Pearson's correlation coefficient between variables allowed us to know which variables have the highest correlation between them, and we found that facet arthropathy has a correlation with the degree of degenerative disc ($p < 0.05$), with the presence of osteophytes ($p < 0.0325$) and with the most affected segment ($p < 0.001$). Likewise, disc degeneration was correlated significantly with the Modic changes ($p < 0.01$) and with marginal osteophytes (p = <0.01), while no significant correlation between osteophytes and Modic changes ($p > 0.19$), practically all in a positive way. This indicates that a maximum ratio of increase of one of these variables increases the corresponding of the other. Spondylolisthesis also correlates significantly with degree of disc degeneration and Modic changes with p-value (< 0.004 and < 0.05) respectively. Annular tear did not show significant correlations with other variables.

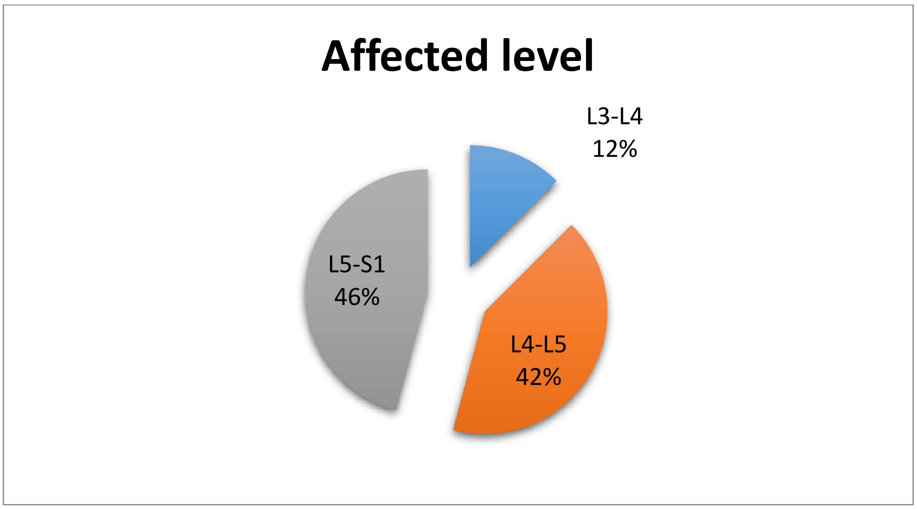

Figure (8): shows the percentage of affected segment

4. DISCUSSION

The indirect MRI findings of lumbar instability that the present study showed are very similar to others, varying the frequency of the findings. We found a greater correlation with advanced degree facet arthropathy, which is caused by greater capsular laxity and subluxations of the facets. With regard to degenerative disc disease, most of the patients presented with annular tear and a higher degree of degeneration, probably due to the poor load distribution that occurs due to the lysis as well as due to the disc's own abnormalities such as decreased content. of water, glycosaminogly cans and the increase of collagen inside the disc[13,14].The most affected segments are L4-L5 and L5-S1 since they have a higher axial load and torsion, which predispose to radial fissures that are predisposing factors for herniation of the nucleus pulposus, and when they involve the fibrous ring, the mobility of the affected segment increases. Here it should be mentioned that changes in terminal platforms, especially type II, representing bone marrow fat replacement, were also shown to be the most frequent, this is comparable with some studies which have shown that the highest correlation with instability is presented by type II [15]. Osteophytes did not have an adequate correlation and the vacuum phenomenon was not studied because it is not adequately assessed by MR[16].Regarding facet arthropathy, most frequent are grades II and III which is similar to results of Jang SY et al[17].Correlations were also made between variables, and those that were statistically significant were facet arthropathy with the disc degeneration, the marginal osteophytes and the most affected segment; this is important so now we know indirectly which segments are more unstable. Likewise, it was identified that disc degeneration not only has acorrelation with facet arthrosis, but thatin the same way you can see correlation with the types of Modic changes and the marginal osteophytes, probably by the correlation of the latter with the fibrous ring, which suffer greater traction by the abnormal forces, those results are comparable to those of some studies [18,19,20].We recommend future studies include larger number of patients and to do control study on patients without instability and on local population. Also, we recommend to add CT findings and correlate them with MRI findings.

5. CONCLUSION

MRI is currently considered the imaging technique of choice for diagnosing spine abnormalities, and can accurately assess the structures that maintain lumbar stability, despite the fact that routine MRI study is a static study, when we find Modic Type II changes in terminal platforms, degenerative disc disease and advanced facet arthritis as well as the listhesis these findings should be considered as indirect data of instability, that in conjunction with functional radiographs dynamics, provide more information on the kinetics of the most mobile vertebral segment.

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