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Association of History Taking and Accuracy of the Interpretation of Cervical and Lumbar Magnetic Resonance Imaging

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Abstract

BACKGROUND: Disk herniation leading to radiculopathy is one of the most important causes of neck and back pain, requiring specific diagnostic tests. Magnetic resonance imaging (MRI) is one of these diagnostic methods. Interpreting the findings of this imaging method by an experienced skilled person is very important.

AIM: The purpose of this study was to investigate the role of history on the accuracy of the lumbar or cervical MRI reports in patients with back and neck pain referring to the radiology department.

METHODS: This study was performed on patients with complaints of lumbar or neck pain that MRI had been performed for them. At first, the MRI was studied by the residents of the 2nd and 3rd years and then a radiologist as a routine, respectively. From 4 to 6 months later, patients' clinical history was presented to the same students and professors and MRI was re-reported. Statistical differences were evaluated and analyzed using SPSS software version 20.

RESULTS: Out of 150 patients with mean age of 42.56 ± 10.65, 87 patients (58%) were female and 63 (42%) were male. Most of the patients were between the ages of 40 and 50 years (34.66%). The most common clinical symptom of patients was waist and neck pain followed by sensory disturbances of the extremities. The most pathologic changes found was disk bulging in 28.8% of patients (68 cases). In terms of lumbar canal stenosis, the most cases were in the L4-L5 levels of the moderate type. The most reported cases of cervical stenosis have been mild. Disk herniation and DOCP were two main factors causing canal stenosis in the study patients. Statistical difference in the MRI reports performed by the residents on most of the variables was statistically significant before and after knowing the clinical history of the patient ($p < 0.05$). However, this difference was less noted in the reports of the radiologists.

CONCLUSION: The results of this study showed that knowing the history of patients in interpreting the results of MRI in patients with vertebral disk hernia is misleading and will lead to many false positive and negative results, especially for radiology residents. It is recommended that the residents and radiologists consider the MRI films before focusing on the biographies and clinical features of the patient, to prevent the occurrence of bias and to increase the accuracy of the reports.

Introduction

For the first time, magnetic resonance imaging (MRI) has allowed intrathecal observation in a non-invasive manner [1]. The non-specific low back pain is one of the most common indications for the MRI requests. The degenerative disk disease is an important issue in occupational health that can lead to worrisome state especially in adults [2], [3], [4]. MRI reports are important in terms of therapeutic decisions, and incorrect reports may result in invasive or non-invasive, but unnecessary, interventions [5], [6]. Incurring additional financial costs to the patient, which ultimately undermines the national economy, are another consequence of inaccurate diagnoses [7]. Today with the remarkable advancement of technology a new imaging modalities including MRI is needed for the therapeutic decision-making and surgical interventions [8]. Therefore, accuracy in MRI reports is very important. One of the effective factors in the accuracy of MRI reports is the medical history of patients in radiology request forms, which can be helpful or, on the other hand, lead to bias and haste in the writing of reports by residents, especially in educational centers with a high workload, so that the residents may use the histories and refrain from classic and systematic reading of MRI images, which would increase the number of false negative and false positive cases and, contrary to popular belief, reduce the accuracy of the reports [9], [10], [11], [12]. The radiologist does not have direct contact with the patient for medical history and physical examination, and thus, an incomplete and inaccurate history may also be misleading [13]. Therefore, the purpose of this study was to compare the accuracy of MRI reports by attending physicians and residents, once with history and once again without history. It should be noted that no similar study has been conducted in Iran so far on the role of medical histories on the accuracy of MRI reports. The question arises as to whether the existence of medical histories in MRI requests is helpful, or on contrary, is confounding and causes haste, and

whether the existence of false histories does not make the less experienced interpreter report inaccurate and unnecessary diagnoses [14], [15], [16], [17], [18], [19]. Some studies have been conducted in this area, including the study of Berbaum *et al.*, who reviewed the effect of clinical history on chest X-ray (CXR) interpretation, concluding that the quality of reports was unaffected by the histories [20]. Another study examined the effect of history on CXR in children with bronchiolitis and proved that positive histories could increase the risk of false positive results [21]. Furthermore, the study of effect of the record and professional experiences in the positron emission tomography and computed tomography (CT) scan report, which proved in this study showed that professional experience did not play a significant role in the accuracy of the reports [22]. Another study demonstrated the effect of clinical parameters on the success of MR guided wire localization [23]. Based on the controversial results of past research and considering the importance of the issue and the lack of a similar study in Iran, we decided in this study to examine the role of medical history and the validity of the history in the accuracy of the cervical and lumbar MRI reports.

Materials and Methods

This study is a comparative study on 150 patients which was performed among patients who were referred to the Imam Reza Hospital Tabriz-Iran with the back or neck pain or the symptoms of radiculopathy and candidate for MRI. The subject underwent MRI examinations for cervical and lumbar spine. The primary outcome (images) was first reported by the 2nd and 3rd years residents who know the clinical history of the patients. The reports were checked according to the checklist and variables and then reviewed by the attending physician. After about 4–6 months, the MRIs of the same patients were again submitted to the 2nd and 3rd years residents by eliminating the histories, and the results were recorded. Furthermore, after the modification by the attending physicians, the changes were recorded. After completion, the reports along with the histories for 150 patients were compared with the reports of the same patients by eliminating the history. Items such as disk surface, herniation side, hernia level, and the degree and type of stenosis were compared. The benchmark for comparing both groups is the MRI and report of the experienced attending physicians on the cervical and lumbar MRI.

All ethical issues such as conflict of interest, misconduct, co-authorship, and double submission were considered carefully. Ethical permission for the study was obtained from the Ethics Committees of Tabriz University of Medical Sciences. The ethical principles of autonomy, beneficence, non-maleficence, fidelity, and confidentiality were adhered to. During the process, both residents and attending physicians were unaware of the fact that they participated in this study.

Statistical analysis

The distributional properties of continuous data were expressed as mean ± standard deviation. The categorical data were presented by frequency and percentage. Patient characteristic data before and after awarding of the clinical history of the patients were compared using paired t-test (for continuous variables). Moreover, other appropriate statistical tests (Chi-square test and Fisher's exact test) applied if needed. Data analysis was performed using SPSS 23 software at a significant level of 0.05.

Results

Demographic features of the study patients

One hundred and fifty patients were enrolled according to inclusion criteria with the mean age of 42.56 ± 10.65 years. Eighty-seven (58%) were female and 63 (42%) were male (Table 1). The largest age group was formed by those between 40 and 50 years old (34.66%). The mean age of males was 47.66 and that of females was 37.46 years. The studied patients had no history of trauma and there was no intervertebral disk retropulsion.

Table 1: Morphology of disk herniation in lumbar and cervical MRI

Disk herniation	Morphology	Number
Cervical	Protrusion	64
	Extrusion	6
	Bulging	36
Lumbar	Protrusion	30
	Extrusion	9
	Bulging	68

MRI: Magnetic resonance imaging.

Clinical and paraclinical characteristics of study patients

The most common symptom of the patients was the waist and neck pain and afterward, the patients complained of sensory impairment of lower and upper extremities. In cases of cervical hernia, most of the symptoms were the pain in the arm or paresthesia in the dermatome where the nerve was involved. Among these 150 cases, only seven cases were referred with paraplegia. Most of the patients referred as the outpatient with primary symptoms and were diagnosed with herniation disk with different levels of disk involvement. Gender did not affect most MRI findings ($p < 0.05$). The age of people with MRI change was

higher than those without the change, and the changes were generally higher in female subjects ($p < 0.05$). In the age range of 60 years and older, the abnormal MRI was more than 50% compared with normal MRI.

Paraclinical findings (MRI reports) before receiving a biography of patients

The patients were referred with low back pain and neck pain and subjected to MRI. The 2nd and 3rd year residents and the attending physicians first reported the images without regarding the patient history. A total of 380 disks were evaluated in 150 patients. Among these, 109 cases of lumbar MRI and 41 cases of cervical MRI were performed. Among the cases of lumbar disk herniation, 68 cases (28.8%) of bulging alone, 30 cases (7.8%) of protrusion, and 9 (2%) extrusion cases were reported. In the cases where bulging was seen, it did not generally have protrusion, and the combination of these two included a small percentage.

The number of cases of cervical and lumbar vertebral hernia morphology is presented in the Table 1.

In the lumbar MRI reports 58 cases (40.7%) of central (median) involvement, 20 cases (21.1%) of only right-side involvement and 31 cases (38.2%) of only left-side involvement were existed. Furthermore, in cases of cervical MRI, before being aware of patient histories, 18 cases (43.9%) of central involvement, 11 cases (26.82%) of right-side involvement, and 12 cases (29.26%) of only left-side involvement were reported. Seventeen cases (11.33%) had osteophytes, mostly on the L4-L5 and L1-L2 levels. Twenty-eight items (18.66%) had spondylolisthesis, mostly on L5-S1 and L4-L5 levels. Thirty-three cases (23.52%) had hypertrophy of ligamentum flavum, which was higher on L4-L5 levels. The following table shows the frequency of this radiologic finding in terms of gender. Osteophytes were seen in most age groups, but it was significantly less in the 30–40 year age group and was more frequent in older ages (50–70 years).

Nineteen cases (6.8%) had L1-L2 disk involvement, mostly in the form of bulging, and in 1 case (0.4%) it resulted in stenosis, mainly in the central area. Twenty-two (7.9%) cases had L2-L3 disk involvement, mostly in the form of bulging, and in 2 cases (0.7%) resulted in stenosis generally in the central area. There were 56 (20%) cases of L3-L4 disk involvement, which was mainly protrusion, leading to stenosis in 11 cases generally in the central area. There were 146 (52.1%) cases of L4-L5 disk involvement, which was mainly protrusion and resulted in stenosis in 47 cases (16.8%). Eighty-two cases (6.8%) had L5-S1 involvement, which was mainly protrusion, and resulted in stenosis in 24 cases (8.6%), mainly in the left paracentral area.

The spinal stenosis is reported as mild, moderate, and severe levels. The frequency and severity of spinal stenosis at different vertebrae levels involved in the study subjects are listed in Table 2.

Table 2: Frequency and severity of canal stenosis in different lumbar vertebrae in the study patients

Level involved	Canal stenosis			
	Mild stenosis (n)	Moderate stenosis (n)	Severe stenosis (n)	Total n (%)
L1-L2	0	3	1	4 (2.63)
L2-L3	1	3	1	5 (5.26)
L3-L4	3	10	5	18 (28.94)
L4-L5	8	19	11	38 (63.15)
Total	12	35	18	65 (100)

Disk herniation has many different etiologic factors, of which four major cases in the lumbar and cervical MRI are mentioned in this study, and the values are listed in Tables 3 and 4.

Table 3: Etiologic factors of lumbar spinal stenosis

Etiologic factor	Stenosis severity	Number
Primary	-	4
DOCP induced	Mild	7
	Moderate	4
	Severe	13
Caused by disk herniation	Mild	20
	Severe	12
More than one etiology	-	5
Total	-	65

Left posterolateral protrusion and left extrusion were the most commonly observed morphology in patient's cervical MRI. Furthermore, 36 cases of disk bulging were reported. Frequency of cervical vertebrae levels (level of involvement) based on MRI report without clinical history showed that C6-C7 were the most common involved levels.

Table 4: Spinal cord stenosis with different etiologies in cervical MRI

Etiologic factor	Stenosis severity	Number
Primary	-	3
DOCP induced	Mild	7
	Moderate	5
	Severe	4
Caused by disk herniation	Mild	9
	Severe	3
More than one etiology	-	2
Total	-	33

MRI: Magnetic resonance imaging.

Paraclinical findings (MRI report) after obtaining history from the patients

After 6 months, the same films were given to the same residents and attending physicians for interpretation, with the difference that this time they knew the history of the patients. The severity of spinal stenosis in cervical and lumbar MRI cases is presented in Table 5 before and after the awareness of the reporting person of the medical history.

Table 5: The severity of vertebral canal stenosis reported before and after the history of patients

Canal stenosis	(Patient number) history taking				p-value
	Before		After		
	Cervical	Lumbar	Cervical	Lumbar	
Mild	28	4	23	5	0.001
Moderate	5	21	8	19	0.000
Severe	7	13	9	14	0.04

The morphology of cervical and lumbar hernia was also compared in Table 6 before and after the history. Table 7 presents the spinal stenosis etiologies in the studied patients before and after awareness of history. The herniation side of the cervical and lumbar

Table 6: Vertebral disk herniation morphology in MRIs reported before and after the history taking

Canal stenosis	(Patient number) history taking				p-value
	Before		After		
	Cervical	Lumbar	Cervical	Lumbar	
Protrusion	64	30	59	36	0.000
Extrusion	6	9	11	10	0.03
Bulging	56	24	24	56	0.01

disks is also listed in Table 8. The results of these findings are described by the reporting person with different experience years in Tables 9-12. The Kappa agreement coefficient for the initial and final findings was - 0.88. The findings showed that the reporting person, before awareness of the patient history, mentioned some cases of hernia or other findings in the MRI report, which, after 6 months and by matching the history of patients, there was a significant difference between the patient histories and the pathology found in MRI.

Table 7: Causes of canal stenosis in the study patients before and after history taking

Etiologic factors	(Patient number) history taking				p-value
	Before		After		
	Cervical	Lumbar	Cervical	Lumbar	
Disk herniation					
Mild	9	20	11	24	0.02
Severe	3	12	5	16	0.00
DOCP					
Mild	7	7	10	12	0.05
Moderate	5	4	8	10	0.001
Severe	4	13	6	19	0.000
Primary	3	4	3	7	0.06
More than one etiology	2	5	3	7	0.00

Table 8: Side of cervical and lumbar disk herniation in the MRI reports

Side of herniation	(Patient number) history taking				p-value
	Before		After		
	Cervical	Lumbar	Cervical	Lumbar	
Central	18	58	10	53	0.2
Left	31	31	19	22	0.02
Right	11	20	12	34	0.05

MRI: Magnetic resonance imaging.

Discussion

Low back pain is one of the common causes for the referral of patients and requests for medical services, and 80–90% of adults (50% of the employed population each year) had a record of back pain [24], [25]. The prevalence in different epidemiological studies varied between 7.5% and 36%, with the highest prevalence in the 45–60 year age group [26], [27], [28], [29]. The neck pain also has 10–20% prevalence in the adult population. The degenerative changes in cervical vertebrae are the most common causes of acute and chronic neck pains [30]. MRI is a non-invasive method and the most sensitive imaging trial for the evaluation of the spinal cord and vertebra, which exactly shows neural structures, particularly compared to CT scan [31], [32]. Such imaging modality can help clinicians to identify a better medical approach and clinical judgment. However, it is important to state that in most circumstances the indication for surgery cannot be established only on the structural changes observed via MRI.

Table 9: The relationship between MRI reports of the 2nd year radiology residents before and after the history taking

Variables	No history (Percent reported)	With history (Percent reported)	p-value
Herniation			
Protrusion	40.53	58.90	0.00
Extrusion	29.35	11.64	0.00
Bulging	30.12	29.46	0.8
Canal stenosis frequency	51.09	70.8	0.2
Canal stenosis etiology			
Primary	18.9	14.69	0.5
Herniation induced	31.79	40.18	0.00
DOCP induced	45.20	33.16	0.02
More than 1 etiology	4.11	11.97	0.04
Side of herniation			
Central	26.3	29.41	0.1
Left	40.52	27.09	0.00
Right	32.7	43.5	0.04

MRI: Magnetic resonance imaging.

Table 10: The relationship between MRI reports of the 3rd year radiology residents before and after the history taking

Variables	No history (Percent reported)	With history (Percent reported)	p-value
Herniation			
Protrusion	44.96	53.60	0.03
Extrusion	5.95	13.06	0.05
Bulging	49.09	33.34	0.00
Canal stenosis frequency	66.3	71.5	0.6
Canal stenosis etiology			
Primary	12.00	15.98	0.1
Herniation induced	39.64	32.09	0.05
DOCP induced	33.50	41.06	0.02
More than 1 etiology	14.86	10.87	0.09
Side of herniation			
Central	40.31	45.6	0.4
Left	20.89	23.5	0.2
Right	38.8	30.9	0.08

MRI: Magnetic resonance imaging.

Table 11: The relationship between MRI reports of the experienced (expert) radiology professors before and after the history taking

Variables	No history (Percent reported)	With history (Percent reported)	p-value
Herniation			
Protrusion	44.13	48.46	0.2
Extrusion	7.04	10.71	0.1
Bulging	48.82	40.81	0.06
Canal stenosis frequency	70.05	75.07	0.6
Canal stenosis etiology			
Primary	6.8	9.09	0.09
Herniation induced	33.54	36.36	0.2
DOCP induced	42.89	44.44	0.1
More than 1 etiology	16.77	5.55	0.02
Side of herniation			
Central	49.67	45	0.2
Left	28.10	31.82	0.1
Right	20.23	23.18	0.8

MRI: Magnetic resonance imaging.

The primary finding of this study is that knowing the medical history of the patient creates a bias in the final reports of MRI. If an unusual or contradictory finding related to the MRI reports was found, there

Table 12: The relationship between MRI reports of the less experienced radiologist before and after the history taking

Variables	No history (Percent reported)	With history (Percent reported)	p-value
Herniation			
Protrusion	45.36	50.9	0.1
Extrusion	8.09	11.56	0.2
Bulging	46.55	37.54	0.05
Canal stenosis frequency	74.65	79.05	0.7
Canal stenosis etiology			
Primary	6.8	9.09	0.23
Herniation induced	33.87	36.02	0.4
DOCP induced	39.25	45.61	0.09
More than 1 etiology	20.08	9.28	0.05
Side of herniation			
Central	48.3	46	0.5
Left	30.09	34.6	0.09
Right	21.61	19.4	0.1

MRI: Magnetic resonance imaging.

should be an examination of presence of confounding and interfering factors. Such phenomenon may well be the subject of a clinical review bias.

The clinical review bias occurs when the researcher becomes biased by knowing a golden standard test, which affects the results and final findings [33]. So far, few studies have been conducted in Iran regarding the accuracy of MRI reports in patients with disk herniation before and after getting clinical history. However, the results of our study are in line with the few results of studies conducted in this field, suggesting that the clinical data existing in the MRI interpretation make intervention [34], [35], [36], [37].

Tudor *et al*. noted that the bias in clinical review led to a slight increase in the specificity of this imaging technique [38], while Berbaum *et al*. did not find any contribution for the effect of this interfering factor [39]. In this study, the most common findings in the pathology of disk hernia were protrusion and bulging, none of which was related to the gender of the individuals. In the reports, the lumbar and cervical MRI were the most frequent cases of central involvement, which was largely similar to the results of the study by Ebeling *et al*. [39]. According to the reports by the residents and attending physicians in this study, the most cervical level involved was C6-C7. The highest level of lumbar involvement was L4-L5. The reason for more frequent disk protrusion in these levels is the greater mechanical pressure. These findings are similar to those of previous studies [39], [40], [41], [42]. The family record of low back pain and the familial susceptibility to the hernia disks have been shown in other studies in the world, such as Matsui *et al*. and Scapinelli *et al*. studies [43], [44]. In the study of Videman *et al.*, the reduced signal of the secondary vertebral tissue to drying out and protrusion is the findings that begin at the age of 35 and increase with the age of the patient [45]. In our study, the highest involved levels were the L4-L5 osteophyte followed by L1-L2. The formation and occurrence of osteophytes can be due to different causes; age-related conditions such as degenerative disk changes, osteoarthritis and spinal stenosis, and rupture may be among the factors. Chanapa *et al*. conducted a study on 180 patients with low back pain and lumbar osteophytes. In the results, they mentioned that the highest prevalence of osteophytes was in the L4 vertebral level, which had the highest correlation with patient age [46]. Spinal stenosis following spinal disk herniation is one of the main causes of neurosurgeon surgeries at high ages and is an important etiologic factor in the occurrence of pain and disability in these individuals [20], [47], [48]. Morshed *et al.*, in a study with a sample of 48 patients, reported about six cases of stenosis induced by lumbar disk herniation, of which one was partial stenosis and six cases were complete stenosis [49]. In our study, the highest prevalence of stenosis was in L4-L5 lumbar levels, which accounts for 38 cases (61.15%) of all stenosis cases. Among these, most cases of moderate stenosis were reported. In the cervical vertebrae, 40 cases of stenosis were reported, which are often the mild cases. The stenosis of spinal cord has different etiologies, including congenital, secondary, and concomitant congenital-secondary stenosis [22], [23], [50], [51]. In our study, the cause of lumbar spinal stenosis was most commonly due to disk herniation followed by the DOCP induced stenosis. In the cervical vertebrae, the highest etiologic factor of stenosis is induced by DOCP. The results of this study showed that there was a statistically significant difference between the reported cases of spinal stenosis, herniation morphology, herniation etiology, and herniation side. The analysis of these results suggests that the accuracy of the reports and findings was reduced after that the residents and attending physicians became aware of the patient history. The residents missed some cases by reading the histories and also exaggerated some cases in the reports, which showed false positive and false positive results in the reports of the residents after knowing the medical history of the patients. For example, the involvement levels and the reported stenosis percentage can be mentioned. In cases of reports prepared by attending physicians, there was no significant difference in most of the studied variables, which indicates that; first, the accuracy of MRI reports is increases with the work experience so that the accuracy of reports prepared by the attending physicians in order is higher than the 3rd and 2nd year residents. The reason for this should be due to the fact that knowing a history concentrates the specialist's mind on a particular case and limits him around a minor issue and the ability to reason and think wider with other involved factors and the possibility of other findings will be denied. The results of this study showed that there was no significant difference between the reports by the attending physicians after knowing the history of the patient.

Some limitations of the present investigation exist due to the study design and practical constraints. There were few similar studies in this field, which made it difficult to compare the results and interpret the findings. Moreover, the conclusions and findings need further verification by larger scale studies.

Conclusion

The results of this study showed that although complete and accurate medical histories are an important part of the patient's diagnosis and treatment process, this does not significantly help the radiologists in providing accurate and complete reports. The experience of specialist is undoubtedly an important factor in this regard. It is recommended that the residents and attending physicians of the field of

radiology, before receiving the patient's clinical history, accurately look at the MRI images so that they could report better results.

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