TITLE

THE PATTERN OF MAGNETIC RESONANCE IMAGING FINDINGS OF PYOGENIC, TUBERCULOUS AND BRUCELLAR SPINAL INFECTIONS AT KENYATTA NATIONAL HOSPITAL.

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DECLARATION

I, **DR. WANDERI PETER KIORIA** declare that the work contained herein is my original idea and has not been presented at any other place to the best of my knowledge.

Signatureé é é é é é é é é é .

Dateé é é é é é é é é é

APPROVAL BY SUPERVISOR

This dissertation has been submitted for examination with my approval as a university supervisor.

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DATE----------

DEDICATION

This dissertation is dedicated to my wife Anne and my son Adrian for their everlasting support and understanding through it all.

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7. Finally, my family and friends for the well wishes and support.

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ABBREVIATIONS

CSF	Cerebral spinal fluid.
CT	Computed Tomography
DTPA	Diethylene Triamine Penta-acetic Acid.
ESR	Erythrocyte Sedimentation Rate.
HIV	Human Immunodeficiency Virus
IP/OP NO	In-patient/Out-patient Number
KNH	Kenyatta National Hospital
MRI	Magnetic Resonance imaging
MRSA	Methicillin resistant Staphylococcus aureus.
RNI	Radionuclide imaging
SE	Spin Echo
SEA	Spinal epidural abcess
SPSS	Statistical Package for Social Scientists
STIR	Short Tau Inversion Recovery.
TB	Tuberculosis
T1W	T1 Weighted images
T2W	T2 Weighted images

ABSTRACT

INTRODUCTION AND BACKGROUND

Spinal infections account for 2 ï 4% of all skeletal infections. The biggest challenge is making an early diagnosis before serious morbidity occurs, this is particularly true in the early stages of infection. Confirmation and localization of a spinal infection usually depends on imaging findings. The imaging modality of choice for spinal infection is MRI. The aim of this study is to understand the pattern of occurrence and to analyze the various pathological features of spinal infections by using MRI at KNH, the largest referral hospital in Kenya.Spinal infections can be classified anatomically as involving the vertebral column, intervertebral disc space, the spinal canal and adjacent soft tissues. Vertebral osteomyelitis is the commonest form. Intervertebral disc space infections involve the space between adjacent vertebrae. Spinal canal infections include spinal epidural abscess, subdural abcess and intramedullary abscess. They can also be classified aetiologically as pyogenic and non-pyogenic.

OBJECTIVE

The main objective of this study was to determine the patterns of MRI findings in patients presenting with pyogenic, tuberculous and brucellar spinal infections at Kenyatta National Hospital.

METHODS

This was a one year cross-sectional descriptive study with retrospective and prospective data collection carried out over the period between February 2013 and February 2014 for 45 patients. Retrospective data collection period was of eight months duration and includedpatients with a previousMRI diagnosis of suspected spinal infection. The prospective data collection period was four months and included patients referredfor spinal MRI with clinically suspected spinal infection.All patients had suspected MRI diagnosis of infection. The gold standard used in this study was MRI findings. Patients in the prospective study were recruited into the study after signing an informed consent. A 1.5 Tesla MRI scanner performed the imaging studies. The images were reviewed by the primary investigator and a consultant radiologist. Data analysis was done using a statistical package for social science research (SPSS 20.0). The results were presented in the form of tables, graphs and charts followed by a discussion of the results.

RESULTS

During the one year study period a total of 45 patients were recruited into the study. The age distribution ranged between 11 and 81 years with spinal infections being most prevalent in the 30-39 age group (31.1%) with a mean age of 36.9 years. There were more males(53.3%) affected by spinal infections.Back pain (36 cases,80%) was the commonest presenting complaint followed by neurological deficits (29 cases, 64.4%) and fever (22 cases, 48.9%). Overall spinal infections affected mainly the thoracic region (17 cases, 37.8%) or lumbar regions (15 cases, 33.3%). Spondylodiscitis present in 77.8% of the cases was the commonest anatomical lesion seen, the rest were isolated epidural abscess (11.1%), spondylitis (8.9%) and discitis (2.2%). The commonest infection was tuberculous, accounting for 38 (84.4%) cases. Pyogenic and brucellar infections were seen 6 (13.3%) cases and 1 (2.2%) case respectively based on suggestive MRI findings.

Neurological deficits and spinal deformities were used to correlate MRI findings with the clinical presentation; Neurological problems were found to correlate poorly with MRI findings but spinal deformities correlated very well with MRI findings.

Plain radiographs performed on 34(75.6%)cases were the only imaging studies done prior to MRI examination. These were done using the standard anteroposterior and lateral views on the vertebral regions affected. Radiographic findings correlated highly with vertebral and disc changes seen on MRI but showed very poor correlation with soft tissue changes seen on MRI. The main risk factor for spinal infections was HIV infection (37.5%) though previous TB infection was the commonest risk factor in TB cases (31.6%). 11.1% of the cases had no identifiable risk factors. Vertebral body changes (39cases, 86.7%), disc changes (37 cases, 82.2%) and soft tissue changes (43 cases, 95.6%) were the main MRI findings in spinal infections.Atypical changes were seen in 36.8% of cases and almost all were seen in TB cases.

1.0 LITERATURE REVIEW

1.1 INTRODUCTIONAND BACKGROUND INFORMATION

Spinal infections are serious, rapidly progressing, disabling and potentially lethaldiseases if poorly managed**[1]**. These rare diseases are difficult to diagnose due to their non-specific symptoms for example back pain, a very common complaint. Diagnostic imaging is important for confirming and localizing these infections**[2]**, with MRI commonly usedas the gold standard**[3]**. Studies have reported MRI to have high sensitivity, specificity and accuracy for diagnosing spinal infection of96%, 92% and 94%, respectively[**4,5**]. Prompt diagnosis which is very important in managementdepends heavily on specific MRI features**[1]**.

Low back pain (LBP) with or without nerve root irritation is a frequent symptom in the United States and the main cause of disability for people under45 years**[6]**. Imaging is not required for uncomplicated backpain as evidenced by some studies**[7]**.The American College of Radiology (ACR) appropriateness criteria on LBP defines complicated back pain as ñpain that is associated with either:- recent significant trauma or milder trauma at age > 50 years, unexplained weight loss, unexplained fever, immunosuppression, history of cancer, intravenous drug use, prolonged use of corticosteroids or osteoporosis, age > 70 years, focal neurologic deficit with progressive or disabling symptoms, and duration > 6 weeks. According to ACR recommendations all complicated back pain should undergo imaging and MRI is recommended as the initial modality of choiceò**[6]**.Complicated LBP is the commonest symptom of spinal infections.

Anatomically spinal infections can either involve the vertebral body (spondylitis), the intervertebral disc (discitis), the vertebral body plus the intervertebral disc (spondylodiscitis), the ligaments and paravertebral soft tissues, the epidural space (epidural abscess), subdural space (subdural abscess), the meninges and subarachnoid space, and very rarely, the spinal cord (myelitis, intramedullary abscesses)**[8]**. The main morphological forms of spinal infections seenare osteomyelitis (spondylitis and spondylodiscitis), discitis and epidural abscess**[9]**.

Vertebral osteomyelitis/spondylodiscitisinvolves two vertebrae and the intervertebraldisc**[10,11]**.Discitis is either primary/isolated or secondary to spread of infection

from an adjacent vertebra (spondylodiscitis). A spinal epidural abscess (SEA) is the presence of pus in the epidural space. It may be isolated or secondary in a manner similar to discitis.

Aetiologically spinal infections are either pyogenic, granulomatous (tuberculous, brucellar, fungal) or parastic**[12]**.

1.2 ANATOMY

The spine includes the vertebral bodies, intervertebral discs and associated joints, muscles, tendons, ligaments and neural elements.

(i) Vertebral column - This consists of the vertebral bones and intervertebral discs. There are 33 vertebral bodies; 7 cervical ,12 thoracic, 5 lumbar, 5 sacral (fused) and 4 coccygeal (fused). The MR appearance depends on the signal from bone marrow. Fat within the marrow of the vertebral bodies, neural arches and articular pillars is hyperintense in T1W and T2W images. The outer dense cortical bone is hypointense in both T1W and T2W images.

The intervertebal disc consists of concentric outer rings of fibrous tissue, the annulus fibrosus and central portion consisting of gelatinous material, the nucleus pulposus. On T2W images the nucleus and medial portions of the annulus are hyperintense while the periphery is hypointense in both T1 and T2W images. The facet joints are hyperintense in between hypointense cortical bones on MRI.

The neural foramina are canals through which spinal nerves exit from the spinal canal. Borders of the neural foramina are formed by the facet joint posterolaterally, verterbral bodies and discs anteromedially and the pedicles superiorly and inferiorly. Due to perineural fat this foramina are bright on both T1 and T2W images outlining the nerve.

(ii) Epidural space - This space surrounds the dura and contains predominantly vascular tissues with small amounts of fat and loose areolar tissues. It extends laterally for a short distance beyond the neural foramina along the spinal sheath. Posterior to the spinal cord the epidural fat pad is seen as a bright signal on both T1W and T2W images

The dura matter and arachnoid separate the epidural space from the subarachnoid space. These membranes are ordinarily obscured by bright signal from the CSF on T2W images or the bright

signal from fat in T1W images and are not usually resolved in conventional SE MRI. The dura is hypointense on T2W gradient echo images. The dural sac extends inferiorly to S2 vertebral level. Below this the arachnoid and dura blend with the pia on the filum terminale which is a thickening of the pia extending from the conus to the first coccygeal vertebrae.

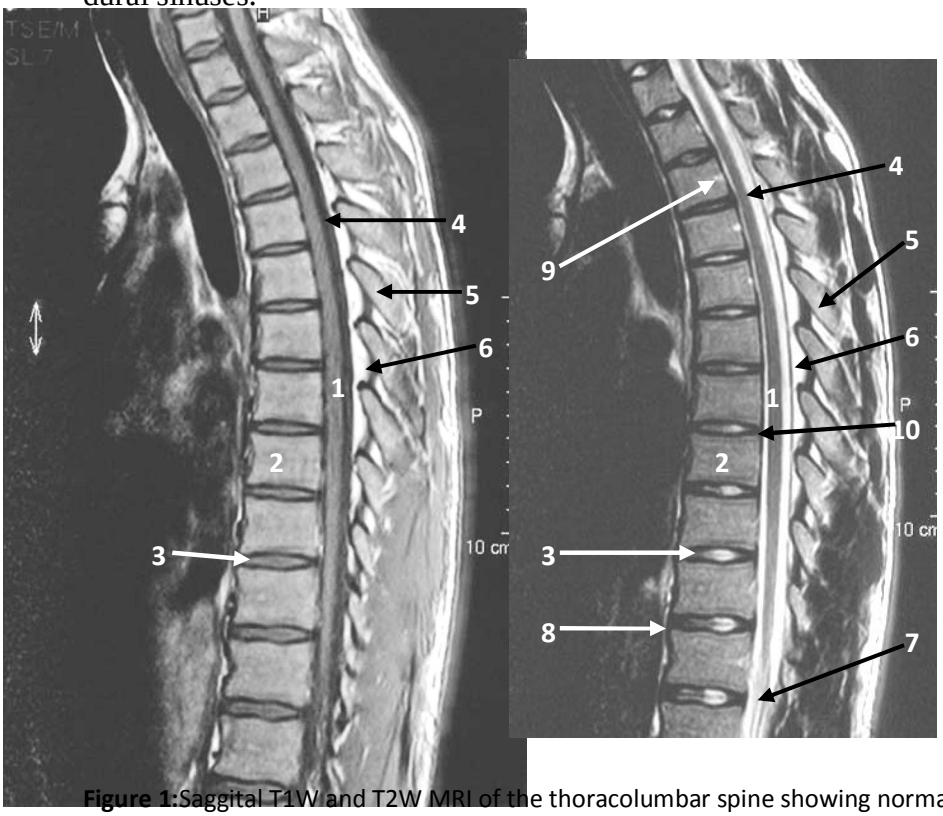
(iii) Subarachnoid space - About half of the spinal canal is occupied by the subarachnoid space.CSF in the subarachnoid space is resolved from the spinal cord, on T1W CSF is hypointense to the cord while on T2W images the CSF is hyperintense to the cord.

(iv) Spinal cord - It extends from the medulla oblongata at the foramen magnum to the conus medullaris, this is at L3 at birth and L1/L2 in adults. Its a conduit for the ascending and descending fiber tracts connecting peripheral and spinal nerves to the brain. There are 31 pairs of spinal nerves on either side (8 cervical, 12 thoracic, 5 lumbar, 5 sacral, 1 coccygeal). On cross-section, the cord consists of central grey (cell bodies) surrounded by white matter (fibre tracts), this is difficult to see on MRI. Cord expansions are seen at C4-T2 (brachial plexus) and T9-L1/2 (lumbar plexus). The nerve roots that exit below the conus at L1/L2 (the cauda equina) are contained within the dura until S2.These spinal nerves can be seen outlined by the CSF.

(v) Blood supply - The vertebrae are supplied by vertebral, intercostal, lumbar or sacral arteries, located at the anterior and anterolateral surfaces. Each artery divides into an ascending and descending branch, which anastomose with corresponding branches of adjacent vertebrae. Arterioles from this network ramify within the vertebral body through central nutrient foramen, being most abundant at the end plates**,** especially in the anterior subchondral region where infection usually begins**[11]**. The spinal cord is supplied by two posterolateral spinal arteries that supply the posterior one third and a single midline anterior spinal artery that supplies the rest.

Venous drainage of is by 3 anterior and 3 posterior spinal veins, which run longitudinally draining the radicular veins. These spinal veins join the basivertebral veins which drain the vertebral bodies to form the internal vertebral venous plexus within the epidural space. This plexus via the external vertebral venous plexus drains into the vertebral and ascending lumbar veins which in turn drain into the azygos and hemiazygos veins. The spinal venous system is valveless thus blood flow is bi-directional. The internal vertebral venous plexus communicates with the deep pelvic veins and thoracic veins via the paravertebral Batson venous plexus forming

an important route of spread of infection and metastasis. It also communicates with intracranial dural sinuses.



1. Spinal cord.
2. Vertebra.
3. Intervertebral disc.
4. CSF.
5. Spinous process.
6. Posterior epidural space.
7. Cauda equina.
8. Anterior longitudinal ligament.
9. Basivertebral vein.
10. Posterior longitudinal ligament.

Figure 1: Saggital T1W and T2W MRI of the thoracolumbar spine showing normal anatomy.

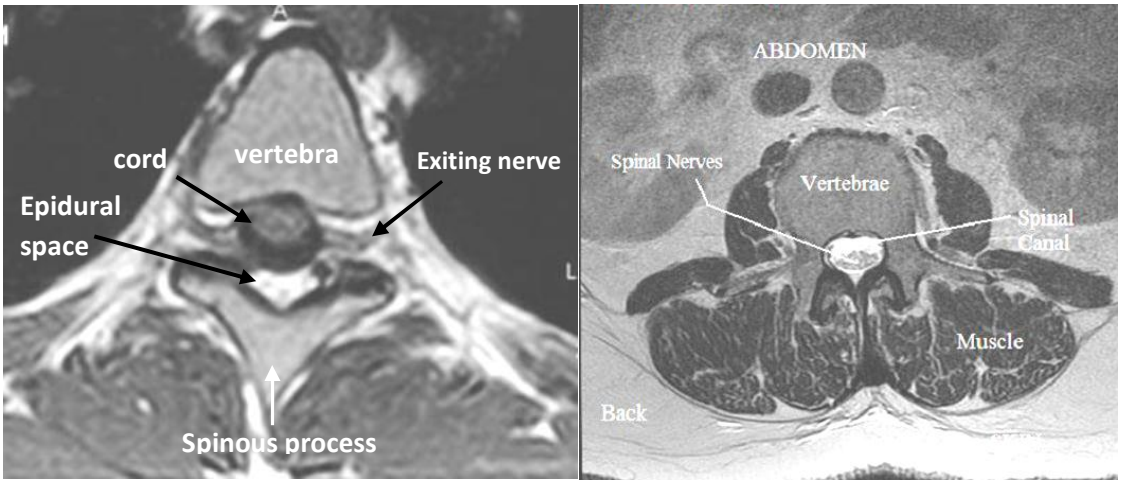


Figure 2: Axial T1W and T2W MRI images of the spine at different levels showing normal anatomy.

1.3 PATHOLOGY

(i) CAUSATIVE ORGANISMS

Although pyogenic bacteria are the main culprits, tuberculosis and brucellosis remain major causes in areaswhere endemic.In some studies TB is viewed as the chief cause globally, being observed in 9% ï 46% of cases in the western world**[13,14]**.

Staphylococcus aureus seen in 55%-90% of cases is by far the principal cause of pyogenic infections**[13,15]**.Other causes include Coagulasenegative staphylococci like staphylococcus epidermidis and MRSA (5% ï 16%), Enterobacteriaceae (7% ï 33%),Streptococcus (viridans and ß-haemolytic streptococci groups A and B) and enterococci (5% ï 20%)**[13,14]**.Rarely (upto 4% of cases) pyogenic infections are caused by Salmonella (seen in sicklers)**,** Pseudomonas aeruginosaand anaerobes**[12,14]**.

Non-pyogenic granulomatous infections are caused by Mycobacterium tuberculosis, Brucella,Fungi such as Aspergillus and Parasites such as Echinococcus**.**

(ii) PATHOGENESIS

a) Pyogenic spinal infections

Accounting for 2% ï 4% of all skeletal infections these infections are quite rare**[16]** and their spread is either via blood-borneorother (non-haematogeneous) routes**[4]**. Blood-borne spread maybe by antegrade flow through the nutrient arterioles of the vertebral bodies or by retrograde flow through the paravertebral Batson venous plexus, with the arterial system being the preferred route**[10]**.Non-haematogenous spread is via direct inoculation for example during surgery or frompenetrating trauma, and by contiguous spread from local infection. Post-operative infections account for 1% - 4%**[17]**.

The blood supply to the disc is age relatedandin turndictates the form of discitis as follows; those with vascularized discs (children under 4 years and the patients with revascularized degenerative discs) develop primary discitis while those with avascular discs develop secondary discitis**[18]**. Spondylodiscitis starts at the anterior vertebral body, close to the end-plate spreading to the whole vertebral body,adjacent disc and vertebra**[10,11]**.Extensive disease causes wedging,

cavitation, compression fractures and soft tissue involvementwith resultantcomplications such as cord compression,abscesses (psoas, paraspinal, epidural and subdural), or meningitis**[1]**.

In the vertebra due to the preferential blood supply to the vertebral body, majority of infections (over 95%) involve the body while the remainder affects the posterior elements**[19]**. Of significance is that posterior element involvement is mainly seen in spinal TB**[13,16]**.

The main primary sources of infection are genitourinary tract (17%), the heart in infective endocarditis (12%), skin and soft tissue (11%), intravascular devices (5%), the gut (5%), respiratory tract and the oral cavity (both at 2%)**[20]**.In about 30% - 40% of cases the source is unknown**[21]**.

SEA (spinal epidural abscess) is a rather ominous infection as it affects the cord by both ischemia and direct compression**[21]**.

Spondylodiscitis mainly affects the lumbar (50-58%), thoracic (30 -35%) and cervical spine (11%)**[20].** Multiple site involvement is seen in 4% of cases**[20]**.SEA is mainly found in the thoracic and lumbosacral spine**[22]**.

b) Spinal Tuberculosis

Musculoskeletal TB constitutes 1% - 5% of TB cases, 50% of which affects the spine**[23]**. It has a wide range of effects on the spine ranging frombony destruction, vertebral collapse, anterior wedging (leading to kyphosis and gibbus deformity), skip lesions,to epidural and paraspinal abscesses amongst others.MRI effectively and efficiently demonstrates these findings rendering it a priceless investigation tool.

TB spreads preferrentially via the haematogenous route**[24]**.Initially the infection is at anterior subperiosteal cancellous bone of the vertebral body, then later it extends to the intervertebral disc and to other parts of vertebrae. The resultant bony destruction causes vertebral body collapse and wedging.Paraspinal, psoas and epidural abscesses are some of the soft tissue manifestations of inflammation. Subligamentous spread involves multiple contiguous vertebrae. TB lacks proteolytic enzymes, this is presumed to be the reason for the relative disc preservation and subligamentous spread seen in TB infection**[25]**.Neurological deficit results from multifactorial causes like vascular engorgement and vertebral collapse.

In children bone destruction is faster and more devastating than in adults, but they heal much faster**[26]**. Infact spinal deformity in children may resolve spontaneously during growth as long as the end-plate and apophyseal ring cartilage are preserved**[27]**.

TB has a predilection for the lower thoracic and the upper lumbar regionsas follows **:-** the lower thoracic spine (40-50%), lumbar spine (35-45%) and cervical spine(10%)**[24,28]**. However according to some studies the lumbar spine predominates**[29]**.Other sites are the craniovertebral junction and isolated sacral each at 0.3-1%, sacroiliitis(10%). Multifocal and multilevel involvement is seen in 1.1% - 16%, intramedullary granuloma is very rare**[30]**.

c) Brucellosis

It is the commonest zoonotic infection,with 4 Brucella species affecting humans; B. melitensis, B. suis, B. abortus and B.canis. B. melitensis is the main culprit and most virulent.

There are two forms of spinal brucellosis; focal and diffuse. In the focal form, blood-borne infection localizes atan anterior end-plate, especially the superior end-plate of a lumbar vertebra at the discovertebral junction resulting in a focal bone destruction. This results inbone sclerosis, anterior osteophyte formation (parrotôs beak) or a small quantity of gas representing localized tissue necrosis. The disc, paraspinal soft tissue, and spinal canal are spared. L4 vertebra is Brucellasô favourite site. It can progress to a diffuse form. The diffuse form occurs in severe infection and affectsthe whole vertebral body, corresponding discs and vertebral bodies, paraspinal soft tissues, epidural space and intraspinal extension with or without cord compression by the granulation tissue**[31]**.

Spinal brucellosis mainly affects the lumbar (60%) especially the lower regions mainly L4, thoracic (19%) and cervical (12%) spines**[32,33]**.Multifocal and multilevel involvement is seen in 3.2% - 9%. Paravertebral and epidural abscesses are exceedingly rare**[32,33]**.

1.4 INCIDENCE AND PREVALENCE

a) Pyogenic spinal infections

Globally, the incidence of spondylodiscitis is estimated at 5 - 5.3 patients per million patients per year**[30]**.A bimodal age distribution with peaks at under 20 years and 50ï 70 years has been reported in some studies**[34,35]**,with a 1.5-2:1 male preponderance**[34,36]**.Factors like an increase in the ageing population, advanced and superior diagnostic practices, increased immunosuppressant drug use, advances in spinal surgery and rising intravenous drug abuse have increased the prevalence of these infections**[37]**.SEA is rare, in the USA incidence ranges from 0.2-1.2 cases per 10,000 hospital admissions**[38]**.It mainly affects people over 50 yearswith no sex preference**[39]**.

b) Tuberculosis

In 2011, 8.7 million people worldwidehad active TB with 1.4 million deaths, most of which (over 95%) were in developing countries, with Sub-Saharan Africa leading**[40]**.Musculoskeletal TB constitutes 1% - 5 % of TB cases, with 40% - 50% involving the spine**[23]**. As previously stated, TB may be the commonest cause of spinal infection worldwide,accounting for 9% ï 46% of cases in developed countries. In a reported series 62%-90% of TB spine cases had no features whatsoever of extraspinal TB**[28,41]**.

Osborn et al stated that in the developing countries TB is prevalent in the younger age group, while in the developed world, age prevalence shifts to the middle age (mean 40-45 years)**[42]**. In a large epidemiological study of spondylodiscitis, TB spine was strongly prevalent in patients aged under 40 years**[36]**. It has a male-to-female ratio of 1.5-2:1**[43]**. In a 10-year retrospective study to highlight hospital data on spinal TB by Solagberu BA et al, a study of records on spinal TB was done at University of Ilorin Teaching Hospital, Nigeria, involving 50 patients treated for spinal TB from January 1990 to December 1999. The results were, of the 50 patients seen, 24 males and 26 females, age range 1.5-70 years (mean 27.1 +/- 22.8 years). Peak prevalence (30%) was in the first 10 years of life**[29]**.

c) Brucellosis

Brucellosis prevalence varies widelybeing endemic in the Mediterranean basin, Middle East, India, Central and Latin America. True estimates in endemic areas are unknown. Globally the male gender is mostly affected. Skeletal involvement in chronic brucellosis varies between 10% - 85%,with lumbar spondylitis as the most commonly encountered pathology**[44]**. It may account for 21% ï 48% of spinal infections in endemic areas, representing the main cause there and commonly presents at 50 to 60years**[13,14,32,33]**. Spinal involvement accounts for 7.5% ï 30% of brucellosis cases**[45]**.

1.5 RISK FACTORS

a) Pyogenic spinal infections

The commonest identifiedrisk factor is diabetes mellitus**[35]**. Other risk factors include old age, intravenous drug use, immunosuppressive conditions (like HIV, cancer), previous spinal surgery, distant site infection andindwelling catheters amongst others.

b) Spinal TB

These include active TB elsewhere, previous TB infection, HIV infection (risk of developing active tuberculosis increases by 21ï 34 times)and other causes of immunosuppression, cigarette smoking, alcoholism and drug addiction[40**]**. In Kenya the high TB burden is mainly due to HIV/AIDS thus HIV infection is a major risk factor locally.

c) Brucellosis

Ingestion of unpasteurized milk or dairy products, occupational hazards like animal handlers, laboratory workers and pathologists, especially in endemic areas.

1.6 DIAGNOSIS OF SPINAL INFECTIONS

Spinal infections are a huge diagnostic dilemma especially in the early stages because of their non-specific symptomatologywhich may lead to diagnostic delay and unwanted outcomessuch aspermanent neurological compromise or fatalities.For example, chronic back pain is the commonestsymptom in TB spine but because it is non-specific, it has been shown to delay diagnosis of TB spine by a reported average duration of 4 months**[41]**. In their retrospective study, Davis *et al*. report on the impact of delayed diagnosis on the outcome of 4 SEA patients: neurologic deterioration occurred in 57% and 45% discharged with residual weakness compared with 13% without such delay**[46]**. Risk factor awareness, serology and utilization of imaging studies preferrably MRI aids in arriving at a quick and definite diagnosis**[47]**.

(i) CLINICAL PRESENTATION

The differences in morphology and clinical features of spinal infections depends on several factors like patientsô age, spread of infection, offending micro-organism, type of infection, site affected, complications and associated comorbidities**[48].** For examplean insidious onset with a chronic clinical course favours a diagnosis of TB rather than pyogenic spinal infection. Even if spinal infections have a non-specific presentationback pain, fever and neurological deficits are the most commonly encountered symptoms**[2,49]**.

The earliest and main symptom is back pain**[34]**, for example it is seen in upto 85% of patients with SEA**[49]**..
Fifty percent of pyogenic spondylodiscitis cases and a lesser percentage of TBspine cases have fever**[20]**.

Motor, sensory or sensori-motor neurological deficits usually present lateand are mostly seen in epidural abscess, delayed diagnosis, cervical lesions**[50]** and spinal TB. In spinal TB it is seen in 23 to 76% [**51]** with paraparesis ranging from 27% - 47%,infact in someTB endemic regions Pottsô disease is only second to trauma as a cause of paraplegia**[43]**.In pyogenic spinal infections especially SEA neurological deficits range from13% - 40%**[20]**with permanent paralysis affecting 4% - 22% of SEA cases**[21]**. Brucellosis has less neurological deficits than the other two i.e pyogenic and tuberculous cases**[14]**.

Spinal deformity (kyphosis and gibbus deformity)is mostly encountered in spinal TB**[14]**.

Cervical spine infections are highly associated with severe neurological compromise and as such considered to bemore serious. They usual present with neck pain and stiffness, torticollis, difficulty in swallowing and stridor**[50]**.

Children mainly have vague symptomsfor example irritability, limping and refusal to walk**.**

Constitutional symptoms such as weight loss, anorexia, malaise and other symptoms such as sinus formation and bowel/bladder dysfunction may be present. Psoas abscess may present as flank and/or hip pain .

In a retrospective study done by Mwachaka et al at KNH in April 2011 involving 129 in-patients admitted between 2004 and 2009 with a diagnosis of spinal TB, they observed that although Kenya isa TB endemic country ithas very little data on spinal TB. The most common symptoms were back pain in 100 patients (77.5%) and limb weakness in 94 patients (72.9%), whereas the main clinical sign was gibbus deformity in 85 patients (65.8%). Majority (79 patients, 61.2%) had severe motor and sensory deficit. The main imaging finding was multilevel disease in 90 patients (79.6%) of which two vertebrae involvement seen in 77 patients (68.1%) was the most prevalent. They concluded that in Kenya TB spine has a late and advanced presentation, and as such a high index of suspicion and early initiation of therapy is required**[52]**.

(ii) LABORATORY FINDINGS

The main investigations are full hemogram, serology, cultures and histology. Full hemogram is non-specific. White blood cell count is high in pyogenic infections,whereas it is normal in spinal TB and Brucellosis. ESR and C-reactive protein are high in many pyogenic infection cases. ESR is very high in TB spine**[15,16]**. Serology is significantin brucellosis. Isolation of micro-organisms requires cultures and histology**[15]**. Histology biopsies may differentiate pyogenic and granulomatous disease**[13]**.

(iii) ROLE OF IMAGING IN SPINAL INFECTIONS

The roles of imaging are**[1]** :-

-Provide fastand accurate diagnosis.

-Monitor disease extent with a keen interest on neural compromise.

-Offer differential diagnoses.

-Image guided biopsies and/or drainage procedures.

-Aid in selecting treatment options (medical vs surgical).

-Treatment monitoring.

Imaging is important for confirming and localizing these infections**[2]**. The imaging modalities used include plain radiography, CT, CT myelography, RNI and MRI.

(a) USE OF MRI AS A DIAGNOSTIC TOOL

MRI provides excellent anatomical detail and thusvery useful in spinal imaging. It is essential in diagnosing any condition where the spine and paraspinal soft tissue anatomy need to be clearly visualized and as such, a very potent diagnostic tool for evaluating spinal infections and ruling out other conditions mimicking infections. MRI is the proven gold standard imaging modality for identifying spinal infection**[3,53,54]**.It is in a class of its own being the only imaging modality which combines both high sensitivity andabove average specificity. Its sensitivity, specificity, and accuracy rates approach 96%, 92%, and 94%, respectively, and its superb in detecting soft tissue involvement[**4,5,53**]. MRIôs superiority in spine imaging is based on its high contrast resolution, direct multiplanar imaging capability, high sensitivity for soft tissue and bone marrow lesions, and non-ionizing radiation**[48,53,55]**. MRI is the best imaging studyfor demonstrating epidural extension, cord and/or thecal sac compression**[1]**. MRI features of spinal infections can be typical or atypical,awareness of these atypical findings alleviates delays in diagnosis and unnecessary/invasive procedures**[2]**.

(b) MRI TECHNIQUE

Spinal MRI is performed with the patient supine using spine surface coils or neck array coils. Standard protocols used for spinal infections include T1W, T2W, gradient echo sequences, inversion recovery (especially STIR) and SE sequences using contrast enhancement (with and without fat suppression). Fluid-sensitive sequences (STIR or fat-saturated T2W images) are very sensitive for early inflammatory oedema thus excellent in detectingearly infection. Addition of T1W SE pre- and postcontrast fat-suppressed sequences enables exquisite demonstration of anatomy and differentiation between vascularised and nonvascularised, necrotic inflammatory components (abscess, sequestrum)**[47]**. Contrast medium commonly used is gadolinium-DTPA.

(c) CONTRAINDICATIONS AND PRECAUTIONS

Acutely traumatized patients are not suitable candidates for MRI because life support systems are not MRI compliant.

One of the greatest potential hazards around a magnet is the missile effect. Objects with iron (ferromagnetic) in them can be pulled towards a magnet and injure persons within or near the magnet. Scissors, hammers, screwdrivers, vacuum cleaner, oxygen tanks and tool boxes should not be brought in the MR room.

Hazards also exist for patients who have medical devices implanted in their bodies.

-Some types of cardiac pacemakers.

-Cerebral aneurysm clips.

-Shrapnel or other metallic foreign bodies.

-Implanted electrodes,such as neuro stimulators and bone growth stimulators.

Caution should be exercised with: -Middle ear prosthesis and metallic bioimplants.

(d) IMAGING FEATURES OF PYOGENIC SPINAL INFECTIONS

i) Plain X-Ray

This is used for screening all patients with suspected infection. Unfortunately, there is a 2 ï 8 week delay between onset of symptoms to the appearance of X-ray changes making it insensitive to early infections**[53]**. Features include reduced disc space, end-plate destruction, bony sclerosis of two contiguous vertebral bodies, reduced vertebral body height, vertebral body collapse and paraspinal soft-tissue mass**[47]**.

ii) CT

CT is second to none in delineating bone pathologiesfor example early end-plate destruction or pathological calcification suggestive of TB**[47]**.It may at times show the soft tissue extent of infection. Presently CT is mainly used for image guided spinal biopsy. MRI is superior to CT in evaluating the disc spaces, neural tissues and abscesses.

iii)RADIONUCLIDE IMAGING (RNI)

Technetium-99mï methylene diphosphonate bone scintigraphy is a very sensitive early indicator of pyogenic spondylodiscitis but does not differentiate it from metastasis or osteoarthritis**[53]**. Gallium 67 is more sensitive in localizing inflammatory lesions, and when combined with technetium (sensitivity of 90%, a specificity of 100% and accuracy of 94%)**[53]**, almost all pyogenic vertebral infections are demonstrated**.**

iv) MRI

Infectious spondylodiscitis is characterized by involvement of two contiguous vertebrae and the intervertebral disc, so much so that it is viewed to be pathognomic**[2]**.The typical signal changes are T1 hypointensity and T2 hyperintensity with a loss of definition of the vertebral end-plate and adjacent vertebral bodies**[53]**. The disc typically shows T1 hypointensity and T2 marked hyperintensity**[53]**.

Enhancement post-contrast is the first sign of infection on MRI**[4]**.In early infections especially, the accuracy of MRI is improved further by disc, vertebral and adjacent soft tissues enhancement**[56]**. The disc shows either homogenous, patchy or peripheral enhancement while the bone marrow enhances diffusely (best seen on fat-suppressed sequences)**[54]**.

Paraspinal and epidural extension may manifest either as a phlegmon or an abscess showing T1 and T2 mixed signal intensities**[2]**. A phlegmon enhances diffusely andhomogenously while an abscess has peripheral rim enhancement**[57]**. Posterolateral extension involves the intervertebral foramina with obliteration of the perineural fat**[1]**. Spinal infection is intimatelyassociated with paraspinous or epidural inflammation, Ledermann et al in their study observed paraspinous inflammation in over 90% and epidural inflammationin almost 90%, and suggested that absence of paraspinal or epidural inflammation may be a valuable sign to exclude spinal infection**[54]**.

Paraspinal or epidural inflammation, disc enhancement, hyperintensity or fluid-equivalent SI on T2W fat-suppression or STIR and destruction of the vertebral endplates on T1W images are features considered to be highly suggestive of infection**[1,54]**.

Healing is signified byrestoration of normaldisc and bone marrow signals, and resolution of soft tissue changes (reduced paravertebral soft tissue swelling, restoration of normal canalanatomyand reduced tissue enhancement). Bone or disc changes may persist or even progress despite clinical improvement[**2]**.

v) Atypical MRI findings

Atypical imaging patterns include involvement of a single vertebral body, one vertebral body and disc, and two vertebral bodies with sparing of the intervening disc**[54]**. Infection of only one vertebral body or disc may represent early infection**[53]**. Vertebral body destruction and collapse is very unusual**[54]**. Involvement of two vertebral bodies without the disc (disc sparing)may mimic a malignancy**[55]**.

Atypical signal intensity include absent T2 hyperintensity**[2,56]**, T1 and T2 isointensity within the vertebral bodies with absent end-plate erosion**[2,54]** and disc T2 iso- or hypointensity**[54]**.

(e) IMAGING FEATURES OF SPINAL TB

A history of TBwith imaging evidence of posterior element involvement and psoas abscesseshighly suggests a diagnosis of TB spine even if cultures are not positive**[13]**.

i) Plain X-ray

Changes appear late and include: -anterior vertebral body destruction with anterior wedging and collapse, involvement of multiple vertebrae, psoas shadow widening (psoas abscess), fusiform paravertebral shadows (abscess). An abscess containing calcifications is pathognomic of spinal TB**[2]**.

ii) CT:

Pathologies are seen earlier than on plain X-ray. CT is excellent in demonstrating calcifications within the cold abscess, bone fragments within epidural inflammations and identifying atypical foci of TB especially in the posterior element involvement thus differentiating TB from other destructive processes like metastases.

iii) MRI

Classically spinal TB involves two anteriorly collapsed vertebral bodies with intervertebral discdestruction**[2]**. Extension to adjoining ligaments and soft tissues is common.Subligamentous spread causes involvement of multiple non-contiguous vertebral levels (skip lesions) and/or posterior elementdestruction**[47]**. Dural sac displacement and spinal cord distortion represents inflammation of epidural tissue. Contrast enhanced fat-suppressed T1W sequences are essential in displayingthe magnitude of dural sac compression and meningeal involvement**[57]**.

A relative early disc sparing, marked paraspinal involvement such as huge paraspinal abscesses with calcifications or well-defined paraspinal region with altered signal intensity; a thin, smooth walled abscess, posterior vertebral involvement, meningeal enhancement, multiple vertebral involvement (>3), skip lesions, whole vertebral body involvement and absence of reactive sclerosis are features highly suggestive of TB spine**[2,16]**.

Failure to demonstrate soft tissue calcifications (very specific for TB infections) is amajor disadvantage of MRI**[2]**.

(f) IMAGING FINDINGS OF SPINAL BRUCELLOSIS

i) Plain radiography and CT

Unfortunately, initial radiographs are usually normal and this may lead to diagnostic delays. In the focal form there are localized erosions, sclerosis, anterior osteophyte formation (parrotôs beak) and intradiskal gas (vacuum phenomenon) while in diffuse disease there is vertebral end plate destruction and disc.+/- epidural extension.

ii) MRI

Brucella typically affects the lower lumbar spine with L4 vertebra as the favoured site. Other features favouring spinal Brucellosis include intact vertebral architecture despite evidence of widespread vertebral infection (change in signal with intact vertebral body morphology), an extremely hyperintense disc on T2W and post contrast images, soft tissue inflammation without abscesses and facet joint involvement (enhance postcontrast)**[2,58]**. Gibbus deformities are unlikely, and paraspinal abscesses are uncommon and smaller in comparison to those TB spondylitis**[31]**. Ozaksoy et al in their study Brucellar spondylitis: MRI findings, found the following patterns of spinal involvement; disc involvement (100.0%), disc and vertebral body involvement (78.6%), disc and soft tissue involvement (78.6%), disc space reduction (50.0%), reduced vertebral body height (50.0%), osteophytic end-plate changes (42.9%) and facet joint involvement (35.7%)**[58]**.

2.0 JUSTIFICATION

Spinal infections though rare, may produce devastating deformity that is, severe bone and joint destruction and severe neurological sequelae. Spinal TB for example is a major cause of nontraumatic paraplegia in many parts of the world. This is largely due to diagnostic delay resulting from their insidious nature of onset and vague symptomatology. Prompt diagnosis and timely intervention is vital to avoid adverse outcomes.

MRI is a powerful diagnostic tool and has been proven to be superior to older imaging modalities like plain X-rays and CT in spinal imaging due to its multiplanar capabilities and excellent soft tissue characterization. It is the only imaging modality that combines high sensitivity, specificity and accuracy in the diagnosis of spinal infections, even in the early stages, thus making it the gold standard in diagnosis and follow-up of these conditions. MRI is also non-ionizing and non-invasive making it a safe diagnostic procedure in spinal infections.

The aim of this study is to review the findings of MRI examination of suspected pyogenic, tuberculous and brucellar spinal infections at KNH. A study of this nature has not been done in this country. It is expected that results from this study will improve the understanding of these spinal infections and their various manifestations on MRI thus leading to early diagnosis and timely intervention of these conditions.

3.0 OBJECTIVES

3.1 BROAD OBJECTIVE

To determine the patterns of MRI findings in patients presenting with suspected pyogenic, tuberculous and brucellar spinal infections at KNH.

3.2 SPECIFIC OBJECTIVES

1. To determine radiologically the commonest type of spinal infections (pyogenic, tuberculous or brucellar) at KNH.

2. To determine the commonest anatomical regions affected by these spinal infections on MRI.

3. To determine the age and sex distribution of these spinal infections at KNH.

4. To correlate MRI findings with the clinical presentation.

5. To correlate MRI findings with findings of other imaging studies done prior to MRI in the workup of spinal infections at KNH.

6. To determine the commonest risk factors to these spinal infections at KNH.

4.0 HYPOTHESIS

MRI has a role in the diagnosis and follow up of patients with suspected pyogenic, tuberculous and brucellar spinal infections.

5.0 STUDY LAYOUT

i) STUDY DESIGN

This was a one year cross-sectional descriptive study with retrospective and prospective data collection conducted from February 2013 to February 2014. The retrospective study period was eight months and the prospective study period was four months. The retrospective study included patients who had a previous MRI diagnosis of suspected spinal infection identified from the record bookscontaining all MRI imaging studies conducted at the KNH radiology unit in 2013-2014. Data was collected from the patients records and available images. The prospective study included those patients referred for spinal MRI by doctors in different specialities with clinical suspicion of spinal infection.

ii) STUDY AREA

The study was conducted at Kenyatta National Hospital, radiology department, MRI unit in collaboration with the KNH records department. KNH is the largest national referral, teaching and research hospital in the country, serving mostly low and middle income patients. On average 70 to 80 spinal MRI exams are performed monthly of which 2 to 3 are for spine infections.

iii) STUDY POPULATION

The study included patients of all ages and both genders who had a MRI diagnosis of suspected spinal infection within the study duration.

-Inclusion criteria. .

This included all patients who had a diagnosis of suspected spinal infection on MRI during the study duration and images were present. The patients within the prospective group were required to have duly signed informed written consent. .

-Exclusion criteria

a).Patients who had inadequate MRI examination. .

b).Patients who had inadequate clinical history. .

c).Patients in the retrospective arm with a MRI diagnosis of spinal infection but MRI images were unavailable. .

d).Patients within the prospective study who refused to consent. .

e).Patients in the prospective group with clinical suspicion of spinal infection but had negative MRI examination.

iv)SAMPLE SIZE DETERMINATION

Due to the rarity of the spinal infections, a small sample size is anticipated hence Fischersô formula with finite population correction**[59]** will be used to calculate the sample. .

$$n^1 = \frac{N \times P(1 - P)}{[N - 1] + [P(1 - P)]}$$

where n^1 = sample size with finite population correction

N = population size

Z = Z statistics for level of confidence

P = expected prevalence or proportion

d = precision

When the formula is applied at $N = 30$, $Z^2 = 1.96$, $P = 0.02$ and $d^2 = 0.01$

$$n^1 = \frac{30 \times 1.96 \times 0.02(1 - 0.02)}{0.01(30 - 1) + 1.96 \times 0.02(1 - 0.02)}$$

Then $n^1 = 29$.

For ease of calculations, the expected sample size was 30 patients.

45 patients were recruited into the study from February 2013 to February 2014 with 35 patients in the retrospective study and 10 in the prospective study .

v) SAMPLING METHOD

Convenient sampling was used. All patients who had a MRI diagnosis of spinal infection and those referred for MRI with suspected spinal infection were included.

vi) METHODOLOGY

For the retrospective study arm, patients who had MRI diagnosis of suspected spinal infection were identified from the MRI record books at the KNH radiology department by the principal investigator. Inpatient/outpatient and X-ray numbers obtained from MRI record books were used to retrieve clinical data, any imaging studies done prior to MRIand the MRI reports from the patients files in the records department. The principal investigator then reviewed the images on the MRI console or stored on softcopies for those not available on the console and then retrieved the MRI reports. Those with all the requirements were entered into the data collection form.

For the prospective study arm, the principal investigator selected all patients sent for MRI for suspected spinal infection, checked the request forms for adequate clinical data and if there were no contraindications to MRI examination, then recruited and sought consent for inclusion into the study aided by the consent explanation form. In cases which had inadequate clinical data on the request form, relevant information was inquired directly from the patient or guardian, or indirectly from scrutiny of the patientôs file if available. The principal investigator also retrieved images and reports of any prior imaging studies done from the patients. The principal investigator assisted the MRI technologist in patient preparation and ensured that approriate MRI sequences for suspected spinal infections were used in all examinations. Upon completion of an adequate MRI examination, the principal investigator viewed all the images, formed an opinion and presented them to a qualified consultant radiologist for his/her opinion. The consensus opinion was considered to be the radiological diagnosis based on suggestive MRI features of spinal infection. For all MRI imagessuspected to have spinal infections all the information gathered was recorded on the data collection form.

For both groups of patients, the information recorded included ;

a). Patient biodata (patient number, age and sex) .

b). Presenting complaints and associated risk factors.

c). Other imaging studies performed prior to MRI.

d). MRI findings on all sequences with type of infection diagnozed and anatomical location affected. .

vii) EQUIPMENT

A 1.5Tesla MRI machine Intera model Phillips unit at the Kenyatta National Teaching and Referral Hospital was used in all the patients recruited into the study, both retrospective and prospective. The standard MRI protocol used for suspected spinal infections was T1W, T2W, STIR and T1W with contrast (Gd-DTPA).

viii) STUDY VARIABLES

The variables used in the study were: type of infection, anatomical location of the infection, patientsô age, sex of the patient, presenting symptoms, risk factors and previous imaging findings prior to MRI.

ix) DATA ANALYSIS

Data was collected using a structured questionnaire.(appendix A) The data collected was entered into the statistical package for social science research (SPSSR) version 20.0. the data was cleaned for errors, inconsistent answers, missing and duplicate entries to ensure high quality data. Descriptive statistics were presented using percentages and frequencies for categorical or nominal data while mean, standard deviation, median, minimum and maximum for continuous/discrete variables. The results were presented in figures, tables, frequency graphs and pie charts. Representative diagnostic images with demonstrable pathology were sampled and presented.

x) ETHICAL CONSIDERATIONS

a). Approval of the research proposal was sought from the Ethical and Research Committee of Kenyatta National Hospital following approval by the supervisors at the departmental level.
b). The patients names did not appear anywhere in the data collection forms in order to maintain confidentiality. The patients were coded with serial numbers. In-patient/outpatient number were recorded for referral purposes only.
c). No additional examinations were done on patients other than the ones requested by the primary physician.
d). Patients within the prospective group had their consents witnessed and duly signed.
e). For children within the prospective group, consent was sought from the parent/guardians.

f). The final write up will be given to the University of Nairobi as part fulfilment for the degree of master of medicine in diagnostic imaging and radiation medicine. Thereafter copies will be availed for future reference.
g). All raw data collected will be completely destroyed upon completion of the study.

xi) LIMITATIONS OF THE STUDY

a). The study was limited to KNH which is a national referral hospital serving mainly the low and middle income populations and hence may not be reflective of the entire population.

b). Images within the MRI console were frequently deleted due to disc space limitation. This affected the data collection and retrieval process especially for the retrospective study. A total of nine patients who were eligible for inclusion in the study were not recruited because it was determined that their MRI images were unavailable.

c). Retrieval of hard copies from previous studies was not possible on occasions. This was attributed to their unavailability due to poor hospital or patient record keeping. Failure to retrieve hard copies of prior studies for 11 patients did not result in patient exclusion, but reduced the effective sample used to report correlation findings between MRI and Xray.

d). Some request forms had inadequate or no clinical data and this hampered data collection.

e). No major comprehensive study has been undertaken locally on spinal infections thus the local prevalence rate of spinal infections is unknown, hence the prevalence rate used here may not be truly representative of the actual local scenario

f). Follow up of lesional biopsies for histological confirmation were not done. Diagnosis depended on clinical presentation and imaging features. Laboratory investigations were not included in this study.

6.0 RESULTS

In total 45 patients with spinal infections at Kenyatta National Hospital were recruited into the study. All participants (n = 45) underwent MRI investigations. The mean age of patients with spinal infections was 36.9 years with a range from 11 to 81 years. Figure 1 presents the age distribution of participating patients. Thirty-one percent were aged 30-39 years and 22.2% were between 40 and 49 years representing the main affected age-groups.

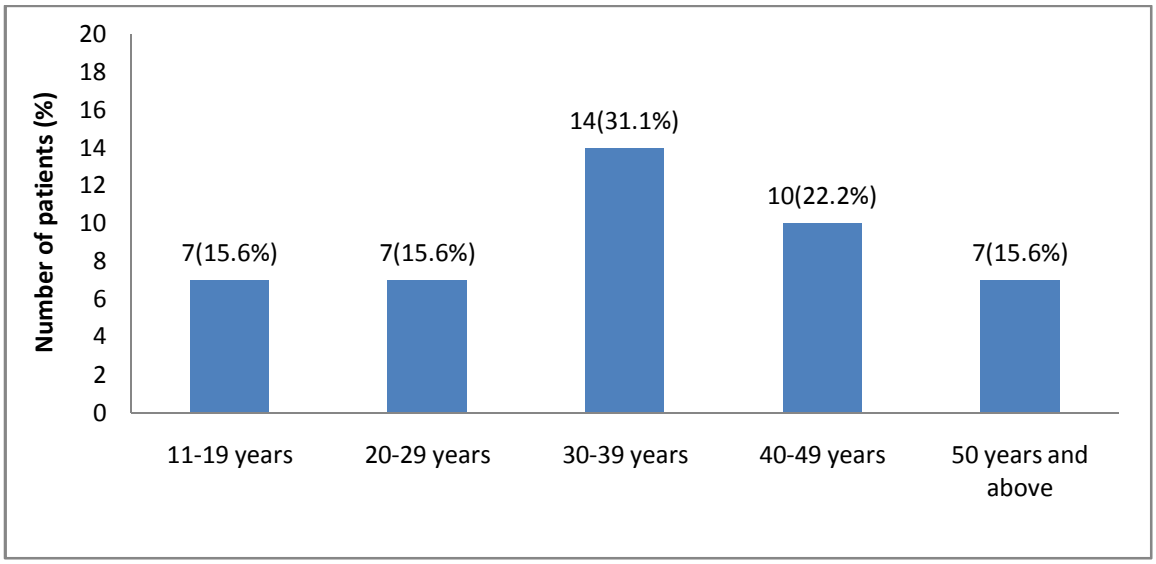


Figure 1: Age distribution of patients with spinal infection at KNH

The distribution of male and female patients is presented in Figure 2. There were 24 males accounting for 53.3% of the patients with spinal infection, Male-to-Female ratio 1.1: 1.

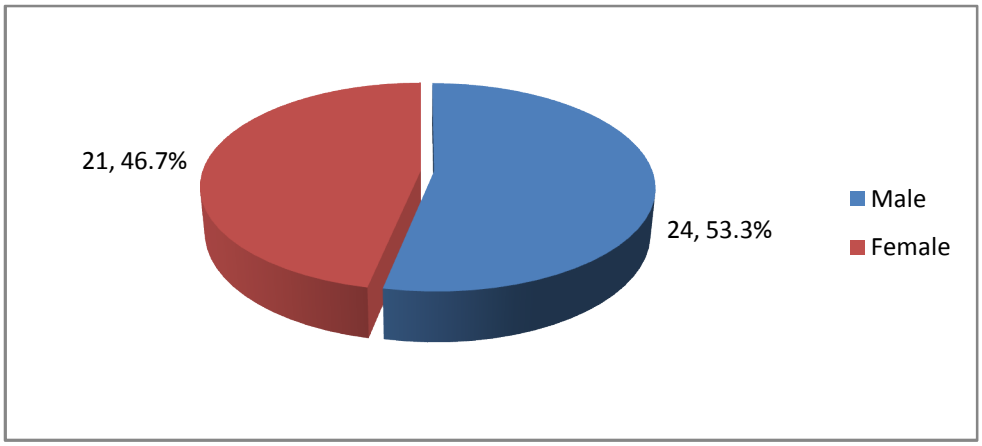


Figure 2: Gender distribution of patients with spinal infection at KNH

Aetiological diagnosis of spinal infections

Thirty-eight (84.4%) patients presenting with spinal infection at KNH had TB infections as shown in Figure 3. There was a single case of brucellar infection and six (13.3%) infections were pyogenic.

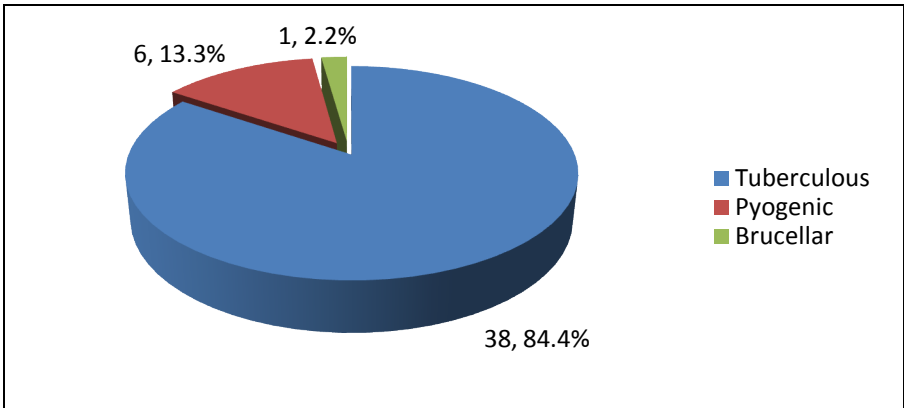


Figure 3: Etiologic types of spinal infection on MRI diagnosis in patient in KNH

Anatomical findings on MRI of patients with spinal infections at KNH

Findings of MRI anatomical diagnosis of spinal infections presented in Figure 4 showed that spondylodiscitis was the most common finding occurring 35 (77.8%) cases. Isolated epidural abscess, spondylitis and discitis affected 11.1%, 8.9% and 2.2% of patients, respectively.

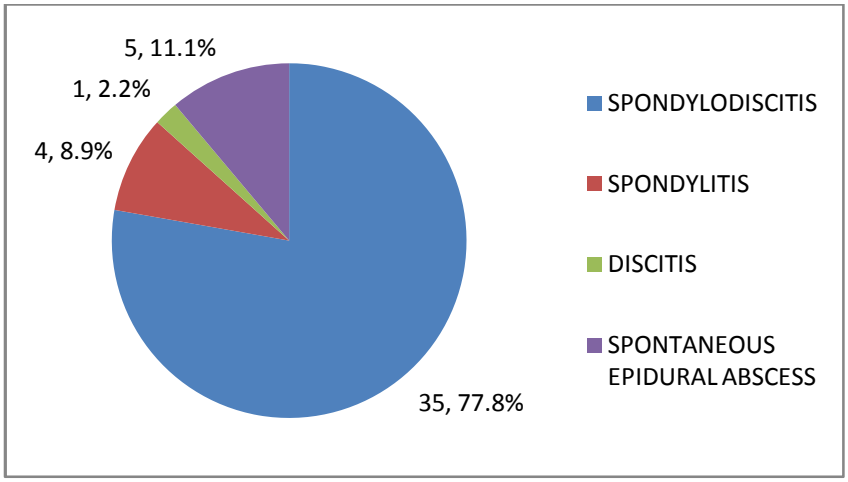


Figure 4: Morphological findings on MRI for patients with spinal infections at KNH

Table 1: Correlation between MRI anatomical and aetiological diagnosis in patients with spinal infections in KNH

	Infection			Total
	Tuberculous	**Pyogenic**	**Brucellar**	
Morphological finding				
Spondylodiscitis	32 (84.21%)	2 (33.3%)	1 (100%)	35 (77.8%)
Spondylitis	4 (10.53%)	0	0	4 (8.9%)
Discitis	1 (2.63%)	0	0	1 (2.2%)
Isolated epidural abscess	1 (2.63%)	4 (66.7%)	0	5 (11.1%)
Total	38 (100%)	6 (100%)	1 (100%)	45 (100%)

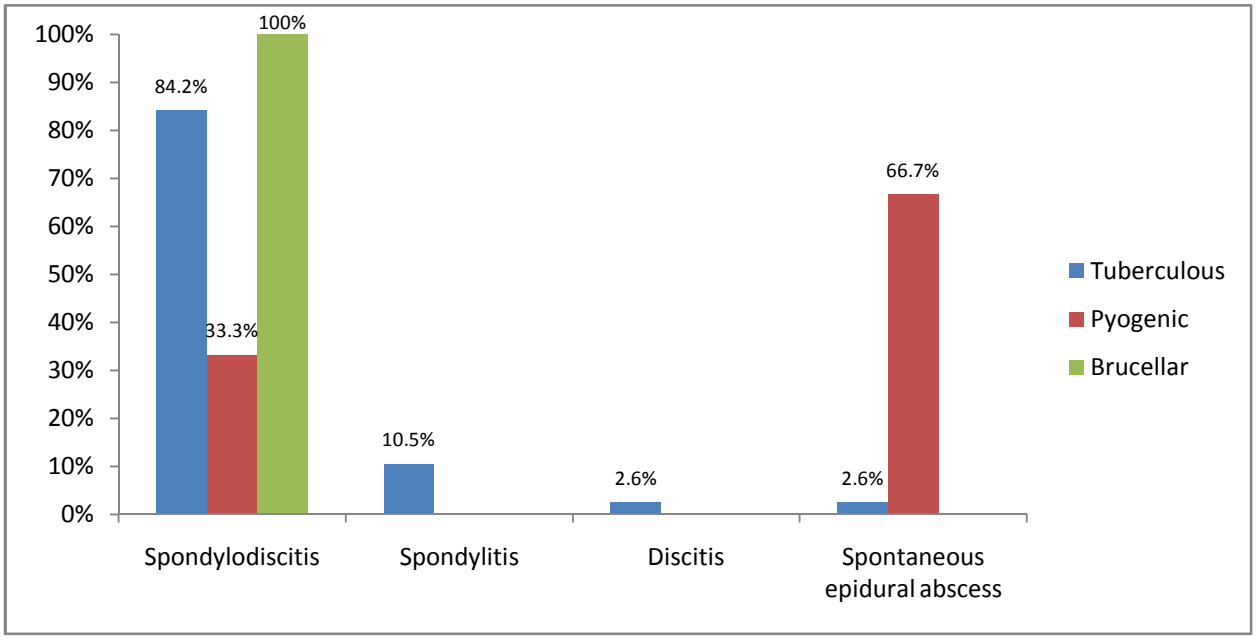


Figure 5: Distribution of anatomical lesions of spinal infections within different etiological diagnosis

In TB spine spondylodiscitis was the main pathological lesion with 32 (84.2%) cases followed by spondylitis with 4 cases (10.5%), discitis and isolated epidural abscesses were the least with 1 (2.63%) case each (Figure 5).

In pyogenic spinal infections isolated epidural abscess was the most common with 4 (66.7%) cases followed by spondylodiscitis with 2 (33.3%) cases, there were no cases of spondylitis or discitis.

The single case of spinal brucellosis was spondylodiscitis.

Anatomical regions affected by spinal infection

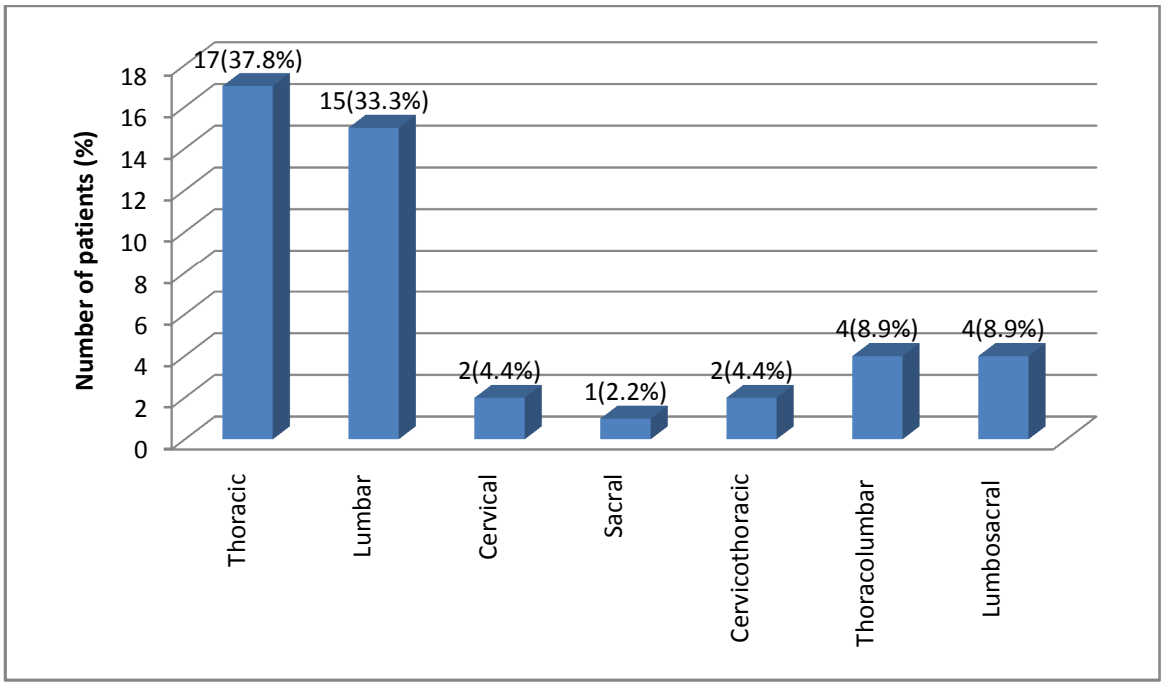


Figure 6: Distribution of spinal infection according to anatomical region

Spinal infections diagnosed on MRI most commonly occurred in the thoracic (n = 17, 37.8%) or lumbar regions (n = 15, 33.3%), Figure 6. They were 10 cases (22.2%) involving multiple regions of the spinal column as follows; thoracolumbar (n = 4, 8.9%), lumbosacral (n = 4, 8.9%) and cervico-thoracic (n=2, 4.4%).

Table 2: Anatomical distribution of spinal infection according to aetiological MRI diagnosis

	Type of infection			
Anatomical region	**Tuberculous**	**Pyogenic**	**Brucellar**	**Total**
Thoracic	16 (42.1%)	1 (16.7%)	0	17 (37.8%)
Lumbar	12 (31.6%)	2 (33.3%)	1 (100%)	15 (33.3%)
Cervical	2 (5.3%)	0	0	2 (4.4%)
Sacral	0	1 (16.7%)	0	1 (2.2%)
Thoracolumbar	3 (7.9%)	1 (16.7%)	0	4 (8.9%)
Lumbosacral	3 (7.9%)	1 (16.7%)	0	4 (8.9%)
Cervico-thoracic	2 (5.3%)	0	0	2 (4.4%)
Total	38	6	1	45

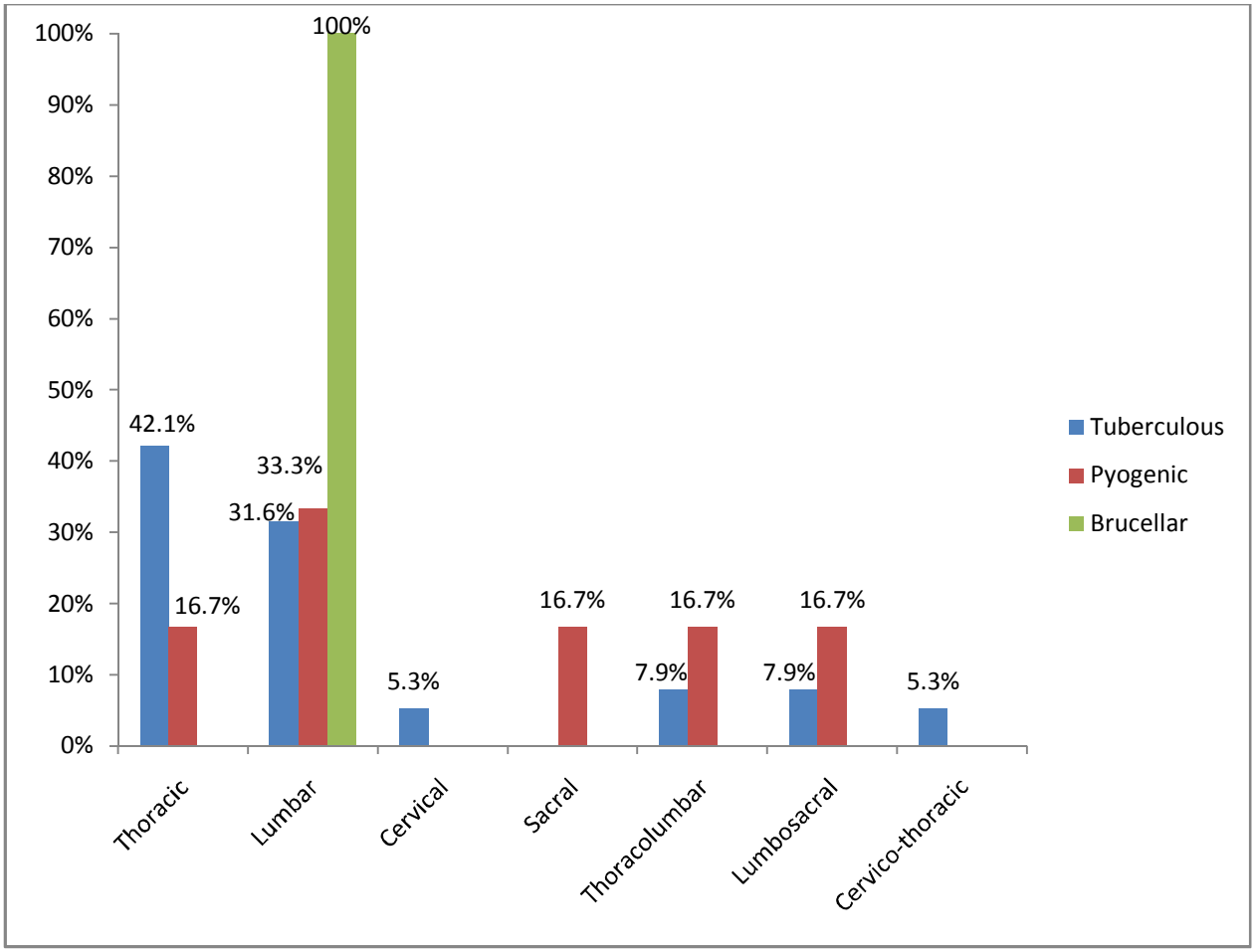


Figure 7: Anatomical distribution of spinal infection according to aetiological MRI diagnosis

In the study, TB mainly affected the thoracic region (16 cases, 42.1%), and pyogenic infection mainly affected the lumbar spine (2 cases, 33.3%). Pyogenic spondylodiscitis was seen exclusively in the lumbar region while isolated epidural abscesses were seen in the thoracic and lumbosacral regions. The single spinal brucellosis case in this study affected the lower lumbar region (L4).

Age and sex distribution of spinal infections

Table 4: Distribution of MRI etiologic diagnosis according to patient age and sex

	Type of infection			
	Tuberculous	**Pyogenic**	**Brucellar**	**Total**
Sex				
Male	20	3	1	24
Female	18	3	0	21
Age				
11-19 years	6	1	0	7
20-29 years	6	1	0	7
30-39 years	12	2	0	14
40-49 years	8	1	1	10
50 years and above	6	1	0	7
Total	38	6	1	45

In this study there was an overall male preponderance of 1.1:1. TB spine shows a male preponderance of 1.1:1(52.6% males), pyogenic spinal infections showed no sex predilection and the single brucellar case was in a male patient.

In the study, both TB spine (12 cases, 31.6%) and pyogenic spinal infection (2 cases, 33.3%) were prevalent in the 30 - 39 years age group (14 cases, 31.1% overall). The mean age for all spinal infections was 36.9 years with TB spine at 36.6 years and pyogenic spinal infections at 37.7 years (45.25 years for isolated pyogenic epidural abscess and 22.5 years for pyogenic spondylodiscitis respectively). The spinal brucellosis patient was 43 years.

MRI findings

In this study MRI findings were grouped as follows; vertebral body changes (39 cases, 86.7%), disc changes (36 cases, 80%), soft tissue changes (43 cases, 95.6%) and atypical changes (14 cases, 36.8%). Each of these groups of changes was described in details below.

Vertebral body changes

Vertebral body changes were observed in 39 cases as follows; 36 TB, 2 pyogenic and 1 brucellar. The most common vertebral body changes observed were end-plate destruction (39, 100%), bone marrow changes (38, 97.4%) and contrast enhancement (36, 92.3%). These changes were also the predominant type of vertebral body change for both TB and pyogenic spondylodiscitis. Bone marrow changes were seen in 38 (84.4%) cases of spinal infections (corresponding to 97.4% of cases with vertebral body changes). It was present in 35 cases (92.1%) of the TB, 2 (33.3%) of the pyogenic cases (all were pyogenic spondylodiscitis) and the brucellosis case.

End-plate destruction was seen in 39 (86.7%) cases of spinal infections and all cases with vertebral body changes (39, 100%). In TB spine contrast enhancement was seen in 94.4% (34) of the 36 cases (34 spondylodiscitis and 2 spondylitis) with vertebral body changes, 100% (33) of the 33 cases with disc changes and 86.8% (33) of the 38 cases with soft tissue changes. All pyogenic cases showed contrast enhancement as follows:-vertebral body and disc enhancement in the spondylodiscitis cases (33.3% of all pyogenic cases), and soft tissue contrast enhancement in the spontaneous epidural abscess cases (66.7% of all pyogenic cases).

Multilevel involvement was observed in 10 patients all of whom had TB spine (22.2% overall, 26.3% of TB cases).

No vertebral body changes were seen in 6 cases (13.3%). This included 2 TB cases (5.3% of TB cases) and 4 pyogenic cases (66.7% of pyogenic cases).

Table 5: Vertebral body changes on MRI among patients with spinal infection at KNH

	Tuberculous		**Pyogenic**		**Brucellar**		**Total**	
	n	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Vertebral body changes	**36**	**92.3**	**2**	**5.1**	**1**	**2.6**	**39**	**100**
Contrast enhancement	34	89.5	2	33.3	0	0	36	80.0
Body collapse	29	76.3	0	0	0	0	29	64.4
Multilevel involvement	10	26.3	0	0	0	0	10	22.2
End-plate destruction	36	94.7	2	33.3	1	100	39	86.7
Bone marrow changes	35	92.1	2	33.3	1	100	38	84.4
Posterior element involvement	3	7.9	0	0	0	0	3	6.7
Skip lesions	2	5.3	0	0	0	0	2	4.4

Disc changes

Disc involvement was seen in 36 (80%) of all the cases as follows; 33 (86.8%) TB spine (32 spondylodiscitis, 1 discitis), 2 (33.3%) pyogenic cases (spondylodiscitis) and the brucellar case (Table 6). All these cases showed signal changes, loss of disc height and contrast enhancement.

Table 6: Disc changes on MRI among patients with spinal infection at KNH

	Tuberculous		Pyogenic		Brucellar		Total	
	n	%	n	%	n	%	n	%
Disc changes								
Signal change	33	86.8	2	33.3	1	16.7	36	80
loss of disc height	33	86.8	2	33.3	1	16.7	36	80
Contract enhancement	33	86.8	2	33.3	1	16.7	36	80
No disc changes	5	13.2	4	66.7	0	0	9	20

Soft tissue changes

Soft tissue changes were the commonest MRI findings observed in 43 (95.6%) cases (all 38 TB cases, 4 pyogenic cases and the single brucellar case). Two cases had no soft tissue changes. Paraspinal inflammation was observed in 66.7% of the cases while epidural inflammation was seen in 57.8% (Table 7). In TB spine paraspinal inflammation and epidural inflammation were observed in 73.7% and 57.9% of the cases respectively. In pyogenic spinal infections, paraspinal inflammation and epidural inflammation were observed in 16.7% and 66.7%of the cases respectively. In spinal brucellosis only paraspinal inflammation was observed.

Psoas abscesses (n=3) were only observed in TB spine cases (6.7% overall, 7.9% in TB).

Table 7: Soft tissue changes on MRI among patients with spinal infection at KNH

	Tuberculous		Pyogenic		Brucellar		Total	
	n	%	n	%	n	%	n	%
Soft tissue changes	**38**	**100**	**4**	**66.7**	**1**	**100**	**43**	**95.6**
Paraspinal inflammation	28	73.7	1	16.7	1	100	30	66.7
Epidural inflammation	22	57.9	4	66.7	0	0	26	57.8
Contrast enhancement	33	86.8	4	66.7	1	100	38	84.4
Cord compression	16	43.2	2	33.3	0	0	18	40
Other soft tissue changes-	37	97.4	4	66.7	0	0	41	91.1
-compression(cord, conus, cauda equina or thecal sac)	34	89.5	3	50			37	82.2
-neural foramina stenosis	5	13.2	0	0			5	11.1
-psoas abscess	3	7.9	0	0			3	6.7
-prevertebral abscess	3	7.9	1	16.7			4	8.9
No soft tissue changes	0	0	2	33.3	0	0	2	4.4

Atypical changes

As shown in Table 8, with the exception of a single arachnoiditis that occurred in pyogenic infection, all remaining atypical changes occurred in TB patients. Disc sparing (4, 10.5%) and bone abscesses (3, 7.9%) in TB spine were the commonest atypical changes seen. Skip lesions were only observed in two TB patients (4.4% overall, 5.3% of TB cases).

Table 8: Atypical changes on MRI in patients with spinal infection at KNH

	Tuberculous		Pyogenic		Total	
	n	%	n	%	n	%
Atypical changes	**13**	**34.2**	**1**	**16.7**	**14**	**36.8**
Bone abscesses	3	7.9	0	0	3	6.6
Disc sparing	4	10.5	0	0	4	8.9
Disc only involvement	1	2.6	0	0	1	2.2
Skip lesions	1	2.6	0	0	1	2.2
Posterior elements involvement	2	5.3	0	0	2	4.4
Posterior elements involvement & skip lesions	1	2.6	0	0	1	2.2
Arachnoiditis	1	2.6	1	16.7	2	4.4

Clinical presentation

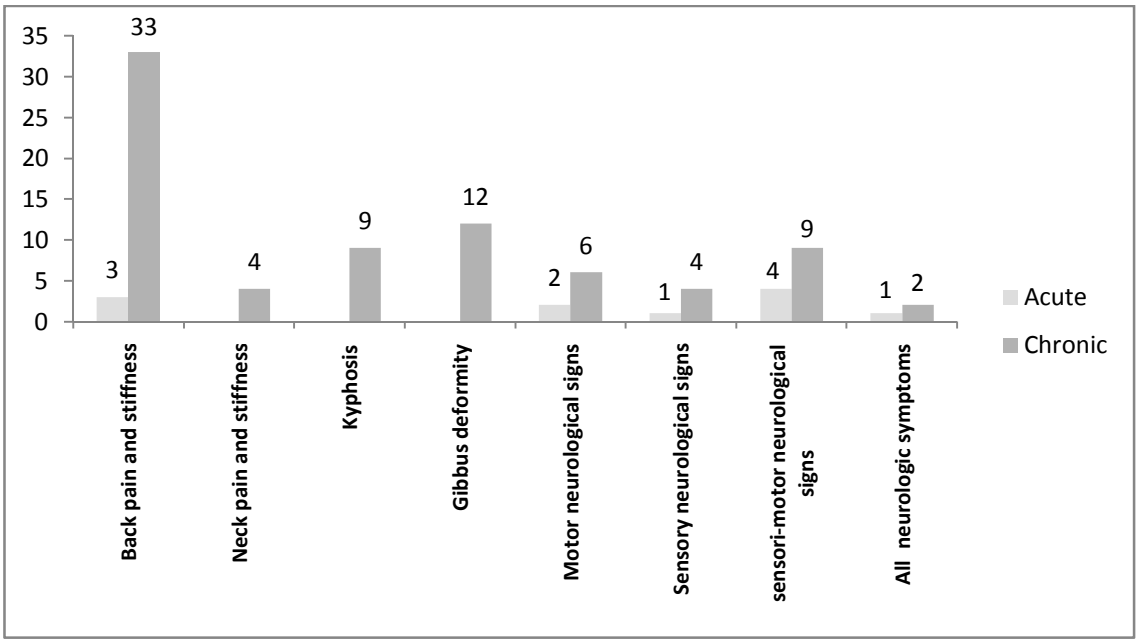


Figure 8: Clinical presentation of patients with spinal infections investigated using MRI at KNH

Table 9: MRI diagnosis and clinical presentation of patients with spinal infection at KNH

	MRI diagnosis			
	Tuberculous (n = 38)	**Pyogenic (n = 6)**	**Brucellar (n = 1)**	**total**
Back pain and stiffness	30 (78.9%)	5 (83.3%)	1	36 (80%)
Neck pain and stiffness	4 (10.5%)	0	0	4 (8.9%)
Spinal deformities	22 (57.9%)	0	0	22 (48.9%)
-Kyphosis	9 (23.7%)	0	0	9 (20%)
-Gibbus deformity	13 (34.2%)	0	0	13 (28.9%)
Neurological problems	26 (68.4%)	3 (50%)	0	29 (64.4%)
-pure motor	7	1	0	8
-pure sensory	5	0	0	5
-Sensori-motor	12	1	0	13
-Sphincter dysfunction alone	0	0	0	0
-All forms of neurological . symptoms	2	1	0	3
-None				16
Constitutional symptoms	18 (47.4%)	3(50%)	1 (100%)	22 (48.9%)
-Fever	2 (5.3%)	3(50%)	1 (100%)	6 (13.3%)
-Fever & weight loss	16 (42.1%)	0	0	16 (35.6%)

In this study the main clinical presentations were back pain (36 cases, 80%), neurological deficits (29 cases, 64.4%) and fever (22 cases, 48.9%).

Back pain

Back pain was the commonest presenting symptom, occurring in 36 (80%) cases distributed as follows; 30 (78.9%) of TB spine cases, 5 (83.3%) of pyogenic cases (100% spondylodiscitis, 75% SEA) and the single brucellosis case. Of the 36 cases with back pain, 3 (8.3%) were acute and 33 (91.7%) were chronic. Majority of TB cases (29, 96.7%) and pyogenic cases (3, 60%) had chronic back pain. The single brucellar case also had chronic back pain.

Neck pain and stiffness was seen in 4 cases (8.9%) all of which were TB spine (10.5% of all TB cases), two affecting the cervical region and two affecting the cervico-thoracic region.

Neurological deficits

In this study neurological deficit were observed in 29 cases (64.4%) as follows; 3 cases (50%) of pyogenic spinal infections and 26 cases (68.4%) of TB spine. The single brucellar case had no neurological impairment. Neurological deficits were mainly chronic (21 cases, 72.4%).

Constitutional symptoms

Constitutional symptoms were observed in 22 (48.9%) cases. Fever was the commonest constitutional symptom either alone (13.3%) or in association with weight loss (35.6%). Fever without weight loss presented in 3 (50%) cases of pyogenic infections and in the single case of brucellosis. In the pyogenic cases fever was seen in 2 (50%) isolated epidural abscess cases and 1 (50%) spondylodiscitis case. In TB spine fever was seen in 47.4% of the cases, of these it occurred alone in 2 (5.3%) cases and with weight loss in 16 (42.1%) cases. In both TB and brucellosis cases the constitutional symptoms were all of chronic duration, while in pyogenic spinal cases they were mainly of acute duration (66.7%).

Spinal deformities (kyphosis and gibbus deformity)

In this study spinal deformity were only observed in TB spine, 57.9% of TB spine cases. Gibbus deformity was the most common spinal deformity at 34.2% while kyphosis occurred in 23.7%. It was absent in both pyogenic and brucellar cases.

Correlation of MRI findings with the clinical presentation

Neurological problems and spinal deformities were used to correlate MRI findings with the clinical presentation. Findings of these correlations are summarized on table 10 and 11.

Table 10: Correlation between MRI findings and neurological problems.

	Neurological problems			
	Yes (n=29)		No (n=16)	
MRI Finding	n	%	n	%
Vertebral body collapse	20	69	9	56.3
Paraspinal inflammation	22	75.9	8	50
Epidural inflammation	22	75.9	4	25
Cord compression	26	89.7	11	68.8
Neural foramina stenosis	2	6.9	0	0

Out of the 29 patients presenting with any form of neurological problems, cord compression was seen on MRI in 26 (89.7%) cases. A similar proportion of patients with neurologic problems also had MRI findings of paraspinal inflammation or epidural inflammation, 22 (75.9%). A large number of patients (68.8%) without neurological problems had cord compression and body collapse.

Table 11: Correlation between MRI findings and spinal deformities.

	MRI vertebral body collapse			
	Yes (n=29)		No (n=16)	
Spinal deformity	n	%	n	%
Kyphosis	9	31	0	0
Gibbus	13	44.8	0	0

All patients presenting with spinal deformity had associated vertebral body collapse on MRI investigation. Spinal deformity is a good clinical sign to predict vertebral body collapse on MRI.

MRI findings and prior imaging studies

Of the 45 patients with spinal infections 34 (75.6%) cases had prior imaging studies done. All these prior investigations were plain radiographs. The findings of previous X-rays were classified in this study to represent vertebral changes, disc changes or soft tissue changes. Using MRI as a gold standard table 12 shows the correlation of MRI and prior imaging studies.

Table 12: Correlation between MRI Findings and X-ray Findings.

	Patients who had both X-Ray and MRI examinations (n=34)	
Correlation factor	**Plain Radiograph**	**MRI**
Vertebral body changes	31	30
Disc changes	27	27
Soft tissue changes	1	34

The X-ray findings highly correlated with MRI findings for disc and vertebral body changes. However of the 34 plain radiographs only a single radiograph reported psoas abscess, a soft tissue change. On MRI all the 34 patients showed associated soft tissue changes. This showed MRI had a 100% pick-up rate for soft tissue lesions confirming its high sensitivity and soft tissue resolution.

Table 13: Risk factors for spinal infections

	n	%overall (n=45)	%risk factor (n=40)
Immunosuppression	16	35.6	40
-HIV	15	33.3	37.5
-Cancer	1	2.2	2.5
Diabetes mellitus	5	11.1	12.5
Post spinal surgery or trauma	5	11.1	12.5
-Post-laminectomy	2	4.4	5
-Post-trauma	3	6.7	7.5
Previous history of TB	12	26.7	30
-PTB	8	17.8	20
-TB spine	4	8.9	10
Other**	2	4.4	5
No identifiable risk factor	5	11.1	NA

**Other ï animal handler (brucellar case) and vertebral congenital defect

Out of the 45 cases of spinal infections only 40 (88.9%) had identifiable risk factors. No identifiable risk factors were seen in 5 cases (11.1%).

Immunosuppression caused by HIV infection seen in 15 (33.3%) patients was the most common identifiable risk factor in this study, accounting for 37.5% of the risk factors. It was the most common risk factor in pyogenic cases while in TB spine cases it was the second most common, 11 TB (28.9%) spine cases and 4 (66.7%) pyogenic infection cases were HIV positive.

In TB spine cases, previous history of TB infection was the most common risk factor at 31.6% (12 of 38 TB cases) with pulmonary TB being the main form at 21% (8 cases).

Diabetes mellitus seen in 5 (11.1%) cases all of which were TB spine, contributed to 12.5% of the risk factors overall and 13.1% of TB spine risk factors.

Previous spinal surgery seen in 2 cases, contributed to 5% of the risk factors.

In the brucellar case, the patient was an animal handler.

7.0SELECTEDIMAGES

(I) TYPICAL CASE OF TB SPINE

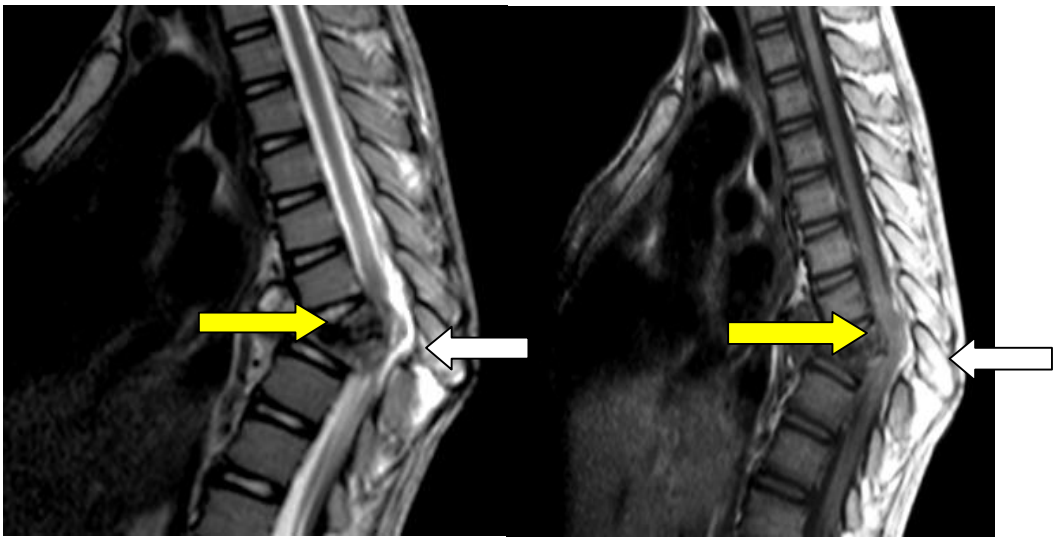


Figure 1: T2W and T1W sagittal MRI images showing T8 vertebral abnormal bone marrow signal, body destruction, anterior wedge collapse of T8 and kyphosis (white arrows). There are prevertebral (yellow arrows) and epidural masses with cord compression at T8 and T9 vertebral level. This case illustrates the typical features of TB spine.

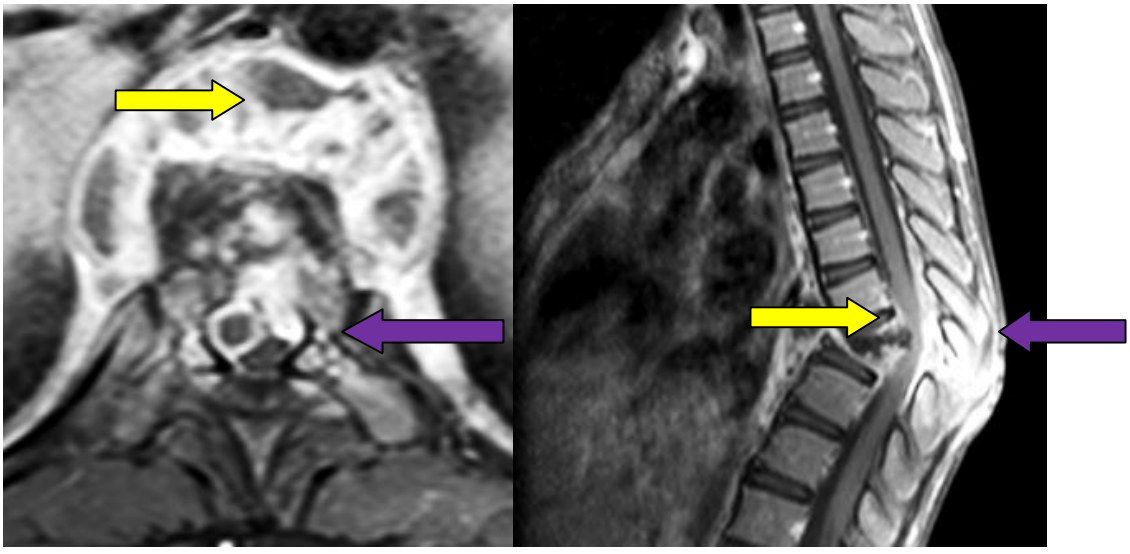


Figure 2: Same patient on contrast enhanced T1W axial and sagittal images showing abnormal T8 vertebral body and posterior elements enhancement. Prevertebral (yellow arrows) and epidural (purple arrows) abscesseswith heterogenous enhancement are also seen.

(II) CERVICO-THORACIC TB EPIDURAL ABSCESS

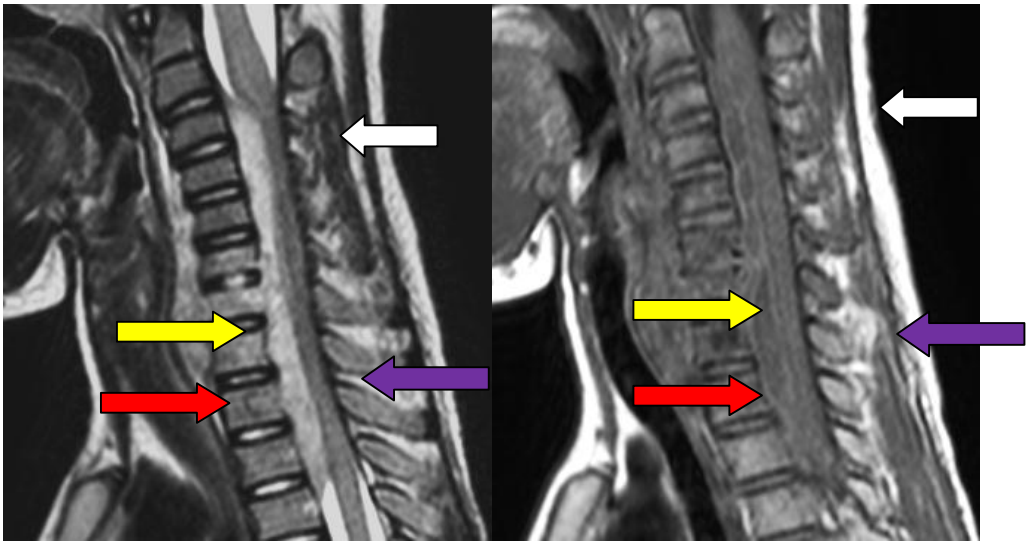


Figure 3: T1W and T2W sagittal images showing prevertebral (yellow arrows) and epidural masses (purple arrows) which are iso- to hypointense on T1W and hyperintense on T2W involving C7 and T1 vertebral bodies. The masses caused compression of the trachea anteriorly (red arrows) and spinal cord posteriorly (white arrows). This was a case of cervico-thoracic spinal tuberculosis.

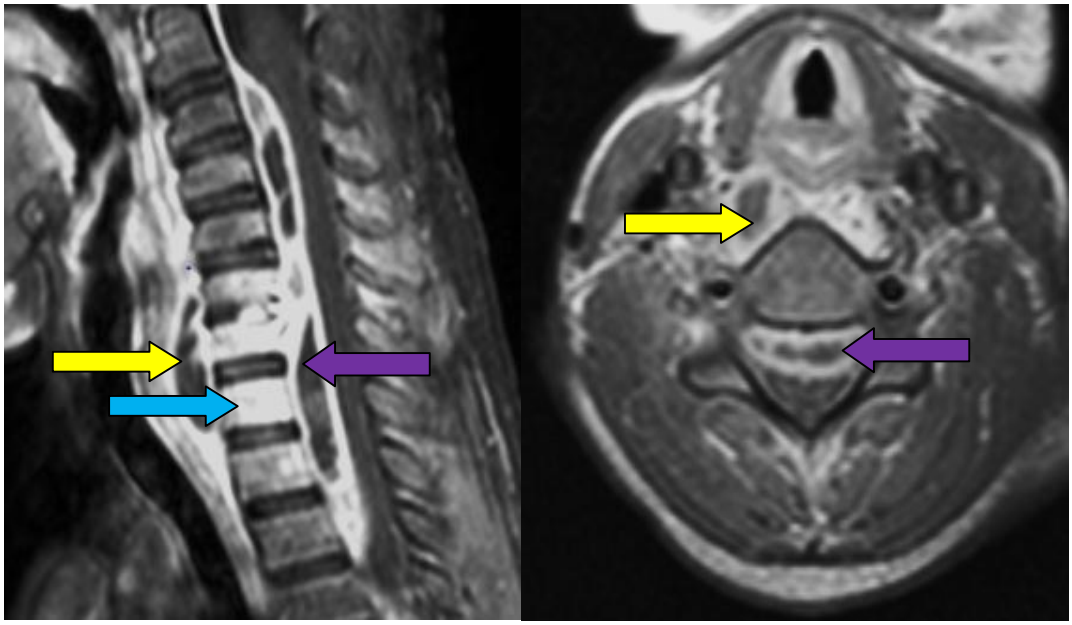


Figure 4: Same patient on contrast enhanced T1W sagittal and axial images showing ring-enhancement of the prevertebral (yellow arrows) and epidural (purple arrows) abscesses, bone marrow enhancement (blue arrow) of C6-T2 vertebral bodies and cord compression.

(III) PSOAS ABSCESS AND GIBBUS DEFORMITY IN TBSPINE

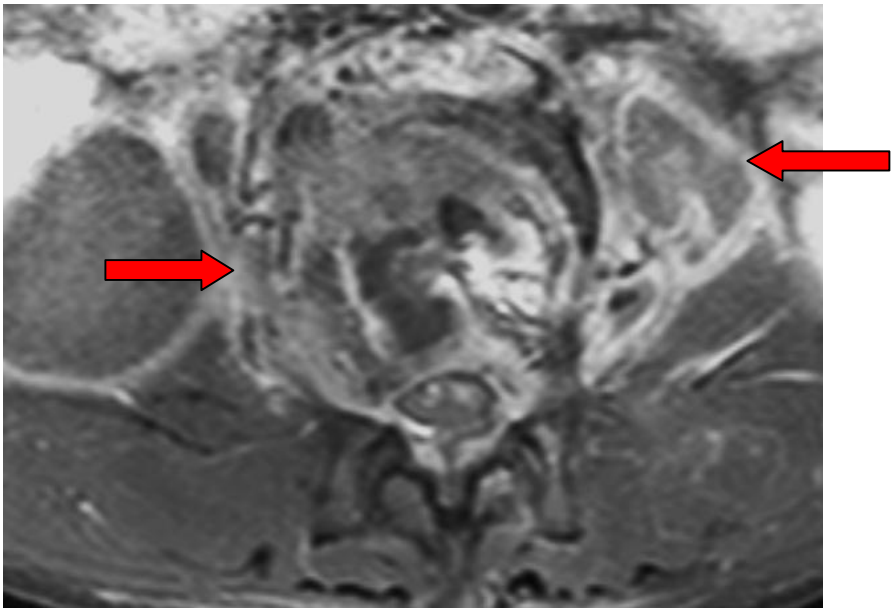


Figure 5: Contrast enhanced T1W axial image showing bilateral psoas abscesses (red arrows) with ring enhancement seen in a case of TB involving the thoracic spine.

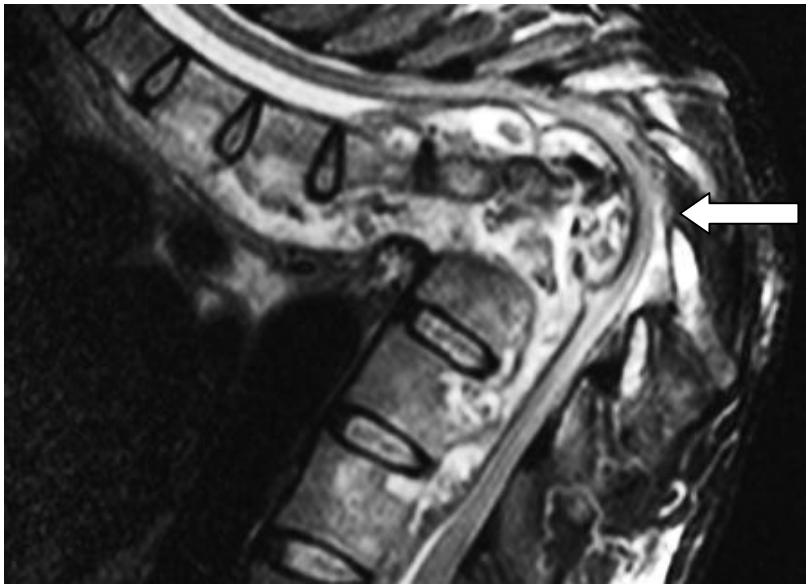


Figure 6: T2W and T2W with fat suppression images showing destruction of T5 to T9 vertebral bodies with anterior wedge collapse and severe gibbus deformity (white arrow). This was a case of TB spine.

(IV) ATYPICAL FINDINGS IN TB SPINE (Disc sparing, Posterior element involvement and skip lesions).

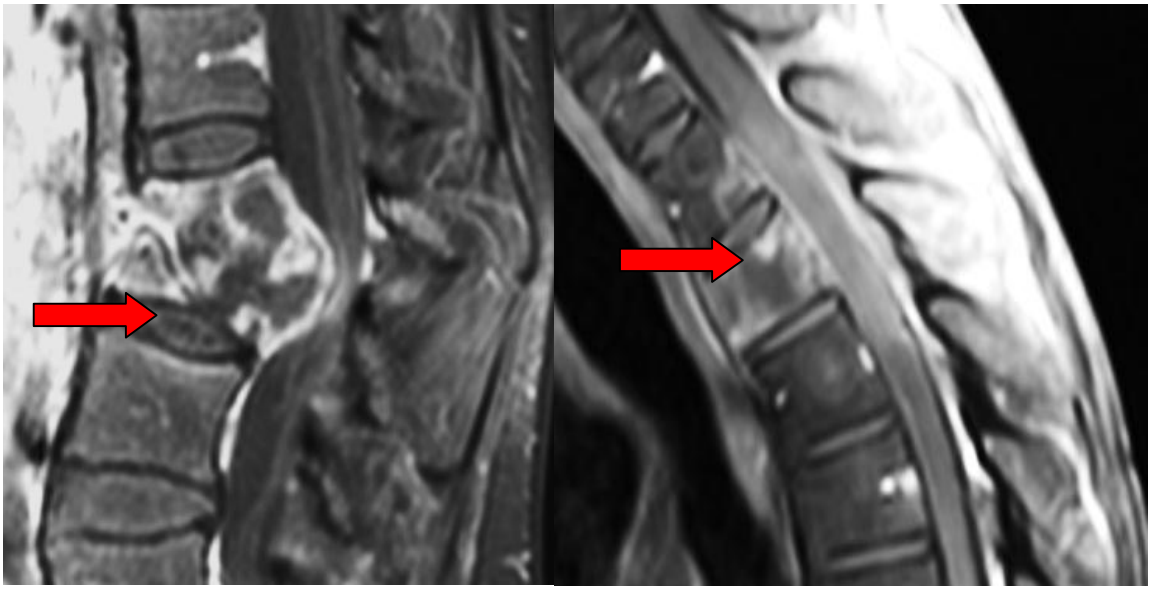


Figure 7: Contrast enhanced T1W sagittal images showing **disc sparing**(red arrows) in two cases of tuberculous spinal infections

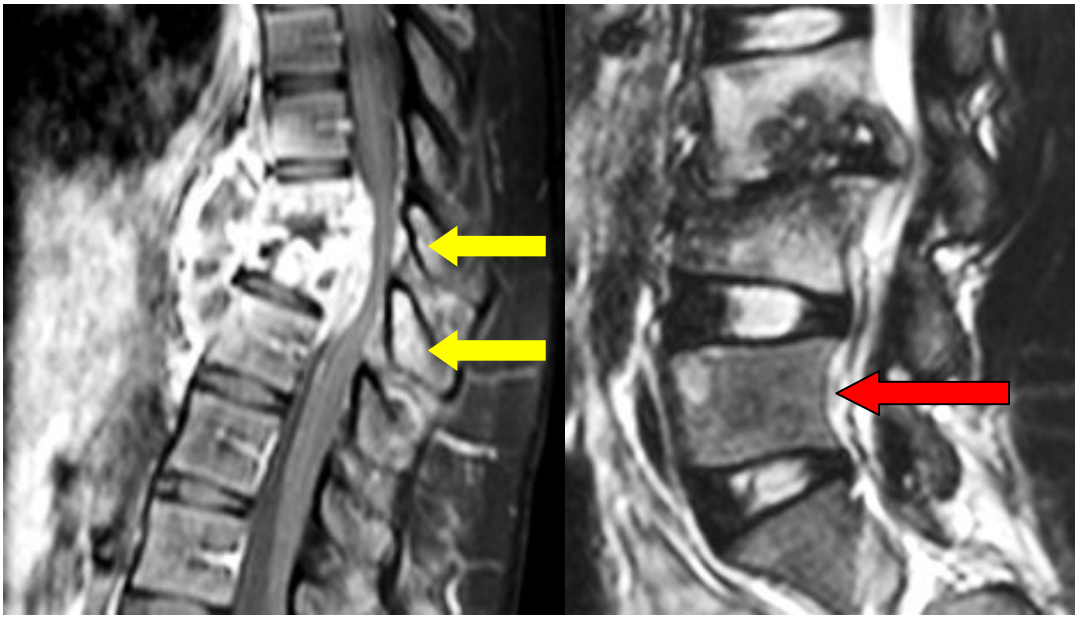


Figure 8: The image on the left is a sagittal T1W with contrast illustrating **posterior elementinvolvement**(yellow arrow) (T9 and T10 posterior elements show abnormal enhancement). The image on the right is a T2W sagittal illustrating **skiplesions**(red arrow) (L3 and L4 involvement with a L5 skip lesion). Both these were cases of TB spine.

(V) PYOGENIC SPINAL INFECTIONS

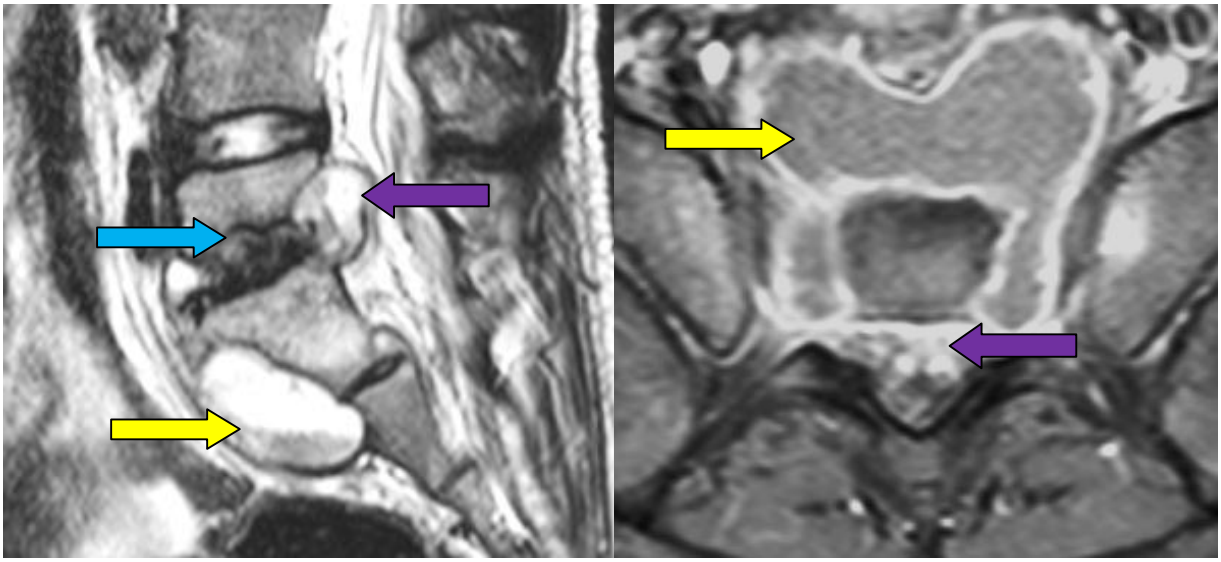


Figure 9: T2W sagittal and contrast enhanced T1W axial images. The images show intra-osseous (blue arrow), prevertebral (yellow arrows) and epidural (purple arrows) masses which are of mixed intensity on T2W and ring enhancement on contrast enhanced T1W. This was a case of pyogenic spinal infection.

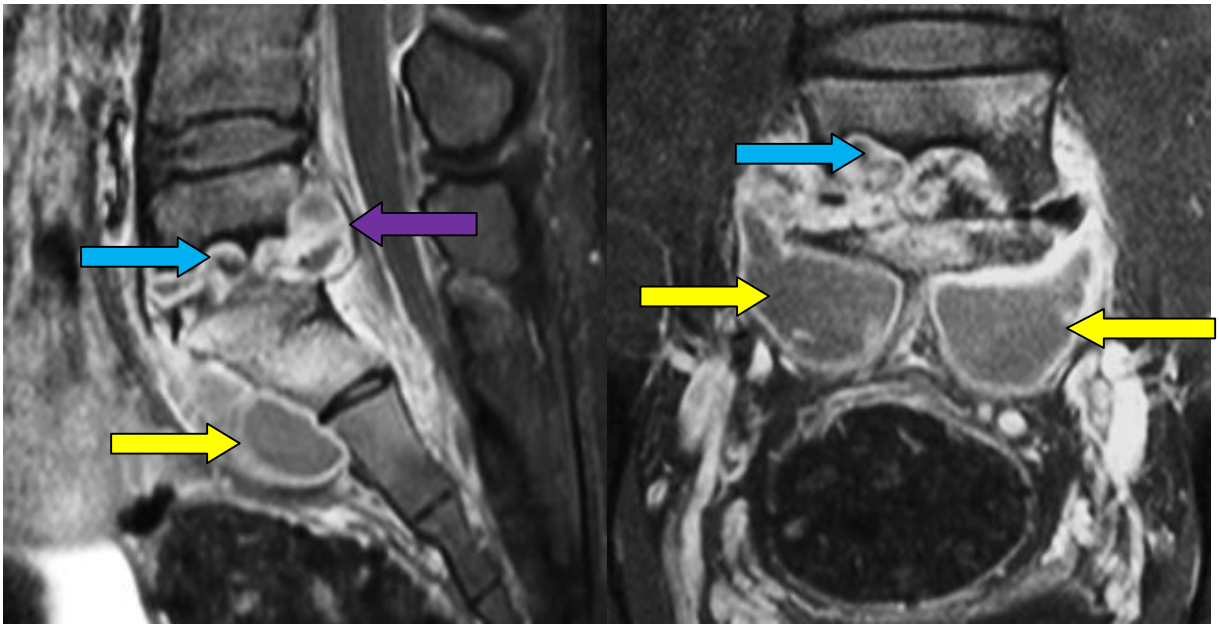


Figure 10: Same patient on sagittal and coronal T1W with contrast. This images show intra-osseous (blue arrows), prevertebral (yellow arrows) and epidural (purple arrow) ring-enhancing lesions at the lumbosacral region

(VI) SPINAL BRUCELLOSIS.

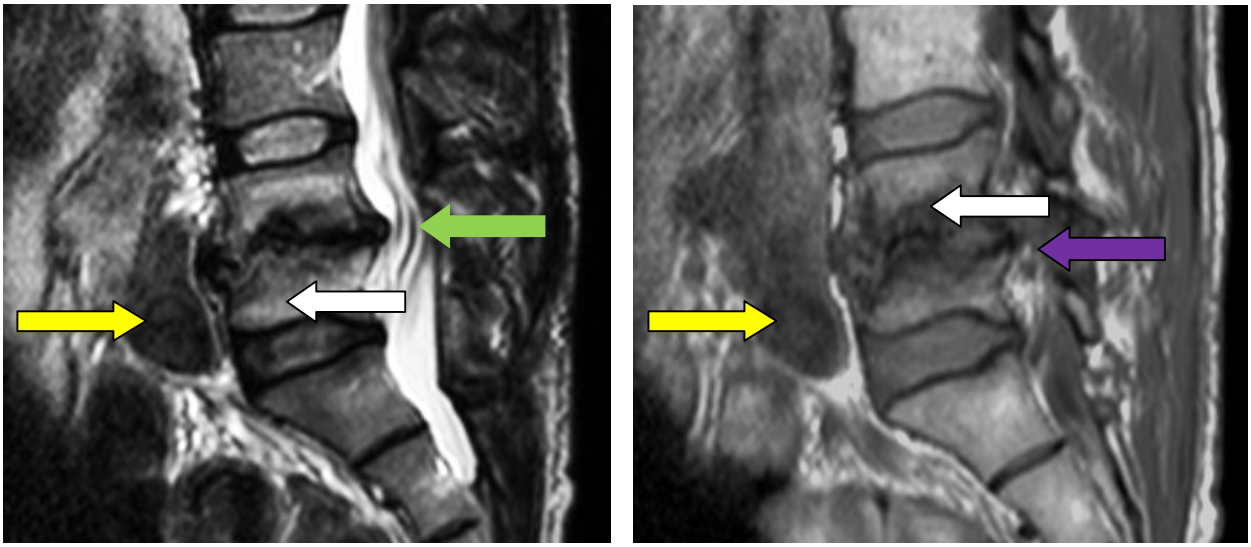


Figure 11: T2W and T1W sagittal images showing destruction of L4-L5 discwith prevertebral (yellow arrows) and epidural inflammatory tissue (purple arrow) compressing the cauda equina (green arrow). There are hyperintense T2W and hypointense T1W bone marrow changes (white arrows). This was a case of suspected brucellar spondylodiscitis.

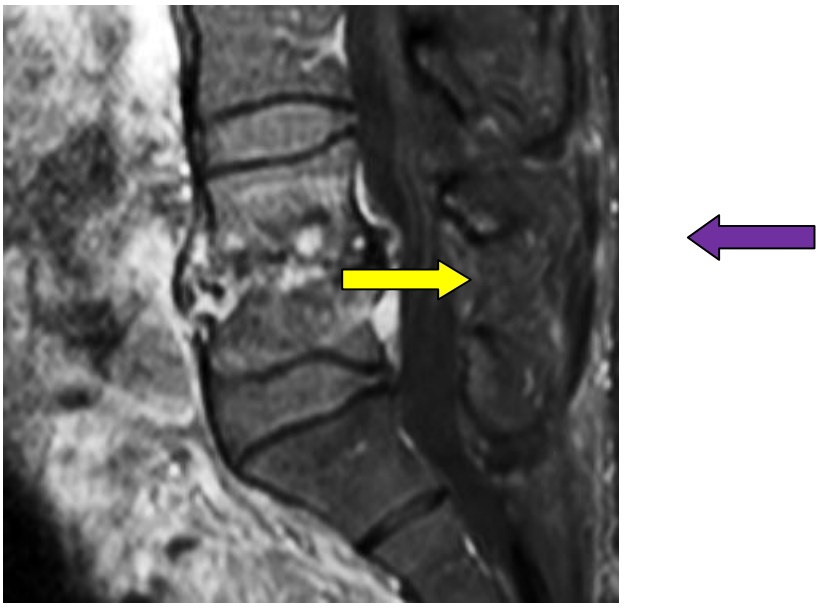


Figure 12: The same brucellosis case on contrast enhanced T1W sagittal image showing heterogeneously enhancing prevertebral (yellow arrow) and epidural inflammatory tissue (purple arrow) with cauda equina compression.

8.0 DISCUSSION

The purpose of this study conducted among patients with suspected pyogenic, tuberculous and brucellar spinal infections seen in a radiology unit within a Kenyan tertiary referral hospital was to describe MRI findings in this patient group. It was determined that tuberculous spinal infection was the most prevalent aetiology (84.4%) and among all patients spondylodiscitis was a common finding on MRI (77.8%).Spondylodiscitis is the main morphological form in most spinal infections**[2,9,30]**. The reported prevalence of tuberculous spinal infection is in the range of studies conducted in sub-Saharan Africa**[52]**. Although the reported aetiology of spinal infection is consistent with existing regional literature, the relatively high prevalence of tuberculous infection causing at least four-fifthsof all spinal infections can be explained by the fact that tuberculosis remains endemic in sub-Saharan Africa**[40]**. In developed countries where tuberculosis is not endemic, pyogenic spinal infection has instead been reported as the leading type of spinal infection**[15]**. Despite these significant geographic variations in spinal infection epidemiology, tuberculosis still ranks as the leading aetiology of spinal infection globally**[13,14]**, because most spinal infections occur in TB endemic countries and up to 95% of TB infection in 2011 occurred in developing countries**[52]**.

In this study spinal infections mainly affected the thoracic (37.8%) or lumbar regions (33.3%). TB had a thoracic region predilection while pyogenic infections and brucellosis favoured the lumbar region as seen in studies both regional and international**[20,24,28,31,52,54,60,61]**.

The main symptom was back pain observed in 80% of cases followed by neurological deficits and fever, these findings are consistent with a local study by Mwachaka and also other studies**[34,52,61,62]**. TB was the main culprit associated with neurological deficit (68.4% of TB cases), studies indicate that neurological compromise is seen in 23 to 76% of TB spine

cases**[51,52]**. Spinal deformities (kyphosis and Gibbus deformity) were only observed in TB spine (57.9% of TB cases), this is in keeping with other studies**[14,52]**. Fever was the main constitutional symptom. Spinal brucellosis is associated with constitutional symptoms especially fever**.** Fever presents in about 50% of pyogenic cases**[20]**. In both TB and brucellar cases the constitutional symptoms presented chronically while in most (66.7%) pyogenic cases it presented acutely. These findings are expected since TB and brucellosis are chronic infections whereas pyogenic infections are usually acute.

Of the MRI findings soft tissue changes (seen in 95.6%) dominated, for example all cases of TB spine had these changes. Soft tissue inflammation has been reported as a typical feature in previous MRI imaging studies with high sensitivity in TB, pyogenic and brucella spinal infections. In existing studies paraspinal inflammation was seen in 55 - 95% of TB spine cases**[42]** and Colmenero reported paraspinal and epidural inflammation in 73.1% and 65.4% of TB cases**[61].** Ledermann suggested that paraspinal or epidural inflammation were very common in pyogenic spondylodiscitis and their absence may exclude it**[54]**. Ozaksoy found soft tissue changes in 78.6% of spinal brucellosis**[58].** Psoas abscesses were only observed in TB spine cases (6.7% overall, 7.9% of TB cases). Psoas abscesses are more common in TB spine.

Of the vertebral body changes examined, end plate destruction considered typical of spinal infection **[54]** occurred in all cases affecting the vertebral body. This observation is consistent with earlier reports indicating that end-plate destruction had good sensitivity for spinal infections**[1,54]**. It is however, important to note that despite the 100% sensitivity of end plate destruction for spinal infection patients in this study the absence of this feature does not exclude spinal infection.

Apart from the typical changes reported it is important for radiologists to be aware of common atypical changes which present diagnostic challenges because these lesion could be indistinguishable from other non-infective spinal lesions liketumours**[2,55]**. Additionally, a high clinical suspicion index for atypical lesions could help in reducing false negatives diagnosis in spinal infections. In this series of Kenyan patients, the main atypical changes reported were bone abscess and disc sparing lesions. These atypical changes appeared to be more specific to TB infections, implying that in settings where TB is not endemic a different set of atypical changes could be seen**[2,54,55]**. Other notable atypical changes were skip lesions and posterior element involvement which were only seen in TB cases. Infact numerous studies indicate posterior element involvement to be highly suggestive of TB**[13,16,63]**.

The MRI findings interrogated for neurological deficits were those known to cause neural element compression like vertebral body collapse, epidural inflammation, paraspinal inflammation and neural foraminal stenosis. These findings occurred in various combinations with an additive effect. Of the 29 cases with neurological deficits the most common MRI findings were cord compression seen in 26 (89.7%) cases, paraspinal inflammation and epidural inflammation at 22 (75.9%) cases each. A significant number of patients without neurological problems had cord compression (68%).

Regarding predictors of MRI findings the study suggests that neurological presentation does not discriminate MRI findings and that absence of neurological problems cannot be used to infer possible MRI findings thus neurological signs are poor predictors of MRI findings. It appears that the degree of neural element compression rather than the simple presence of neural element compression leads to neurological deficits. With the involvement of large numbers of cord compression seen on MRI in this study it can be postulated that MRI did not fail to pick any case

with cord compression, this implies that MRI provides good definition of thecal sac and cord compression**[1]**. Conversely, some clinical signs did appear to have a clear correlation with MRI findings. When correlated with vertebral body collapse on MRI, all patients with spinal deformity clinically had associated vertebral body collapse with kyphosis or gibbus on MRI investigation implying that spinal deformity is a good clinical sign to predict vertebral body collapse on MRI. While neurological problems will not predict MRI findings spinal deformities highly correlated with vertebral body collapse on MRI.

MRI investigation was in most cases ordered following prior imaging studies (most commonly plain X-rays). The patients without plain X-rays had most probably misplaced their radiographic films. These observations related to prior imaging and the availability of these X-ray data provide an opportunity for feedback to KNH on organization and management of radiology data. First, there is need to explore the reasons for the unavailability of X-ray data for almost one-quarter of patients recruited in this study. A separate area of quality assurance will be determining whether the current imaging protocol recommendations at KNH are being adhered to. Findings on X-ray for spinal infections correlated highly with MRI findings of disc and vertebral body changes but an additional benefit of MRI imaging was in identifying soft tissue change. In the current study soft tissue changes were rarely picked up on plain x-ray but MRI showed evidence of soft tissue changes in each of this cases. The ability of MRI to discriminate soft tissue changes represents the main additional utility of MRI over X-ray in our study. Considering the high sensitivity of the presence of soft tissue changes for spinal infection this finding therefore forms a case for referring patients with equivocal X-ray findings in suspected spinal infections for MRI investigation**[3,47,53].**

Immunosuppression caused by HIV infection, at 37.5%, was the main risk factor for pyogenic spinal infections (66.7%) and second most common in TB spine cases (28.9%). Results of TB spine and HIV co-infection concur with a study done in South Africa by Godlwana which reported HIV co-infection in 28% of the TB spine cases**[64].**

In TB cases, previous history of TB infection was the main risk factor at 31.6% especially pulmonary TB (21%). Similar results have been seen in other studies. TrecarichI suggested that a previous history of TB ranges from 5% to 100% in TB spine**[63].** Pertuiset in France observed previous TB in general at 18% and pulmonary TB at 15.5%**[62],** the difference with this study is probably due to epidemiological differences of TB in the two study settings.

In this study diabetes mellitus, only seen in TB cases, contributed to 12.5% of the risk factors. This is similar to Colmenerosô study which reported diabetes in 11% of TB cases**[61].** Diabetes is the major risk factor for spinal infections in numerous western studies**[35]** but in this study HIV was the main risk factor. This is attributed to the high HIV prevalence in this country.

Previous spinal surgery was identified in 5% of risk factors. This finding was similar to various western studies which show post-operative risk to be 1-4%. The rise seen in this study implies that we have inferior post-operative infection prevention measures than western countries.

The brucellar patient was an animal handler which is prevalent amongst them.

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9.0 CONCLUSION

1. Spinal infections affect all age groups but the peak age group varies with the different etiologies. The peak age group for all spinal infections, tuberculosis and pyogenic infections is 30-39 years(The mean age for all spinal infections is 36.9 years with TB at 36.6 years and pyogenic infections at 37.7 years), and the single brucellosis patient is 43 years old. Spinal infections are more common in males.

2. Tuberculosis is the main cause of spinal infection in this country followed by pyogenic infections. Brucellosis is rare. Spondylodiscitis is the commonest anatomical lesion in spinal infections.

3. Spinal infections mostly affect the thoracic or lumbar regions. Locally TB spine mainly affects the thoracic region while pyogenic and brucellar infections affect the lumbar region.

4. Although spinal infections have vague symptomatology back pain (commonest symptom), neurological deficit and fever are the main clinical presentations.

5. Neurological deficits are poor predictors of MRI findings and as such should not be used to screen patients for MRI examinations.

6. MRI is the imaging modality of choice in spinal infections due its superior contrast resolution and sensitivity to soft tissues lesions. It is the only imaging modality that combines high sensitivity, specificity and accuracy in spinal infection imaging. Contrast should be administered in all cases of suspected spinal infections.

7. HIV infection is the major risk factor for spinal infections locally. In TB cases a previous history of TB infection is a significant risk factor.

10.0RECOMMENDATIONS

1. In the presence of qualified and experienced clinicians (neurosurgeons and orthopedic surgeons) patients presenting with suspected spinal infections will benefit from MRI examinations as this will reduce diagnostic delays thus development of severe complications, avoid unnecessary surgery and reduce patientsô hospital stay.
2. Clinicians should be aware of definite features which complicate back pain and that MRI is the recommended initial imaging modality of choice as it is efficient for detecting conditions which cause complicated back pain.
3. A study to correlate the magnitude of cord compression seen on MRI and clinical neurological compromise is recommended to facilitate early intervention and management.
4. A comparative study between plain X-ray and MRI findings of spinal infections in the local setup is recommended.This would be beneficial locally because plain X-rays are the initial imaging modality requested by clinicians upon suspicion of spinal infections due to cost, accessibility and availability of X-rays. In addition this study will confirm the added value that MRI provides and also enhance the cliniciansô awareness of X-ray findings suggestive of spinal infections, and promptly refer those cases for MRI to confirm the diagnosis thus avoiding diagnostic delays and ensure prompt accurate diagnosis.
5. A study which will correlate MRI findings and histological/laboratory findings of spinal infections in the local setup is recommended to assess the accuracy of MRI findings.
6. Picture archiving and communication system (PACS) is required for efficient, accurate and timely retrieval of patient information and images which not only facilitates research but also proper patient management.

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APPENDIX A

QUESTIONNAIRE

1.Patient's Biodata

Serial No é é é é é é é é é é é ...é é .

Inpatient / Outpatient No é é é é é é é é é é é é é é é é

X-ray No é é é é é é é é é é é é é é é .é é é é .

Age in yearsé é é é é é é é é é é é .é é .

Gender Male é é é .. Femaleé é é é é

2. P**resenting complaint**.

a). Back pain and stiffnessé é é é Durationé é é .

b). Neck pain and stiffnessé é é é Durationé é é

c). Spinal deformity ï Kyphosisé é é . Gibbus deformityé é é ..

d). Neurological problems. Motor é é é .. Durationé é é

Sensoryé é é . Durationé é é

Sphincter dysfuctioné é .. Durationé é é

e). Constitutional symptoms (specify)é é é .. Durationé é é

f). Others(specify).

3. Risk factors.

a). Immunosuppression (specify)é é é é é é é é

b). Diabetes Mellitusé é é é é é é é é é é ..

c). Previous spinal surgery or invasive procedures or traumaé é é é é é ..

d). Previous history of TBé é é é é é é é .

e). Others (specify)é é é é é é é é é ...

4. Imaging studies performed prior to MRI.

a). Plain radiographé é .. Findingsé é é é é é é é ..

b). CTé é é é é é é é Findingsé é é é é é é é ..

c). RNIé é é é é é .. Findingsé é é é é é é é ..

5. MRI findings and diagnosis.

a). Vertebral region affected ï Cervicalé é é Thoracicé é é . Lumbaré é é Sacralé é é .

b). Vertebral body changes ï Endplate destructioné é é é é é ..é é .

Bone marrow changesé é é é é é é é

Body collapseé é é é é é é é é .

Multilevel involvement (> 3 vertebrae)é é é

Skip lesionsé é é é é é é é é é é é é ..é ..

Posterior elements involvementé é é é é é ..é ..

Contrast enhancementé é é é é é é é ..é .

c). Disc changes. Signal changesé é é é é é é é é é é é é é é é é .

Loss of disc heighté é é é é é é é é .é .

Contrast enhancementé é é é é é é é é ..é é .

d). Soft tissue involvement. Paraspinal inflammationé é é é é é é é é ..

Epidural inflammationé é é é é é é é ..é .

Others (specify)é é é é é é é é é é é é ..

Contrast enhancementé é é é é é é é é ..

e). Atypical changes (specify).

f). Suspected MRI diagnosis. Pyogenic infectioné é é é é é é é é é é é é ..

Non-pyogenic infection. TBé é é é é é é é é é .

Brucellosisé é é é é é é

APPENDIX BCONSENT EXPLANATION FORM

Study title: <u>The patterns of MRI findings of pyogenic, tuberculous and brucellar spinal infections at Kenyatta National Hospital</u>.

Introduction:

I am Dr Wanderi Peter Kioria, a master of medicine student in the department of Diagnostic imaging and Radiation Medicine at the University of Nairobi. I am doing a study on infections of the spine and their MRI findings at KNH. Spinal infections are serious and rapidly progressing diseases which, if untreated, cause permanent deformity, nerve problems like paralysis or even death. Early diagnosis and management is important to prevent these poor outcomes. Imaging has a key role in diagnosis and management of these diseases. MRI, a radiological examination that views internal organs, is currently the best imaging method for this disease and is safe as it offers no harmful radiation.This study will review the findings of these diseases on MRI.

Purpose of the study:

1).To know the commonest cause, site, age and sex distribution of spinal infections.

2).To identify the main risk factors to spinal infections.

3).To correlate the clinical features and other imaging findings with MRI findings.

Your attending doctor referred you for MRI to help him/her in the management of your disease. I would like you/your patient to be part of this study. Please note that your participation is voluntary, you have a right to decline or withdraw from the study at any time and you will not incur any extra costs by participating

Procedure :

For patients who accept to participate in this study (which takes approximately 30 minutes for a brief interview and review of images), they will be requested to:

1. Answer questions about their disease which are relevant to the study.

2. To avail images and reports of any other imaging studies done prior to MRI in relation to the current illness for review by the principal investigator.

-The principal investigator will review images of the MRI investigations ordered by the attending clinicians.

-All the information gathered above will be recorded in the data collection form.

Risks

It is not predicted that the patient will suffer any harm from participating in this study

Benefits

1. No extra cost will be incurred by the patient participating in the study.
2. Results of the study will help to further understand MRI features of spinal infections and it is hoped this will improve on clinical management of patients.

Confidentiality:

Strict confidentiality will be maintained and data obtained will be kept and used for purposes of this study only.The patientsô name will not be used only the hospital number will be used for reference purposes and after the study ends all the patientsô information held by the principal investigator will be destroyed.

More information:

1). Participation is voluntary. Patients/guardians have the right to decline to participate or withdraw from the study at any time during the course of this study period.
2). For those who decline to participate in this study, the quality of treatment will not be compromised, they will continue to receive treatment as usual and will not be discriminated against in any way.
3). The principal investigator will only review images of the investigations ordered by the attending clinicians and no other investigation will be done that was not requested by the attending doctor. Any intervention arising from such review will be for the patients benefit and not the principal investigator. The principal investigator will have no financial or material gain.
4). The principal investigator will answer any other questions that may arise about the study.
5). No compensation will be offered for participating in the study.

The study has been reviewed and approved by the Kenyatta National Hospital/University of Nairobi Ethics and Research Committee(KNH/UON-ERC), which is a committee whose task is to make sure that the research participants are protected from harm. .

In case of any queries concerning this study please contact any of the following persons:

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PATIENT CONSENT FORM

Ié é é é é é é é é é é é é é é é ..after having read the consent explanation form and having been explained to, do voluntarily agree to participate in this study titled ñ The patterns of MRI findings of pyogenic, tuberculous and brucellar spinal infections at Kenyatta National Hospital.ò I am also aware that I can withdraw from this study without losing my healthcare benefits or quality of management of my condition being affected.

Signatureé é é é é é é é é é é é é é é é é

Dateé é é é é é é é é é é é é é é é é é ..

I certify that the patient/guardian has understood and consented participation in the study.

Dr Wanderi Peter Kioria.(witness)

Signature é é é é é é é é é é é é é é é é é

Date é é é é é é é é é é é é é é é é é é é

MAELEZO YA RIDHAA

Utambulisho

JinalanguniDaktari Wanderi Peter Kioria. Mwanafunziwamasomoyaupigajipichaza mwilikatikachuokikuu cha Nairobi. Ninafanyautafitiwamaambukizoyamgongo, haswa upigaji pichakutumia MRI. Maambukizoyamgongonimagonjwahatarinahueneaharaka, bilamatibabu, yanasababishashidazamishipakamaulemavu au kifo.
Utambuzinamatibabuyamapemainazuiamatokeohayamabaya.
Upigajipichanimuhumukwautambuzi. MRI ni machine inayopigapichazaviungovyandanivyamwili**,** ndio bora zaidi kwakupigapichazahayamagonjwananisalamahainamionzihatari**.** Huuutafitiutachunguza matokeo yahayamagonjwakwa MRI.

Nia yaUtafiti

1). Kujua sababisha kuu, eneoyamgongoilioathirika, umrinajinsiazinazoathiriwasananamaambukizoyamgongo .
2). Kutambuahatariza kuambukizwamaambukizoyamgongo .
3). Kulinganishaisharanadalilizaugonjwa, matokeoyapichazinginenaza MRI

Daktarianayekuhudumiaameagizaupigwepichaya MRI ileimusaidiekwamatibabuyako.
Ninaombaruhusayako, niwezekupatanakutumiataarifazakokatikautafitiwangu, ilihatimayemaoniyautafitiwanguyafaidikatikamatibabuyamagonjwayanamna hii.
Tafadhalifahamukushirikikatikautafitihuunihiari, mgonjwa au mlezi wake anahakiyakukatakushiriki au kujitoakwenyeutafitiwakatiwowotenautafitiwoteutafanywabilamalipoziadakutokakwamgonjwa

Taratibu

-Kwa mgonjwa anayekubalikushirikikatikautafitihuu (kwamudaawadakikaishirinizakuhojiwanakukaguapicha) ataombwa:

1). Ajibumaswalikuhusuugonjwa wake inayoambatananautafiti.
2). Kuletamajibunapichazozotealizopigwakablaya MRI kuhusuhuuugonjwandiomtafitiazikague
-Mtafitiatazikaguazilepichaza MRI zimeagizwa na daktari .

ï Taarifazotezitakazochukuliwazitajazwakwenyefomuyakuchukua data.

Hatari: Hakunahatariinayohisiwakutokananakushirikikwahuuutafiti.

Faidazakushiriki:

1).Uchunguziwoteutafanywabilamalipoziadakutokakwamgonjwa.

2).Maoniyautafitihuuitasaidiakuelewazaidimaambukizoyamgongokutumia MRI nainatarajiwayatafaidikatikamatibabuyamagonjwayanamnahii

Usiri:

Majibuyoyoteyatakayotokananautafitihuuyatahifadhiwakwasirinakutumiwakwaajiliyautafitihuutu.Jina lako halitatumiwa ila nitatumia nambari ya hospitali tu ili kukutambulisha na mwishowe wa utafiti taarifa zote za mgonjwa zitakuwa na mtafiti zitafutwa.

Taarifa Zaidi:

1). Kushirikikatikautafitihuunihiari. Mgonjwa au mlezi wake anahakikukataakushiriki au kujitoakwenyeutafitiwakatiwowotena uborawamatibabuyakehautaathirika, ataendeleakutibiwakamakawaidanahataonyeshwaubaguziwowote**.**

2). Yeyoteatakayekata kushirikikatikautafitihuu, uborawamatibabuyakehautaathirika, ataendeleakutibiwakamakawaidanahataonyeshwaubaguziwowote. 3). Mtafitiatakaguazilepichazimeagizwana daktari anayekutibutuu, naikiwakunahajayamatibabuyaziadaitakuwakwamanufaaya magonjwa nasioyamtafiti. Hakunauchunguzimwingineutakaotekelezwaisipokuwaileimehidhinishwanadaktari wako. Mtafitihafaidiki kwa fedhaamarasilimalizozote.

4). Mtafitiatayajibumaswaliyoyoteinayohusuhuuutafiti

5). Hakunapesautakayopewailikufidiakushirikikwakokatikautafitihuu.

Huu utafiti umekaguliwa na kupitishwa na Kamati ya Maadili ya Utafiti ya Hospitali kuu ya Kenyatta na Chuo kikuu cha Nairobi (KNH/UON-ERC), kamati hii huhakikisha kuwa washiriki wa utafiti wamelindwa kutoka madhara yoyote.

Kwamaelezonamaswaliyoyote kuhusuutafitihuu, unawezakuuliza**:**

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KIBALI CHA MGONJWA

Mimié é é é é é é é é é é é é é é é ..baada ya kusoma maelezo ya idhini na kuelezwa zaidi, natoa ridhaa kwa hiari yangu kushiriki kwa utafiti unaoitwañ The patterns of MRI findings of pyogenic, tuberculous and brucellar spinal infections at Kenyatta National Hospital.ò Ninaelewa pia ninaweza kujitoakwenyeutafitiwakatiwowote na uborawamatibabuyanguhaitaathirika, nitaendeleakutibiwakamakawaidanasitaonyeshwaubaguziwowote.

Sahihié é é é é é é é é é é é é é é é é

Tareheé é é é é é é é é é é é é é é é é ..

Nathibitisha ya kwamba mhusika ameelewa na ameridhia kushiriki katika utafiti huu.

Daktari Wanderi Peter Kioria (shahidi)

Sahihi é é é é é é é é é é é é é é é é é

Tarehe é é é é é é é é é é é

APPENDIX C

TABLE 1.TIME FRAME

Number	Activity	Estimated Time
1	Proposal Development	January- August 2013
2	Proposal Submission to the department for marking	September 2013
3	Submission of proposal for ethical approval	November 2013
4	Data Collection	January 2014 to March 2014
5	Data Analysis	March 2014
7	Dissertation writing	March to April 2014
8	Dissertation submission	May 2014

TABLE 2.ESTIMATED BUDGET

ALLOCATION	BREAK DOWN	AMOUNT IN KES.
Stationary	4 reams Printing paper@1.000/-	4,000
	Biro pens (1Box) @ 1,000/-	1,000
	10 Folders @200	2,000
Ethics board	Ethics Fee	2,000
Secretarial services	Typist fees	5,000
	Photocopy	3,000
Computer and Printer	Laptop Computer	65,000
	Computer soft wares	6,000
	Printer and Cartridges	8,000
Internet hours	50hours@ 60/-	3,000
Data collection and analysis	Statistician services	30,000
Printing and Binding	Proposal	4,000
	Final report	8,000
Contingencies	Contingencies	10,000
	TOTAL AMOUNT	**151,000**

The above expenses were met by the researcher himself.