Assessment of various lumbosacral spine abnormalities on magnetic resonance imaging scans of patients with low back pain

Bello O. Usman, Abdulfatahi A. Oyewole, Nuhu D. Chom, Abdulaziz Umar[1]

Departments of [1]Radiology and [2]Medicine, College of Medical Sciences, Ahmadu Bello University, Zaria, Nigeria

Abstract

Background: Low back pain (LBP) is a cardinal sign of many lumbosacral spine abnormalities. Magnetic resonance imaging (MRI) has revolutionised the management of LBP through precise diagnosis and accurate definition of the extent of the problem.

Aim: This study was carried out to determine the lumbosacral spine abnormalities on MRI scans of patients with LBP.

Methods: The prospective study was conducted within 4 years at the MRI suite of the Department of Radiology, Ahmadu Bello University Teaching Hospital, Zaria. This study included 200 patients who had LBP on whom MRI scan was performed. All MRI scans were done with permanent magnet 0.2 T 'open' MRI unit. The images were stored in a computer and subsequently viewed on the screen.

Results: The MRI findings of 200 patients involved in the study showed that more males (124 [62%]) were affected than females (76 [38%]). The age of the patients ranged from 11 to 80 years, with a mean of 47.8 (standard deviation 1.4). The peak incidence of LBP was (55 [27.5%]) in the fourth and fifth decade of life. Majority of the patients (172 [86%]) had intervertebral disc prolapse/herniation. Thecal sac, spinal cord (at L1/L2 only) and cauda equina were compressed in 159 (92.4%), 4 (2.3%) and 73 (42.3%) patients, respectively. Compression of multiple structures in the spinal canal was seen in 64 (37%) patients.

Conclusion: MRI examination has improved the management of patients with LBP, and the results obtained from this study will assist clinicians to quantitatively evaluate patients with LBP.

Keywords: Abnormalities, low back pain, lumbosacral spine, magnetic resonance imaging scans, Zaria

Address for correspondence: Dr. Bello O. Usman, Department of Radiology, College of Medical Sciences, Ahmadu Bello University, Zaria, Nigeria.
E-mail: muhammedbello111@yahoo.com

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INTRODUCTION

The term low back pain (LBP) as defined by Anderson and used in most surveys is defined as pain limited to the region between the lower margins of the 12th rib and the gluteal folds.[1]

LBP has always been a common complaint amongst adults of both sexes in this environment. In the United States, lower back pain is the second most common complaint encountered by primary care physicians after the common cold.[2,3] LBP affects 70%–80% of the general population at some time in their lives and is a leading cause of disability

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and activity limitation in persons between 35 and 40 years of age.[4]

LBP is a well-recognised cause of morbidity in the industrialised world, where a major study in typical Nigerian (Murtala Muhammed Specialist Hospital and Ethiopian Jimma University Specialized Hospital) specialised hospitals[5] has reported the occurrence of LBP in general population and occupational settings.

Initially, conventional radiography was the diagnostic imaging modality for the evaluation of diseases of the lumbosacral spine. Radiographic projections were designed to demonstrate abnormal processes in the spinal canal, intervertebral foramina, disc spaces, vertebral bodies, posterior elements and facet joints.[3] Radiography is commonly used as a diagnostic test for patients with acute back pain, because of low cost and easy availability, and this makes plain radiography the most common spinal imaging test. A study showed that during the acute back pain episode, 46% of the patients had radiography while 9% had computed tomography (CT) or magnetic resonance imaging (MRI) as a diagnostic imaging modality.[6]

The use of CT and MRI has improved the diagnostic capabilities by enabling location and characterisation of tumours, cysts and inflammatory diseases in the lower spine and aiding in early diagnosis and treatment.[3]

MRI is a non-invasive direct multiplanar imaging method that uses radiofrequency waves and a powerful magnetic field to provide clear and detailed images of the lumbar spine. This imaging technique has greatly improved the ability to visualise normal and diseased tissue of the lumbar spine. T1- and T2-weighted imaging sequences provide excellent assessment of the anatomy and morphological change in the lumbar spine, respectively.[6]

MRI generally offers superior soft tissue resolution, which allows nucleus pulposus of the disc to be distinguished from annulus fibrosus. Ligaments, vertebral marrow and contents of the spinal canal are well demonstrated. However, it cannot directly visualise cortical bone, which produces a black "signal void" on MRI. When bony anatomy is critical, CT may be preferable. The use of contrast medium (gadolinium-DTPA) improves image quality and may further delineate hidden lesions.

LBP exists in epidemic proportions in the Western world and is on the increase there.[7] However, while literature of the epidemiology of LBP is rapidly accumulating, information from developing world is scanty and little epidemiological data has come from Nigeria.[7,8] Therefore, research into the most effective strategies to prevent and manage LBP in Africa is warranted. Moreover, further research into knowledge of precise aetiology may also throw more light in managing individual cases and in designing preventive measures.

The economic, societal and public health effects of LBP appear to be increasing, incurring billions of dollars in medical expenditure each year. For example, in the USA, the total expenditure on LBP exceeds $100 billion annually.[9] Moreover, this economic burden is of particular concern in poorer nations such as Nigeria, where limited healthcare funds are already directed towards malaria, tuberculosis, diarrhoea diseases, etc.

The lack of information on the prevalence of LBP in developing countries is therefore a significant shortcoming, particularly as it is predicted that the greatest increases in LBP prevalence in the next decade will be in developing nations,[8] like Nigeria. This study determines various forms of lumbosacral spine abnormalities on MRI scan of patients with LBP referred for MRI of the lumbosacral spine at Ahmadu Bello University Teaching Hospital (ABUTH), Zaria.

METHODS

Study design

This is a prospective study carried out within a period of 4 years, from 1st December 2011 to 4th January 2016 at the Department of Radiology, ABUTH, Zaria, Kaduna State, Nigeria.

Study area

Zaria is situated in the north-western zone of Nigeria. The institution serves a population of about 40 million people, which spread over the entire north-west, parts of north-east and north-central regions. It also serves parts of Niger, Cameroun and Chad republics.

Ethical clearance

Ethical clearance was obtained from the Ethics Committee of the ABUTH and patients' consent forms were duly obtained for the study.

Inclusion criteria

The study included all patients (Nigerians) with LBP who were referred to the Radiology Department for MRI scan of the lumbosacral spine from the surgical clinics and wards of the ABUTH. Patients referred from other hospitals with a history of LBP were also used for this study, e.g., acute and chronic LBP, and back injuries.

Exclusion criteria

Patients excluded from the study are those whose request for MRI were due to other reasons for LBP, e.g., malignant tumours and infections.

Patients with spinal metallic implants that may cause errors in imaging were excluded. Individuals with ferromagnetic prosthesis and pregnancy were also excluded from the study.

Sample size

A total of 200 patients were used for the study having calculated the sample size using the formula by Araoye,[10] where P = prevalence rate of LBP from a previous study, using 85% in the study done by Omokhodion.[11] However, allowing for attrition and concession made for non-response, the final sample size was a round figure of 200.

Sampling method

The study population involved a purpose selection which is a simple random sampling technique. It was the selections of subjects of who the investigator believes or presumes are typical patients with LBP of the population to be studied.

Materials and techniques

Permanent magnet 0.2 T 'open' MRI unit (Magnetom Concerto Syngo MR 2004A, Siemens Erlangen, Germany), body coil, intravenous (IV) contrast medium (gadolinium-DTPA), cannulas/needles and syringes for securing IV line, MRI films and laser printer, calibrated weighing scale and height measuring stadiometer were used.

Having ascertained the eligibility of the subjects, the procedure was explained to them and informed consent was obtained from patients, parents or guardians as applicable.

Patients were then led to the changing room where they had to remove their clothes, one at a time and wore examination gown. The participants were also instructed to remove all metallic objects including jewelleries, watches, hairpins and phones, aimed at averting missile injury and radiofrequency interference.

Patients were registered and weighed in kilograms using a calibrated scale and the height was measured in meters using a height measuring stadiometer. It was necessary to weigh these patients as some of them required IV contrast medium (gadolinium) whose dose is normally calculated per body weight (0.2 mmol/kg body weight). Gadolinium was used to enhance the visibility of certain tissues or blood vessels.

An IV line was secured on any of the forearm veins under aseptic condition using cannular of appropriate size. Restless individuals were given sedations when necessary.

Patients were positioned on the examination couch that can be moved back and forth, into and out of the new 'patient-friendly' open MRI unit. The table moved by an automatic mechanism operated by the radiographer. The examination was carried out in the supine position, and the lower limbs were rested on a pillow. They were instructed not to move during imaging because motion will blur the images. The radiofrequency coil (body coil) was then applied and the field of view centred in the midline. Earplugs were used to block the noise heard during the imaging procedure.

Each MRI study generally takes about 30–45 min although only a fraction of that time is needed for the actual imaging. Each imaging sequence takes few minutes and produces sectional views or 'slices' of the spine in different planes.

The imaging protocol consists of a localiser, serial pre- and post-contrast sagittal, coronal and axial slices of T1- and T2-weighted spin echo and STIR sequences imaging of the entire lumbosacral spine.

Average T1-weighted time was 400/12 (repetition time in ms/echo time in ms) with T2-weighted time of 5000/140 (repetition time in ms/echo time in ms). The image matrix of 512 × 256 with 5 mm section thickness, field of view 575 × 250 mm and 0.5 mm intersection gap were obtained with the MR system by the use of a 42 cm diameter body coil. The scan range spanned from the lower thoracic vertebra (T12) to the last sacral vertebra (S5) covering the entire lumbosacral spine.

The slices were obtained of all abnormal disc levels and of at least one disc level with a normal appearance. These provide a detailed appearance at the tissues making up the spinal column. The images were stored in a computer and subsequently viewed on screen for detailed analysis in answering the relevant questions.

All procedures were done under the close supervision of consultant radiologist who further re-examined and vetted the images and sent a report to the patient's personal physician within a day for appropriate treatment if any.

Method of data analysis

Data from the pro forma were transferred into Microsoft Excel for analysis using the Statistical Package for the Social Sciences Version 16.0 (SPSS Inc., Chicago, IL, USA). The results were presented as frequency tables, means and percentages.

Descriptive statistics of frequencies and percentages were used to describe the categorical variables, while the Chi-square contingency table technique was used to compare variables. All tests of significance were two-tailed, and $P < 0.05$ (95% confidence interval) was considered statistically significant.

RESULTS

A total of 200 patients were included in this study; their age ranged from 11 to 80 years, with a mean of 47.8 years and standard deviation of 1.4.

One hundred and twenty-four (62%) patients were male while 76 (38%) were female. The age and sex distribution are as shown in Table 1.

The peak incidence was in the fourth and fifth decades of life with the same number of patients (55 [27.5%]). These two groups were dominated by the males. The prevalence of LBP was significantly associated with age or ageing ($\chi^2 = 93.2$; $P < 0.0001$).

The highest number of males (38 [19%]) and females (25 [12.5%]) was found in the 51–60 and 31–40 years of age group, respectively. The least incidence (6 [3%]) was seen in the 11–20 years of age group.

Overall, there were more males (124 [62%]) than females (76 [38%]) who participated in this study. There was a significant gender difference ($\chi^2 = 11.5$; $P < 0.001$) with a male-to-female ratio of 1.6:1 [Table 1]. In all the age groups, males were more in number except in the 31–40 years of age group where female dominance was noticed.

MRI findings on the vertebral bodies of the patients are presented in Table 2 where majority of the patients (168 [84%]) had straightened lumbosacral spine. Kyphosis and scoliosis accounted for 3 (1.5%) and 4 (2%) patients, respectively. Exaggerated lordosis was seen in 3 (1.5%) but 22 (11%) of the patients had normal lumbar lordosis.

Reduction in height and fracture of the vertebral bodies were seen in 18 (9%) and 7 (3.5%) of the patients, respectively. Marginal osteophytes were noted in 145 (72.5%) of the patients. Spondylolisthesis was found in 7 (3.5%) patients, 5 (2.5%) of which involved L4 and L5 vertebrae while 2 (1%) involved L5 and S1 as seen in Figure 1a.

Lumbarisation and sacralisation (normal variants) were found in 2 (1%) and 3 (1.5%) of the patients, respectively. Ligamentum flavum/facet joint hypertrophy was found in 15 (7.5%) patients [Figure 1b].

Reduction in height of the vertebral bodies as seen in Table 3 showed majority to be at the level of L4, which numbered 5 (27.8%) followed by L2 and L3 each with 4 (22.2%) patients. Fracture was most common on L4 and L5 vertebral bodies with each accounting for 2 (28.7%) patients.

MRI findings on the intervertebral disc cartilages [Table 4] showed reduction in height of the disc cartilages in

Table 1: Distribution of the study population based on age group and gender

Age group (years)	Gender		Total (%)
	Males	Females	
11-20	5	1	6 (3.0)
21-30	12	2	14 (7.0)
31-40	12	25	37 (18.5)
41-50	32	23	55 (27.5)
51-60	38	17	55 (27.5)
61-70	20	6	26 (13.0)
71-80	5	2	7 (3.5)
Total	124	76	200 (100)

$\chi^2=93.2$, df=6, $P<0.0001$

Table 2: Magnetic resonance imaging findings on the vertebral bodies of the 200 patients

MRI findings	Number of patients (%)
Lumbosacral curvature	
Normal	22 (11)
Exaggerated lordosis	3 (1.5)
Straightening	168 (84)
Kyphosis	3 (1.5)
Scoliosis	4 (2)
Height of the vertebral body	
Normal	182 (91)
Reduced	18 (9)
Fracture of the vertebral body	
Normal	193 (96.5)
Fracture	7 (3.5)
Osteophytes	
Normal	55 (27.5)
Present	145 (72.5)
Spondylolisthesis	
Normal	193 (96.5)
L4/L5	5 (2.5)
L5/S1	2 (1)
Variants (normal)	
Non-variant	195 (97.5)
Lumbarisation	2 (1)
Sacralisation	3 (1.5)
Ligamentum flavum/facet joint	
Normal	185 (92.5)
Hypertrophy	15 (7.5)

MRI: Magnetic resonance imaging

29 (14.5%) patients and dehydrated discs was observed in 72 (36%) patients [Figures 2 and 3]. Disc prolapse was noted in 172 (86%) patients and exit foramina/nerve roots compression was seen in 14 (7%) patients [Figure 4].

Table 5 shows the level and distribution of intervertebral disc lesions where majority of the lesions occurred at the level of L4/L5, except for the vacuum phenomenon which was found on L3/L4 and L5/S1 in the two patients involved. The least occurrence was noted at L1/L2 level. All of these lesions showed multiple level involvement.

Table 3: Site of reduction in height and fracture of vertebral body

Level of vertebra	Reduced height, *n* (%)	Fracture, *n* (%)
L1	3 (16.7)	1 (14.2)
L2	4 (22.2)	1 (14.2)
L3	4 (22.2)	1 (14.2)
L4	5 (27.8)	2 (28.7)
L5	2 (11.1)	2 (28.7)
Total	18 (100)	7 (100)

Level of compression of the spinal canal contents by the intervertebral disc prolapse [Table 6] showed L4/L5 intervertebral disc prolapse accounting for most of the compression of the thecal sac (135 [84.9%]) and cauda equina (60 [82.2%]), followed by L5/S1 numbering 105 (66%) and 46 (63%), respectively. Multiple level thecal sac and cauda equina compression were observed in 124 (78%) and 51 (70%) patients, respectively. Spinal cord compression was observed only at L1/L2 level where the true spinal cord ends in only 4 (2.3%) patients. Least number (18 [11.3%]) of thecal sac compression was also noticed at this level.

Figure 1: Sagittal T2 weighted (a) and Axial T1 weighted (b) MRI images of the lumbosacral spine showing L5/S1 spondylolisthesis and central canal stenosis due to a combination of zygo-apophysial joint and ligamentum flavum hypertrophy respectively

Figure 2: Coronal T1-weighted magnetic resonance imaging image of the lumbosacral spine. Mild scoliosis with convexity to the left is noted

Figure 3: Sagittal T2-weighted magnetic resonance imaging of the lumbosacral spine showing multiple levels of intervertebral disc dehydration and prolapse and straightened lumbar lordosis

Figure 4: Parasagittal T2-weighted magnetic resonance imaging of the lumbosacral spine showing multiple levels intervertebral disc dehydration and prolapse with mild narrowing of L4 exit foramen

DISCUSSION

MRI scanning of the lumbosacral spine has now gained broad acceptance as a highly accurate neurodiagnostic technique, greatly altering the approach to diagnostic evaluation of patients with LBP. [12]

Majority of the patients (168 [84%]) showed straightened normal lumbosacral lordosis which is similar to the report by Adeyinka and Omidiji[13] on straightening of the normal lumbar lordosis as the second most common findings in degenerative disease.

Kyphosis and scoliosis in this study accounted for 1.5% and 2%, respectively, and exaggerated lordosis was seen in 1.5%. Only 11% of the patients had normal lumbosacral lordosis.

Adeyinka and Omidiji[13] showed that osteophyte formation was the most common degenerative disease, present in 56 cases (62.0%) of 99 patients who were symptomatic for LBP. This is comparable to the findings of the current study where marginal osteophytes were noted in 145 (72.5%) of the patients. Umerah also found degenerative process of ageing termed spondylosis as the most common cause of the LBP. [14]

Spondylolisthesis was found in 3.2% of patients by Adeyinka and Omidiji,[13] and this corresponds to the findings of 7 (3.5%) in the current study. The incidence of 8.8% recorded by Umerah[14] was however higher.

Table 4: Magnetic resonance imaging findings on the intervertebral disc of the 200 patients

MRI findings	Number of patients (%)
Height of the disc element	
Normal	171 (85.5)
Reduced	29 (14.5)
Dehydration	
Normal	128 (64)
Dehydrated	72 (36)
Herniation	
Normal	28 (14)
Bulging	20 (10)
Protrusion	143 (71.5)
Extrusion	9 (4.5)
Exit foramina/nerve root	
Normal	186 (93)
Compressed	14 (7)

MRI: Magnetic resonance imaging

Reduction in height and fracture of the vertebral bodies were seen in 18 (9%) and 7 (3.5%) of the patients, respectively, probably resulting from chronic degenerative process of ageing, antecedent trauma, malignancy, infection and other systemic diseases which occasionally cause acute back pain.[15]

Lumbarisation and sacralisation (normal variants) were found in 2 (1%) and 3 (1.5%) of the patients, respectively, and similar to the results recorded by Umerah.[14]

The reduction in height and dehydration of the intervertebral disc elements seen in 29 (14.5%) and 72 (36%) of patients in this study, respectively, corroborate the findings of lumbar degenerative disease (spondylosis) by Adeyinka and Omidiji[13] and Umerah[14] using MRI, respectively.

Degeneration of the intervertebral disc begins early in life and is partly a consequence of ageing. Although the actual cause is not known, many factors (autoimmune, genetic, re-absorption and biomechanical) have been implicated in accelerating the process.[16]

Majority of the patients (172 [86%]) in the present study had intervertebral disc prolapse/herniation, of which 104 (60.5%) were male and 68 (39.5%) were female with male-to-female ratio of 1.5:1. This male preponderance is the usual presentation in the lumbar disc prolapse.[17]

In addition, most of the disc diseases involved L3/L4, L4/L5 and L5/S1 disc levels, and the upper lumbar disc herniations have been reported to occur with a frequency of <5% of all disc herniations,[18] similar to the findings in this current study.

In most cases, stenosis of the lumbar canal may be attributed to acquired degenerative or arthritic changes of the intervertebral discs, ligaments and facet joints surrounding the lumbar canal. These changes include cartilaginous hypertrophy of the articulations surrounding the canal, intervertebral disc herniations or bulges, hypertrophy

Table 5: Level and distribution of intervertebral disc lesions

Site	Reduced height	Dehydrated	Prolapse			Vacuum phenomena
			Bulging	Protrusion	Extrusion	
L1/L2	2	13	2	22	0	0
L2/L3	9	32	3	60	2	0
L3/L4	7	34	20	100	2	1
L4/L5	15	50	25	129	3	0
L5/S1	7	39	20	98	2	1
Total	40	168	70	409	9	2

Table 6: Level of compression by the intervertebral disc prolapse

Site	Thecal sac	Spinal cord	Cauda equina
LI/L2	18	4	0
L2/L3	53	0	24
L3/L4	102	0	36
L4/L5	135	0	60
L5/S1	105	0	46

of the ligamentum flavum and osteophyte formation.[19] Mechanical compromise and chemical irritation of the nerve root by nucleus pulposus tissue are two important pathophysiologic mechanisms that cause sciatica.

Although intervertebral disc herniation accounts mostly for a cause of LBP and sciatica, it is nowadays generally accepted that posterior structures (ligamentum flavum) and facet joint play also an important role in this pathology.[20] In cases of posterior spinal elements' symptomatology, the pain is referred pain originating from the posterior ramus of the spinal nerve.

Walter and Bartynskia[21] reported that MRI (performed on a 1.5-T system) underestimated root compression in 28%–29% of the cases in which root impingement was surgically confirmed. Only 14 (7%) patients in the present study were noticed to have root compression.

Thecal sac, spinal cord and cauda equina were compressed in 159 (92.4%), 4 (2.3%) and 72 (41.8%) patients, respectively, with preponderance of males. Compression of multiple structures was seen in 64 (37%) of the patients in this study, resulting from narrowing of the spinal canal. Güner *et al*.[22] noted that lumbar canal diameters from 10 to 12 mm may be connected with the characteristic syndrome associated with lumbar stenosis termed neurogenic intermittent claudication.

L4/L5 intervertebral disc prolapse accounted for most of the compression of the thecal sac and cauda equina, followed by L5/S1. These are consistent with the previous findings where most of the disc prolapse occurred at L4/L5 and L5/S1 levels.[18,23]

Spinal cord compression was observed only at L1/L2 level in all the 4 (2.3%) patients consequent upon termination of the spinal cord at the conus medullaris (L1/L2 level). Cauda equina syndromes usually occur as a result of compression of the nerve roots in the lumbosacral spine distal to the conus medullaris.[12]

The use of low strength (0.2 T) permanent magnet 'open' MRI system has lower image quality with possible underestimation of root compression caused by degenerative changes in the lateral recess. However, this was reduced to the barest minimum by going through each image thrice. Small study population due to high cost of the MRI scan may also be a constraint.

CONCLUSION

MRI (0.2 T) was used as the state-of-the-art imaging modality to demonstrate the disc prolapse. MRI examination has improved the management of patients with LBP, and the results obtained from this study will assist clinicians to quantitatively evaluate patients with LBP.

Recommendation

A similar study in other geopolitical zones of the country by radiologists is also recommended as varying factors are known to affect the prevalence and severity of LBP and possibly with the use of higher Tesla MRI system.

Further follow-up research in collaboration with the neurosurgeons is necessary to monitor the progress of these patients and to design the most effective strategies to prevent and manage LBP.

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Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Galukande M, Muwazi S, Mugisa DB. Aetiology of low back pain in Mulago Hospital, Uganda. Afr Health Sci 2005;5:164-7.
2. Michael NB, Steven C. Low back pain. Radiology 2000;217:321-30.
3. Weber AL. History of head and neck radiology: Past, present, and future. Radiology 2001;218:15-24.
4. Edmond SL, Felson DT. Prevalence of back symptoms in elders. J Rheumatol 2000;27:220-5.
5. Sikiru L, Shmaila H. Prevalence and risk factors of low back pain among nurses in Africa: Nigerian and Ethiopian specialized hospitals survey study. East Afr J Public Health 2009;1:6.
6. Jarvik JG, Deyo RA. Diagnostic evaluation of low back pain with emphasis on imaging. Ann Intern Med 2002;137:586-97.
7. Oniankitan O, Magnan A, Fianyo E, Mijiyawa M. Lumbar spinal stenosis in an outpatient clinic in Lome, Togo. Med Trop (Mars) 2007;67:263-6.
8. Walker BF. The prevalence of low back pain: A systematic review of the literature from 1966 to 1998. J Spinal Disord 2000;13:205-17.
9. Katz JN. Lumbar disc disorders and low-back pain: Socioeconomic factors and consequences. J Bone Joint Surg Am 2006;88(Suppl 2):21-4.
10. Araoye MO. Research Methodology with Statistics for Health and Social Sciences. Vol. 115. Ilorin: Nathadex Publisher; 2003. p. 25-120.
11. Omokhodion FO. Low back pain in urban population in South West Nigeria. Trop Doct 2004;34:17-20.
12. Chad DA. Lumbar spinal stenosis. Neurol Clin 2007;25:407-18.
13. Adeyinka AO, Omidiji OA. Magnetic Resonance Imaging Diagnoses in the lumbar spine of adults with low back pain in South West, Nigeria. WAJR 2011;18:1-9.

14. Umerah CK. Magnetic Resonance Imaging Evaluation of low back pain in adult Nigerians at the National Hospital Abuja, Nigeria . FMCR Dissertation. National Postgraduate Medical College of Nigeria. November 2014.
15. Woolf AD, Pfleger B. Burden of major musculoskeletal conditions. Bull World Health Organ 2003;81:646-56.
16. Johannessen W, Vresilovic EJ, Wright AC, Elliott DM. Intervertebral disc mechanics are restored following cyclic loading and unloaded recovery. Ann Biom Eng 2004;32:70-6.
17. Euro U, Knekt P, Rissanen H, Aromaa A, Karppinen J, Heliövaara M. Risk factors for sciatica leading to hospitalization. Eur Spine J 2018;27:1501-8.
18. Sanderson SP, Houten J, Errico T, Forshaw D, Bauman J, Cooper PR. The unique characteristics of "upper" lumbar disc herniations. Neurosurgery 2004;55:385-9.
19. Christian W. A, Pfirrmann, Claudio Dora. MR Image–based Grading of lumbar nerve root compromise due to disk herniation: Reliability study with surgical correlation. Radiology 2004;230:583-8.
20. Jacobson JA, Girish G, Jiang Y, Resnick D. Radiographic evaluation of arthritis: Inflammatory conditions. Radiology 2008;248:378-89.
21. Walter S, Bartynskia LL. Lumbar root compression in the lateral recess Imaging. MRI, Conventional Myelography, and CT Myelography comparison with surgical confirmation. Am J Neuroradiol 2003;24:348-60.
22. Güner G, Elmalı N, Ertem K. Lumbal Spinal Stenoz. J Inonu Univer Med Fac 2010;4:236-42.
23. Saberi H, Isfahani AV. Higher preoperative Oswestry Disability Index is associated with better surgical outcome in upper lumbar disc herniations. Eur Spine J 2008;17:117-21.