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"Magnetic Resonance Imaging Evaluation of Lumbar Spine: Degenerative Disc Disease with Regard to Intervertebral Disc Desiccation – Correlation in between Pfirrmann's Grading System and Apparent Diffusion Coefficient on Magnetic Resonance Imaging."

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Abstract:
Background:A huge variety of degenerative abnormalities is found in degenerative disc disease. A disorder that can effect young and middle-aged people may be low back pain secondary to degenerative disc disease. Intervertebral discs with neighbouring spine formation are affected in degenerative diseases. Magnetic resonance imaging (MAGNETIC RESONANCE IMAGING) enables a comprehensive measurement of static and dynamic influences associated with the state of the spine.
Objectives: During this study we aim to measure the degenerative disc changes in lumbosacral spine with regard to intervertebral disc desiccation – correlation in between" Pfirrmann's grading system and apparent diffusion coefficient values on Magnetic resonance imaging."
Methodology: this is often a time bound prospective, cross sectional study during which 203 patients referred for MAGNETIC RESONANCE IMAGING to department of radiodiagnosis of Acharya VinobaBhave Rural Hospital with clinical diagnosis/suspicion of any degenerative disease are going to be subjected to MAGNETIC RESONANCE IMAGINGlumbosacral spine with the assistance of a "GE 1.5 Tesla MAGNETIC RESONANCE IMAGING scanner "
Results: After performing statistical analysis with the assistance of appropriate statistical models, we through this study to seek out a direct correlation between Pfirrmann's

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classification of disc condition and APPARENT DIFFUSION COEFFICIENT values of nucleus pulposus which indicate appropriate hydration of disc which acts as cushion between vertebrae,early detection of disc dehydration and appropriate management can reduce adverse outcomes of disc degeneration .

Conclusion: During this prospective, cross sectional study, we expect to seek out the correlation of severity of disc degeneration consistent with qualitative assessment by Pfirrmann's classification with quantitative assessment by APPARENT DIFFUSION COEFFICIENT values of nucleus pulposus and appropriate management accordingly.

Keyword:MAGNETIC RESONANCE IMAGING ,Degenerative disc disease,Pfirrmann'sclassification,correlation with APPARENT DIFFUSION COEFFICIENT and appropriate diagnosis and management.

INTRODUCTION

A wide variety of degenerative disorders are found in degenerative disc disease. A syndrome which may affect young to middle-aged individuals is low back pain secondary to degenerative disc disease. In degenerative conditions, the intervertebral disc is damaged by the adjacent spine system. Magnetic resonance imaging (MRI) facilitates the full measurement of static and dynamic influences involved with spine degenerative disease.[1]

One of the most prevalent musculoskeletal disorders is lumbar degenerative disc disease.One of the most common musculoskeletal complaints for which patients seek medical consultation is lumbar degenerative disc disease. In this article, complete or partial diagnostic automation, e.g. disc desiccation, is a beneficial step in having the radiologist do his job considering the high demand for lower back pain diagnosis (LBP). In the United States, LBP is the second most prevalent neurological condition after headache, according to the National Institute of Neurological Disorders and Stroke (NINDS[),2] Americans invest at least $50 billion per year on lower back pain (LBP) and more than 12 million Americans have a form of intervertebral disc disease (IDD). Magnetic resonance imaging (MRI) is the only appropriate approach to detect disc degeneration, but it is also acceptable to have radiographic proof. Disc signal amplitude in T2 weighted MRI is the most sensitive symptom of intervertebral disc degeneration and in particular, diagnosis of disc desiccation. However, disc signals (intensities) vary for reasons other than the variation in water content due to the magnetic field in homogeneity. In addition, the MRI protocol also influences this signal. With regard to an adjacent intra-body reference, this prompted radiologists to measure the disc signal.

The changes at the molecular level include breakdown of the very ingredients of the intervertebral discs with reference to the proteoglycans ultimately leading to the deterioration of the extracellular matrix component[4]. This ability of this imaging modality to perceive such changes at the molecular level makes it the most choicednoninvasive imaging modality with proper regard to disc integrity[3].

There have been multiple systems making an effort to classify these changes till date of which the most widely accepted system –" Pfirrmann's scoring system has stood upto the cause with a refined semiquantitative assessment"[3]

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When we are talking about pinpointing useful pieces of information, it is worthy to mention the vital role of Apparent Diffusion Coefficient, a value derived from "Diffusion Weighted Imaging on MAGNETIC RESONANCE IMAGING" in letting the radiologist know about "the degree of diffusion of water molecules "across the subjected tissue of interest[4]. Also, there have been a number of studies which refer to the fact that a decrease in this said value has association with reduction of intervertebral disc nutrition status[5].
Therefore the main objective of this analysis is to examine the association between the intervertebral disc desiccation grades of Pfirrmann and the apparent diffusion coefficient values obtained from the nucleus pulposus of the lumbosacral spine intervertebral discs.[6]A possible trend signifying the nature of changes in degeneration of the lumbar intervertebral discs with due reference to their respective grades obtained as against the respective values of the Apparent diffusion coefficient thus obtained is the main objective of this endeavour.

RATIONALE

Onadailybasis,radiologistsencounteranumberofpatientswhopresentwithcomplaints of lower back pain. A significant number of them need surgical intervention. The study of relation between the grading of these degenerative diseases with the apparent diffusion coefficient values can ensure early detection and correction and prevents undesirable complication. Even though clinical and basic radiologic evaluation provide a fairly good idea about the pathology involved,MAGNETIC RESONANCEimagingplaysasuperiorroletothem.[7]
MAGNETIC RESONANCEimaginggivesanexcellenthigh resolution image of soft tissue within and around the spine, as well as the bony components. There is a small number of studies based on the relationship between disc degenerative disease and the apparent diffusion coefficient values in regard to rating schemes in vogue. This study aims to proceed in the aforesaid direction.

AIM

To evaluate the degenerative disc changes in lumbosacral spine with reference to intervertebral disc desiccation – correlation in between Pfirrmann's grading system and" apparent diffusion coefficient values "on " magnetic resonance imaging."

OBJECTIVES

1)To grade the changes of intervertebral disc desiccation in lumbosacral spine in patients of degenerative disc disease as per Pfirrmann's system of grading intervertebral disc desiccation.
2)To determine the apparent diffusion coefficient value within the intervertebral discs in lumbosacral spine in patients of degenerative disc disease
3)To determine correlation in between the apparent coefficient values and pfirrmann's system of grading intervertebral disc changes.

Research hypothesis :The intervertebral disc desiccationin terms of the specified Pfirrmann's grading system in lumbosacral spine shows an inverse proportion with the apparent diffusion coefficient value taken at the level of the" nucleus pulposus of the intervertebral disc".

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Null hypothesis :The intervertebral disc desiccationin terms of the specified Pfirrmann's grading system in lumbosacral spine shows no relation with the apparent diffusion coefficient value taken at the level of the" nucleus pulposus of the intervertebral disc".

Alternative hypothesis :The intervertebral disc desiccationin terms of the specified Pfirrmann's grading system in lumbosacral spine shows an inverse proportion with the apparent diffusion coefficient value taken at the level of the "nucleus pulposus of the intervertebral disc".

MATERIALS AND METHODS:

StudyArea:AcharyaVinoba BhaveRuralHospital(AVBRH),Sawangiand Jawaharlal Nehru Medical College(JNMC)
SourceofData:Patients from AVBRHattached to DMIMS.Thepatients will be enrolled in the present study frombothIPDandOPDbasis after obtaining an informed consent from the participants.
Research design:Prospective cross-sectional analytical study
Subjects:Patients presentingwithDEGENERATIVE INTERVERTEBRALDISC DISEASE OF THE LUMBOSACRAL SPINE referred to department of Radiodiagnosis forMAGNETIC RESONANCE IMAGING investigatory purposes.

Sampling Procedure: All patients referred to the department of Radiology, AVBRH, with DEGENERATIVE INTERVERTEBRALDISC DISEASE OF THE LUMBOSACRAL SPINE will be subjected for the study after obtaining their informed consent.

$\boldsymbol{x2 \cdot N \cdot (1 - P)}$
N = $\boldsymbol{(N - 1) + x2 \cdot (1 - P)}$
"Where; $\boldsymbol{x2}$ = Chi Square value for 1 degree of freedom at some desired probability level".
This is 3.84 at 5% level of significance.
"P = 50% proportion C = confidence interval of the one choice = 0.05 "
N = No. of patients of INTERVERTEBRAL DISC DISEASES =428 3.84x428x0.5x0.5 N = = 202.65
Therefore, projected number of patients needed in the study is 203 or more .
Duration of study: 2020 – 2022

INCLUSION CRITERIA:
This analysis would contain the following criteria:

- All patients with low back pain and radiculopathy or not.
- Patients were referred to physicians with possible lumbosacral spine degenerative disorder.

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EXCLUSION CRITERIA:
Patients with history of spinal trauma
Post-operativepatients with history of spinal surgery
Pregnantpatients
Patients with metallic implants, pacemaker/cochlearimplants
Patients with claustrophobia
Uncooperativepatients
Patients not consenting to participate

STATISTICAL ANALYSIS
Appropriate statistical analysis will be applied.

DATA COLLECTION TOOLS ANDSEQUENCES
This prospective study will be subjected to Institutional Ethics Committee for approval.
The intervertebral disc levels of interest will be" L1-L2, L2-L3, L3-L4, L4-L5 and L5-S1 intervertebral disc levels" respectively.
Imaging will be performed on a "1.5 Tesla MAGNETIC RESONANCE IMAGING scanner (GE 1.5 tesla)" .
TheMAGNETIC RESONANCE images will be acquired using the following sequences:
(1)"T2-weighted imaging (T2-WI): repetition time/echo time (TR/TE) = 3,000/96 ms; slice thickness = 4 mm; distance = 0.4 mm; field of view (FOV) = 260 mm x 260 mm; matrix = 320 x 240; number of slices = 8; band width = 284 Hz/Pixel; sagittal and axial, turbo spin-echo (TSE). Signal-intensity acquisition number = 2".
(2) "Sagittal TSE T1-WI: TR/TE = 3000/96 ms, field of view = 260 mm x 260 mm, matrix = 320 x 240, thickness of slice = 4 mm, intersection distance = 0,4 mm, number of slices = 8, width of band = 284 Hz/pixel, number of acquisitions of signal strength = 2".
(3) "Te sagittal diffusion-weighted images will be obtained by using "readout-segmented echo sequence".
(4)"In order to calculate "APPARENT DIFFUSION COEFFICIENT values, region of interests (ROIs) according to T2-WI images will be manually drawn to define nucleus pulposus (NP)."
(5)" If the inner NP in extremely degenerative INTERVERTEBRAL DISCs is not distinguishable from the outer annulus fibrosus, the procedure requires using T2-WI as a reference, regions of interest (ROIs) would be drawn manually over the T2 map of the discs".

EXPECTED RESULTS:

After reviewing the literature we expect that there is inverse relation between the Pfirmanns grading for lumbar disc degeneration and apparent diffusion coefficient values so by this study cut off values can be evaluated for each grade and implication of these values in proper treatment and prophylaxis of adverse outcomes of disc degeneration in young population as ADC values of disc indicates the proper hydration of disc and its nutrition and save patients from surgical interventions .

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DISCUSSION:

There are several studies conducted in view of degenerative disc disease ,its causes and several outcomes noted so this study is subjected to see the various outcomes in Indian population.

Hon J. Yu et al[8] (2014)found out a significant correlation between degenerative scores and "APPARENT DIFFUSION COEFFICIENT" in assessment of disc degeneration reinforcing the importance of Pfirrmann's grading system beyond mere morphological status of the intervertebral discs.

Rania SobhyAbouKhadrah et al (2019)[9.] The T2 relaxometry values were analysed and found to decrease with increased disc degeneration, except for grade V, along with a negative association between T2 values and disc degeneration semiquantitative grading (Pfirrmann Grading). They also concluded that by compared grade I to V with another finding that ADC values were observed to decline with the increased degree of disc degeneration, the T2 values were substantially different. They also observed that a weakly important negative association occurred between age and T2 mapping values, nucleus pulposus ADC values, and the whole disc

G. Niu et al (2011)[10] It shows that with the increasing Pfirrmann grades, all T2 and ADC values were observed to decrease with the exception of T2 in grade V with substantial T2 variations between grades I-IV, but not between grades IV and V. They noticed that there were no significant differences in ADC between grades I-III. Their linear regression analysis showed that T2 was associated with age more strongly than ADC.

H. J. Yu1 et al (2009)[11] A strong link between the Pfirrmann classification and ADC lumbar IVD values was shown to reflect the multifactorial changes taking place in the course of IVD degeneration, taking into account the gross morphological changes as calculated by the Pfirrmann classification and ADC.

Kohat et al[12] An study was carried out in 72 patients with chronic lower back pain aged 20-70 years without trauma, inflammation, cancer, metastasis and vascular malformation, taking into account demographic characteristics. LUMBOSACRAL MAGNETIC RESONANCE IMAGING wascarried out and 19 MAGNETIC RESONANCE IMAGING parameters were observed at six stages (D12-L1-L5-S1). The Oswestry Disability Index was assessed for the severity of pain by the Numeric Rating Scale (NRS, 0-10) and impairment (ODI). As a result, MAGNETIC RESONANCE IMAGING was abnormal in all patients, with disc desiccation (90.3 percent) being the most common, followed by arthropathy of the facet joint (75 percent) and nerve root compression (72.2 percent).

Changes in the endplate and high pressure region were found in 58 and 50% of patients respectively. However, one-third of facetal joint arthropathy cases is below 30 years of age. On MAGNETIC RESONANCE IMAGING, nerve root compression had 61.3 percent sensitivity and 10 percent accuracy for clinical radiculopathy. With localised chronic lower back ache, facet joint arthropathy had 60.7% sensitivity and 15.9 percent accuracy." None of the parameters of MAGNETIC RESONANCE IMAGING and the amount of MAGNETIC RESONANCE IMAGING is associated with NRS and ODI. NRS was an unbiased predictor

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of ODI in multivariate regression (odds ratio 0.58, 95% confidence interval 0.35-0.98, P=0.04).
They concluded that MAGNETIC RESONANCE IMAGING nerve root compression demonstrated limited specificity with subsequent clinical radiculopathy and facetal joint arthropathy with localised backache in patients with persistent lower back ache. None of the anomalies of MAGNETIC RESONANCE IMAGING associate with the magnitude of pain or injury..

Ay Offor [13]A research was undertaken to determine the extent and pattern of disc herniation activity and to examine the correlation of disc herniation with clinical symptoms with magnetic resonance imaging. The research was performed with a total of 120 adult patients who arrived at the Department of Radiology of the University of Port-Harcourt Teaching Hospital for a 1-year magnetic resonance imaging scan of the lumbosacral spine.. For form, scale, and location of lumbar disc herniation, the end plates of 600 lumbar interspaces were graded. As a result, they concluded that patients' age distribution ranged from 18-80 years; mean age was 51.0, suggesting that the middle aged demographic was the most affected age group in their fifth and sixth decades of life.

Rodrigues et al [14]A research was undertaken with the primary objective of assessing the association between biomarkers and intervertebral disc degeneration. They reported that in all cases of intervertebral disc degeneration, hyaluronic acid levels were elevated, along with elevated levels of interleukin 6 and cathepsin B.

Duran S et al[15] In their retrospective study, a total of 150 patients in the 20-60 age group who were evaluated for the incidence of intervertebral disc degeneration or herniation and the degree of degeneration at both lumbar levels were identified. Vertebral endplate morphology was analysed based on endplate sagittal diameter, endplate sagittal concave angle (ECA), and endplate sagittal concave depth (ECD) on sagittal MRI.The correlation between intervertebral disc degeneration or herniation and morphological measurements of the endplate was studied. As a result, they concluded that an association occurs between morphology of the vertebral endplate and degeneration of the lumbar intervertebral disc. At the degenerated disc stage, vertebral endplates become flat; the magnitude of this flattening is correlated to the degree of degeneration of the disc. A number of related studies were reviewed [16-19]. Paul and Kashikar reported on role of magnetic resonance imaging in the evaluation of low backache [20]. Vaidya et. al. reported on other studies on diagnostic utility of MRI in joint problems [21,22].

Scope:
MAGNETIC RESONANCE IMAGING has had a very pivotal role in assessment of disc degenerative disease and further outcome of this due its wide availability, good resolution and lack of ionizing radiation. An accurate scan can help clinician in better treatment of patient with reference to additional information regarding the apparent diffusion coefficient values denoting the “degree of diffusion of water molecules “across the tissue subjected within the region of interest in addition to the grading systems in vogue.

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Implications:
MAGNETIC RESONANCE IMAGING study can be used in early detection and management of disc desiccation and its related adverse outcomes in this manner – AVERSION of ADVERSION. In other words, complications can be avoided by detecting the degenerative changes early, thereby dodging any other difficulties.

CONCLUSION :

After reviewing the literature pertaining to the study, appropriate conclusion will be discussed therein.

PATIENT CONSENT:
Informed consent will beobtained fromthe patients or one of the patient's relatives on a printed form with signature along with the clinical history which will also be taken to fulfil the criteria of the study. Study will be properly explained to the patient or patient relatives in their own understandable manner making use of their vernacular language. The participants of this study will be explained about the procedure to be undergone, the advantages and disadvantages with due note towards potential benefits and losses where they will be free to consent to participate and they will be able to voluntarily opt out of the study if they feel so, without any consequences.

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