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Research Article

Role of MRI in Metastatic Spinal Disease

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Abstract

Background and objective: Our prime objective is to evaluate the significant impact of MRI on the diagnosis of osseous spinal metastasis and secondly to be distinguished from other pathologies that may mimic spinal metastasis**.**

Method: This prospective cross section study was carried out in MRI department of both Diagnostic Imaging Center /Sulimani Teaching Hospital & Shahid Heman Teaching Hospital of Sulimani Governorate -Kurdistan Region -Iraq, from November 2016 until August 2017. A total number of 100 (54 male and 46 female) consecutive patients were involved. MRI examination was conducted by 1.5 Tesla MRI; Siemens (Magnetom Harmony Symphony Sonata Version) & Philips (Achieva 2007). The age of patients was ranging between (16-82 years) with mean age for spinal metastasis was (53.5 years). Tissue diagnosis was depended for the final diagnosis of spinal metastasis.

Results: The results revealed that spinal metastatic lesions were predominantly from CA breast & CA prostate accounting for (26 %) & (15 %) in female & male respectively, while other primary tumors include; bronchogenic carcinoma (10%), NHL in (7%), renal cell carcinoma in (4 %) and colonic cancer in (3%). The most frequent location of spinal metastasis was in a descending order, i.e. dorsal, lumbar, cervical and sacral were affected in rate of (68%, 26%, 4 % and 2%) respectively, with an incidence around (100%) for vertebral body metastases, followed by (32%) for pedicles, and only (2%) of laminae and cost vertebral junction. Ninety six percent or (96%) of patients had multiple vertebral involvement, (64%) of them were contagious, (10%) were non-contagious, (22%) were combined, while patterns of spinal metastatic lesions were osteolytic In (70%) of patients with spinal metastasis, osteosclerotic in (11%), and (19%) was mixed. Eighty (80%) out of 100 patients were of focal multiple patterns, while 15 patients (15%) showed diffuse bone marrow changes, and five patients (5%) had focal solitary pattern. Vertebral body collapse was seen in 34% of patients, while non showed intervertebral disc involvement even in infection cases.

Conclusion: It was concluded from the current study that the overall MRI accuracy for detection of spinal metastasis was 93%.

Keywords: MRI, Metastatic cancer, spinal metastasis.

Background and objective

Spinal metastatic disease is considered to be the most prevalent tumor of spine, and it accounts around ninety percent of lesions detected by spinal imaging. Osseous metastasis is more frequently occurring form of spinal metastases , thoracic spinal column being on the top, followed by, lumbar spine , whereas the cervical part is the minimum possible site exhibiting metastasis[1,2]. Spinal metastasis might result in instability, ache and nervous damages. This can occur, as a result of presence of an epidural mass that may cause deformity of spinal cord, which leads to demyelination or devastation of axons[3].

It has been reported that principal tumors most frequently causing bone metastasis are prostate, breast, kidney, lung, and thyroid cancer[4]. Autopsy studies have revealed that skeletal metastasis incidence is of 73 %in the breast cancer, 68 percent within the prostate cancer, while in thyroid cancer it is 42 %, in the lung cancer it is 36%, in the kidney cancer it is 35 %, but it was11 % in the rectal cancer, 6%in the esophageal cancer, and 5% in the gastrointestinal tract cancers[5]. More than 80% of the metastatic bone disease cases are due to cancers of breast, prostate, as well as lung, since they are of great cancer frequency[6].

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In a previous study, it was mentioned that bone metastasis could be developed in about 70 % of individuals who have breast or prostate cancers, and in 15 - 30 % of individuals who have lung, kidney, colon, or bladder cancers[7]. It was found that, in women, the most commonly occur malignant tumor is breast cancer and it is the major reason for bone metastasis[8]. Among persons who get died due to the breast cancer, almost 70 % will reveal radiological verification of skeletal metastasis prior to dying and the initial metastatic place is the bone in 40% percent of the cases[9]. On the other hand, amongst men, the occurrence of prostate and lung metastasis are the more commonly occur[10]. Unfortunately, in nine percent of the patients of spinal metastases, the primary tumor couldn't be determined[11].

Magnetic resonance imaging (MRI) is an imaging technique in which a powerful magnetic field and computerized radio waves are used to create detailed anatomical images of the organs and tissues inside the body[12]. MRI is distinguished from the computed tomography (CT) scan and/or Positron emission tomography (PET) scans as x-rays or ionizing radiation are not involved in MRI but the nuclear magnetic resonance (NMR) are involved. Spinal cord, nerves, brain, as well as ligaments, and muscles, could be distinguish much more obviously via MRI than by the usual CT scans and x-rays scans[13]. It was shown that MRI possesses a significant effect on assessment of tumor of spine. Currently MRI is considered the gold standard imaging modality for both early diagnosis and morphological delineation of spinal metastatic disease[14], as certain pertinent diagnostic information can be obtained such as the diagnosis of metastasis, the description of the involvement degrees, in addition to identification of any related compression of spinal cord. Involvement of bones as well as neural compression as a result of epidural tumor is verifiable via using MRI[15].

Hence our prime objective is to evaluate the significant impact of MRI on the diagnosis of osseous spinal metastasis and secondly to be distinguished from other pathologies that may mimic spinal metastasis.

Method

This prospective cross section study was conducted in MRI departments of both Diagnostic Imaging Center - Sulimani & Shahid Heman Teaching Hospitals, respectively Kurdistan Region -Iraq, from November 2016 to August 2017. 100 consecutive patients with suspected spinal metastatic involvement as well as follow up cases with osseous spinal metastasis following radiotherapy & / or chemotherapy, those with suspected spinal metastasis presented with; back pain, motor or sensory disturbance in a form of weakness, parasthesia, sphincter dysfunction & spinal cord compression were enrolled in this study; 54 males and46 females aged from (16 to 82 years) (mean age 53.3 years). MRI examination was conducted by 1.5 Tesla MRI Siemens (Magnetom Harmony Symphony Sonata Version) & Philips (Achieva 2007). The MRI findings were independently recorded and later compared and interpreted in comparison to previous studies if available. Tissue diagnosis was depended for the final diagnosis of spinal metastasis, which was obtained either with CT guided needle biopsy or open biopsy in 74 and 26 patients respectively.

The standard protocol for spine MRI consists of the following:

- T1 weighted axial and sagittal planes (TR = 478ms, TE =10ms, slices thickness 4mm).

- T1 weighted & / or T1 FS +Gd (axial, sagittal, ±coronal planes).

- T2 weighted axial and sagittal planes (TR=400ms, TE=116ms, slices thickness 4mm).

- T2 weighted fat suppression (sagittal plane) (TR = 3900ms, TE =60 ms,slices thickness 4mm).

Contrast enhancement:

Gadolinium- DTP A, 469mg/1 ml, about 0.01mmol/Kg was giving mainly with fat saturation T1-weighted sequences, due to isointensity of enhancing metastases with normal bone marrow in T1 sequence and hence it may be obscured. T1 postcontrast with fat saturation can increase the ability of discrimination of enhancing marrow lesions by suppressing the background high fatty marrow signal[16].

Results and discussion

Recognition and discrimination of various patterns of spinal metastatic disease is crucial as spine is the most common site of osseous metastatic disease. MRI is valuable imaging modality in various spinal pathology due to its high spatial resolution bone marrow delineation[16,17].

MRI is superior in its ability to discriminate among tissues and evaluate their physiological and pathological features, in a non-invasive way, as evaluation of concomitant soft tissue involvement, bone marrow infiltration and intra - spinal extension[15].

A total number of 100 (54 male and 46 female) consecutive patients were involved. Out of 100 cases, 93 patients (93%) were confirmed by biopsy to be secondary malignancy, four patients (4%) were with infections, and three patients (3%) were with Multiple Myeloma.

Age of Patients with spinal metastatic disease:

The results of this study revealed that age was regarded as one of risk factors for malignancy, Figure (1).This result was in agreement with study done by Aebi[18] who emphasized that metastasis becomes particularly apparent in older patients over 60 years than who are at the middle age (40 years old). Also, this result come at line with the study of Pal & Hurria[19] where it was shown that older patients are at higher risk for emerging spinal metastasis as the occurrence of cancer also rises with age. In addition, persons over the age of 65 years, have a cancer incidence of around 60 % and cancer deaths about 70%.

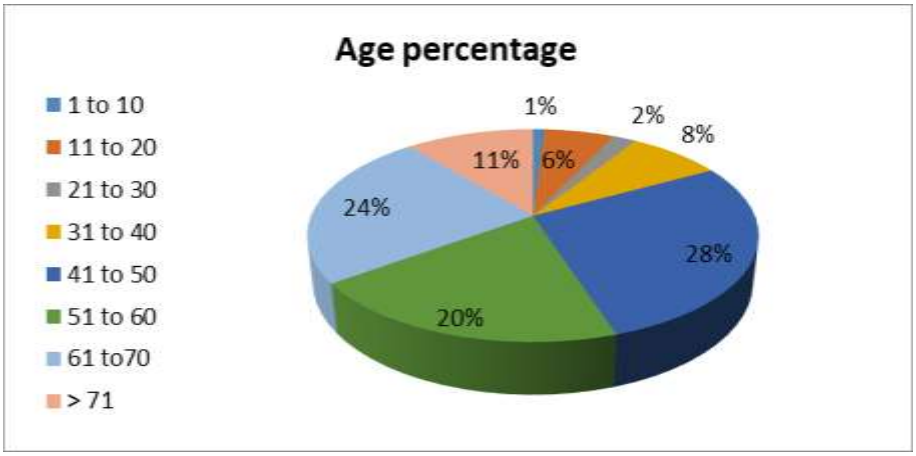

Fig. (1): Age of patients with spinal metastatic disease.

The gender of patients with spinal metastatic disease:

The gender of patients with spinal metastasis was illustrated in Figure (2). The spinal metastasis is slightly more common in male patients (54 %) than the female patients (46%), M/F=2.2:1.9 that was statistically significant. In this study, Prostatic Cancer, Ca Bronchus and Renal Cell Carcinoma were exclusively of male patients, which makes male more affected than female. These results agreed with the results of the study by Aycan, et al.[20] in which male patients were more affected, M/F=3:2. However, Gupta et al.[21] showed different results where no sex predilection was found.

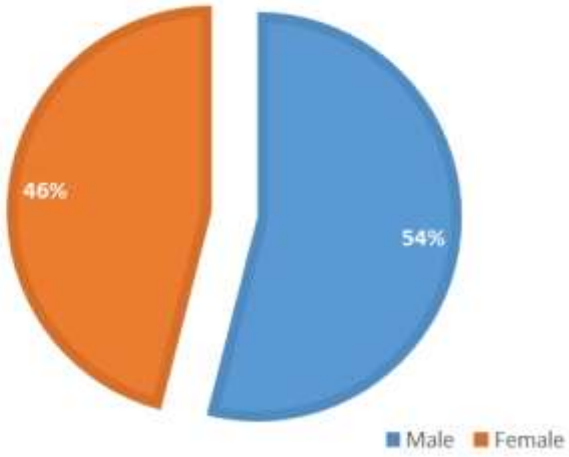

Figure. 2. The frequency of patients according to gender**.**

The clinical presentations:

The most common presenting symptom in the patients with spinal metastasis was back and/or cervical pain before performing MRI study. Patients with spinal metastasis showed local pain of two types; 1- Tumor related pain; (inflammatory, tumor stretching or irritation of periosteum). 2- Mechanical pain; structural abnormalities such as pathological, compression and neurological impairment. These findings were in agreement with the findings of Robson[22] as well as Sciubba & Gokaslan[23], who reported that back pain was observed in (95%) of the study patients.

Spinal levels- Parts and vertebral parts of metastasis:

This study revealed that the dorso-lumbar level of spinal column was more commonly involved (56%), followed by dorsal level (29%) and lumbar level (5%), while the least frequent affected levels were lumbosacral & sacrum levels with 1% for each. The most frequent location of spinal metastasis in a descending order , i.e. dorsal, lumbar, cervical and sacral are affected in rate of (68%, 26%, 4 %, 2%) respectively. The most common locations of spinal metastasis were in caudal direction / increasing volume of the bone marrow within the vertebral bodies from cervical to lumbar region of spine, Figure (3). Moreover, the results of the study by Mundy[24] showed that the frequency of spinal metastasis was more common in the thoracic region, followed by the lumbar region, whereas the least probable site for finding metastasis was the cervical region. On the other hand, it was mentioned that the site more concerned with metastasis is the thoracic spine[25], whereas previous studies underlined that the lumbar spine is more concerned[26], in addition, the least implicated site for metastasis is the cervical spine (10%)[27].

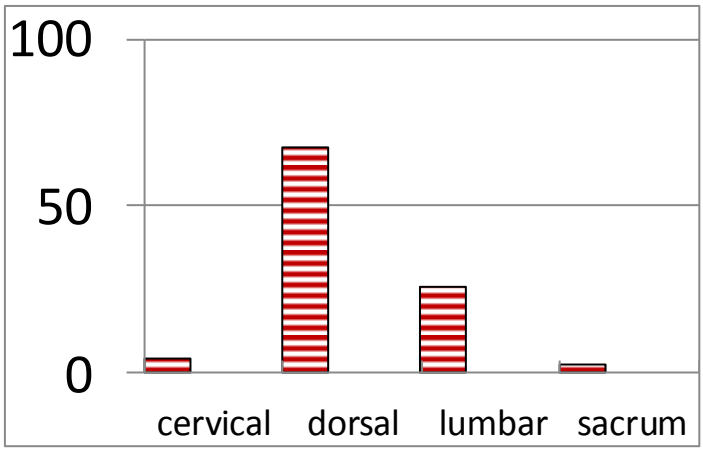

Figure. 3: The parts of spinal column for metastasis (236, and 90 , 15 & 8 out of 349 vert.)

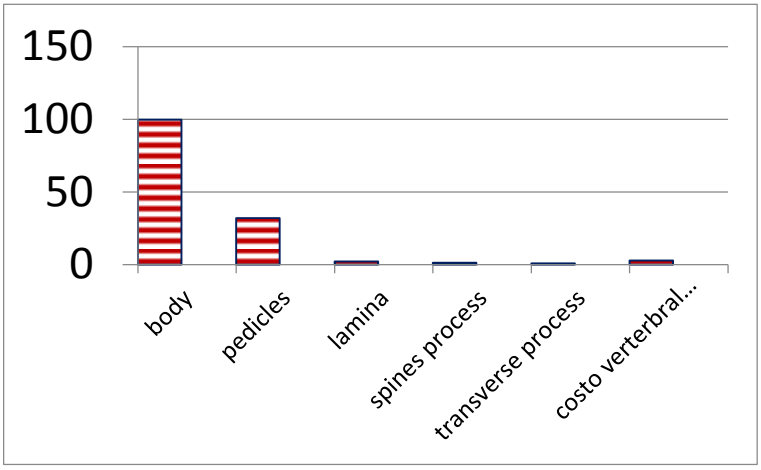

Figure. 4: The parts of vertebrae involved by metastasis.

From figure (4), it is clear that all the 349 vertebrae involved by spinal metastases showed vertebral body involvement except in one, giving an incidence around (100%) for vertebral body metastases, then (32%) for pedicles, and only (2%) of laminae and cost vertebral junction were affected. Similarly, it was stated that vertebral body has been broadly assumed to be the most affected by metastasis[28]. Also the findings were in agreement with the study by Algra et al.[29] who revealed that the most probable sites were vertebral body, followed by pedicles then laminae. Leri[30] also stated that the vertebral body is the most common primary place of metastasis.

Contagious vertebrae:

The current study showed that (96%) of patients had multiple vertebral involvement, (64%) of them were contagious, (10%) were non-contagious, (22%) were combined, and (4%) of cases had single vertebral involvement, Figure (5). These results were in agreement with the study done by Yeom et al.[31] as the results revealed that the most of the vertebral involvement with spinal metastasis were contagious.

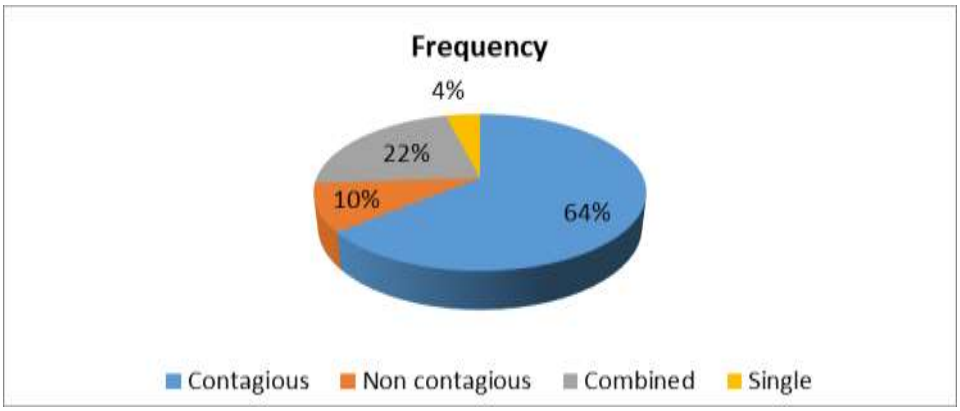

Figure 5. The frequency of contagious vertebrae

Patterns of spinal metastatic lesions:

The patterns of spinal metastatic lesions were illustrated in Table (1), Figure (6 and7). In (70%) of patients with spinal metastasis, the pattern was osteolytic, while (11%) showed osteosclerotic, and (19%) was mixed. Eighty (80%) out of 100 patients were of focal multiple pattern, 15 patients (15%) had diffuse bone marrow changes, and five patients (5%) had focal solitary pattern. These results were in agreement with the study done by Celli & Fanti[32] study where it showed that the patterns of metastatic lesions from breast cancer were (50%) lytic, (40%) mixed, and about (10%) sclerotic lesions. In contrast, these results were in disagreement with the study done by Ciray et al.[33] who showed that the patterns of spinal metastatic lesions were new sclerotic lesions were mostly detected (52 new lesions among the study patients), followed by lytic lesions[24] and then the mixed lesions were less detected.

Table (1) :The Patterns of spinal metastatic lesions:

Pattern of lesion	Frequency	Percent
Focal solitary lytic	3	3
Focal solitary sclerotic	1	1
Focal solitary mixed	1	1
Focal multiple lytic	58	58
Focal multiple sclerotic	9	9
Focal multiple mixed	13	13
Diffuse bone marrow change (lytic)	9	9
Diffuse bone marrow change (sclerotic)	1	1
Diffuse bone marrow change (mixed)	5	5
Total	100	100

Figure. 6: Mixed focal & diffuse lesions

T1	T2	Pre contrast	Post contrast

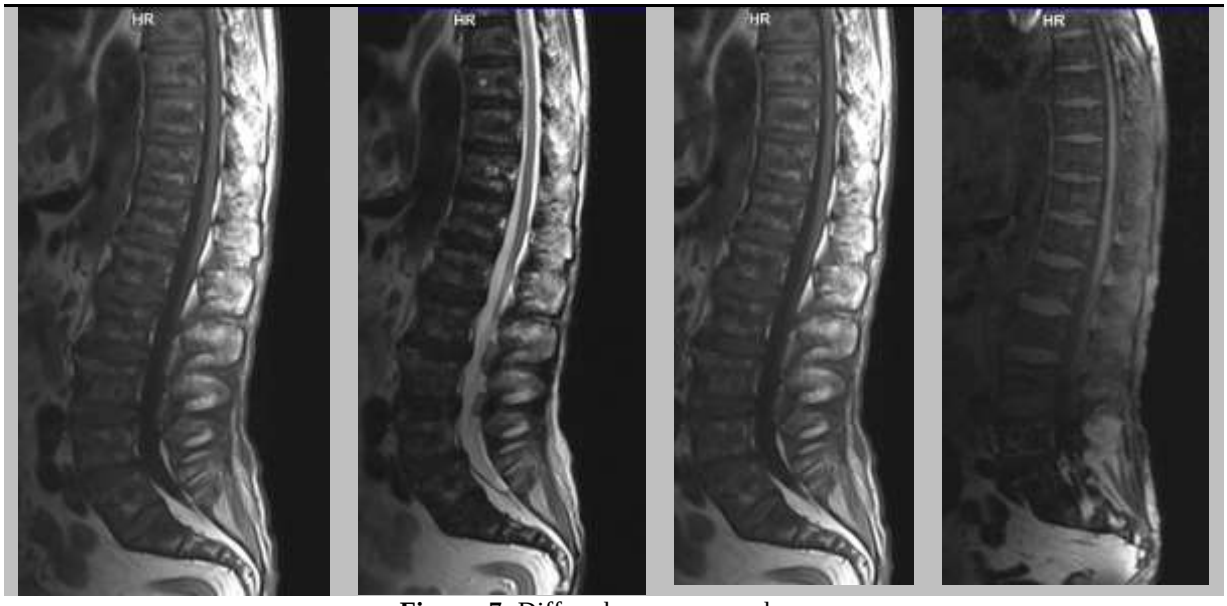

Figure. 7: Diffuse bone marrow change

(T1	T2	Pre contrast	Post contrast) figure 6

Vertebral collapse:

The current study results showed that the vertebral collapse was seen in (34%) of patients, (60%) of those collapsed vertebrae are seen in dorso-lumbar level of spinal column, (28%) were in dorsal level of spinal column.

Likewise, the results of this study agreed with study of Chi JH et al. [34] who showed that the pathological collapsed vertebrae were in dorso-lumbar spine.

Signal intensity & enhancement pattern of spinal metastatic lesions:

Ninety nine percent of the current study showed hypo intense T1 SI and 68 % hyper intense T2 SI for the metastatic osseous lesions with lytic nature, and 20 % showed hypo intense T2 SI for the osteoblastic nature while the remaining 12 % showed mixed signal intensity for both lytic & sclerotic activity of the metastatic bony lesion as shown in table (2) .None of the cases showed hyperintense T1 SI. Osseous metastases showed gadolinium enhancement due to increased vascularity[35].

Table 2. The Signal intensity and enhancement pattern of spinal metastatic lesions

Signal intensity	Frequency	Percent
T1 signal intensity		
Hypo	99	99
Iso	1	1
T2 signal intensity		
Hypo	20	20
Hyper	68	68
Heterogeneous	12	12
Enhancement pattern		
Diffuse homogenous	72	72
Diffuse inhomogeneous	12	12
Focal enhancement	9	9
Rim enhancement	7	7

Inter vertebral disc involvement in spinal metastasis:

In the current study, inter vertebral discs were preserved in all patients even in cases with infections. The disc was found to be dense, highly organized, cross linked with collagen fibers, and avascular. The current study findings were in agreement with the findings of the both studies of Choi et al.[36] and Shah & Salzman[37] who showed preservation of inter vertebral disc in all patients with spinal metastases.

Non osseous MRI findings:

It was noticed that the para-vertebral soft tissue was observed in 17 patients (17%). In addition, 10 out of 17 were identified with known primary malignancies for them initial MRI examination was performed while the remaining 7 are CUO. Furthermore, Para vertebral soft tissue was more common during the active stage of disease, due to the rapid and aggressive growth of tumors, table (3). It was mentioned that in spinal metastasis, the lateral or anterior extension of tumor away from the vertebral body might enlarge continuously and stretch the periosteal layer till it becomes ineffectual, or it might destroy the collagen sheet and directly access into the muscular layer. Additionally, the tumor could escape its local barriers (pathological fracture or collapse of diseased vertebra)[38,39].

Shah and Salzman[37] study results were in agreement with the findings of the current study, where the results revealed that 15% of patients had paravertebral soft tissues. In addition, Chou et al.[38] showed similar results, where (19 %) of patients in that study had paravertebral soft tissue. Also, the current study results showed that (24%) of patients had pathological thecal sac and/or spinal cord compression, and (15%) of patients had pathological nerve root entrapment. The results were in agreement with Shah and Salzman[37] study results where (10-21%) of cases showed pathological thecal sac &/ or spinal cord compression. Also, Prasad & Schiff[39] showed that malignant spinal cord compression is usually due to extradural tumor compressing the thecal sac.

Table 3. The non-osseous MRI findings

Non osseous MRI findings	Frequency	Percent
Epidural component		
No	95	95
Yes	5	5
Para vertebral soft tissue		
No	83	83
Yes	17	17
Thecal sac and/or Spinal cord compression		
No	76	76
Yes	24	24
Nerve root entrapment		
No	85	85
Yes	15	15
Intra medullary lesions		
Yes	1	1
No	0	0

Sites of primary cancer:

In the present study, Ninety three out of one hundred patients showed true positive diagnosis of metastasis giving an overall accuracy of (93 %).Our results revealed that the metastatic lesions were predominantly from primary tumors as breast cancer (26%), and prostatic cancer (15%), followed by bronchogenic carcinoma and NHL (10%, and 7%, respectively). The most common primary tumor among female patients was breast cancer while in male patients was prostatic cancer, figure (8). Similarly, the study by ZIU[2] stated that the primary type of cancer for spinal metastasis was 70% - 90% for breast and prostate cancers.

Conversely, the study of Jayarangaia & Kariyanna[40] showed different results as the most common primary malignancy was Prostate cancer (the greatest risk for bone metastases (18% - 29%)) followed by lung, renal, or breast cancer.

In this study 55% of our cases have primary malignancy & MRI examination done for the first time , while 25% without history of primary & its first MRI , and the remaining 25 % had follow up study following receiving (Chemotherapy &/or Radiotherapy) , figure (9) .

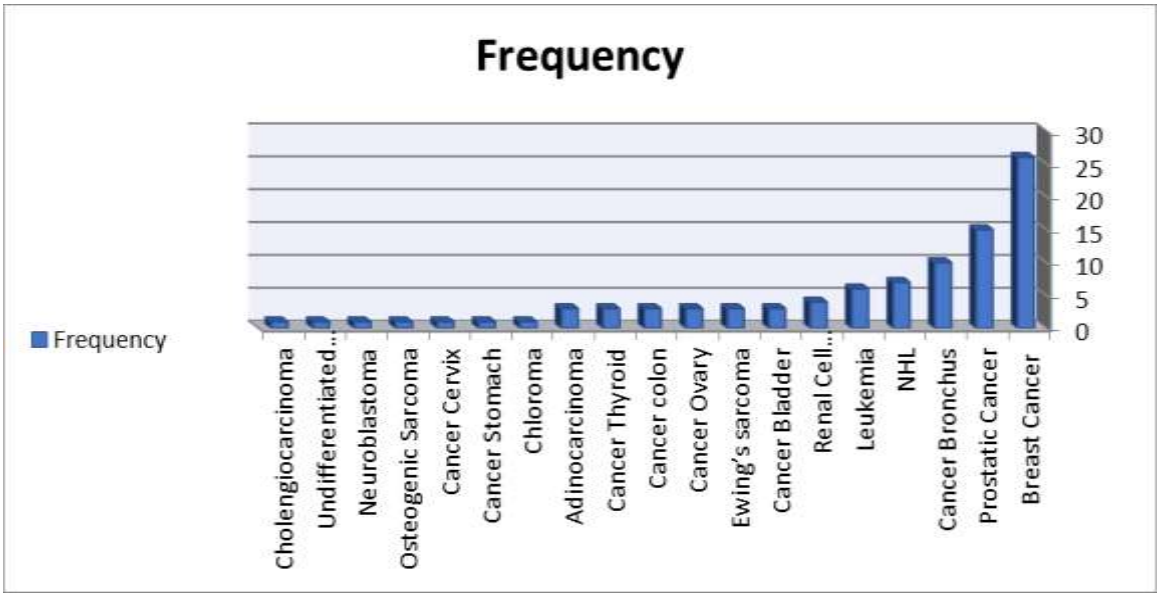

Figure. 8. The sites of primary cancer with 7% false positive for metastasis with (4 cases infection & 3 cases MM)

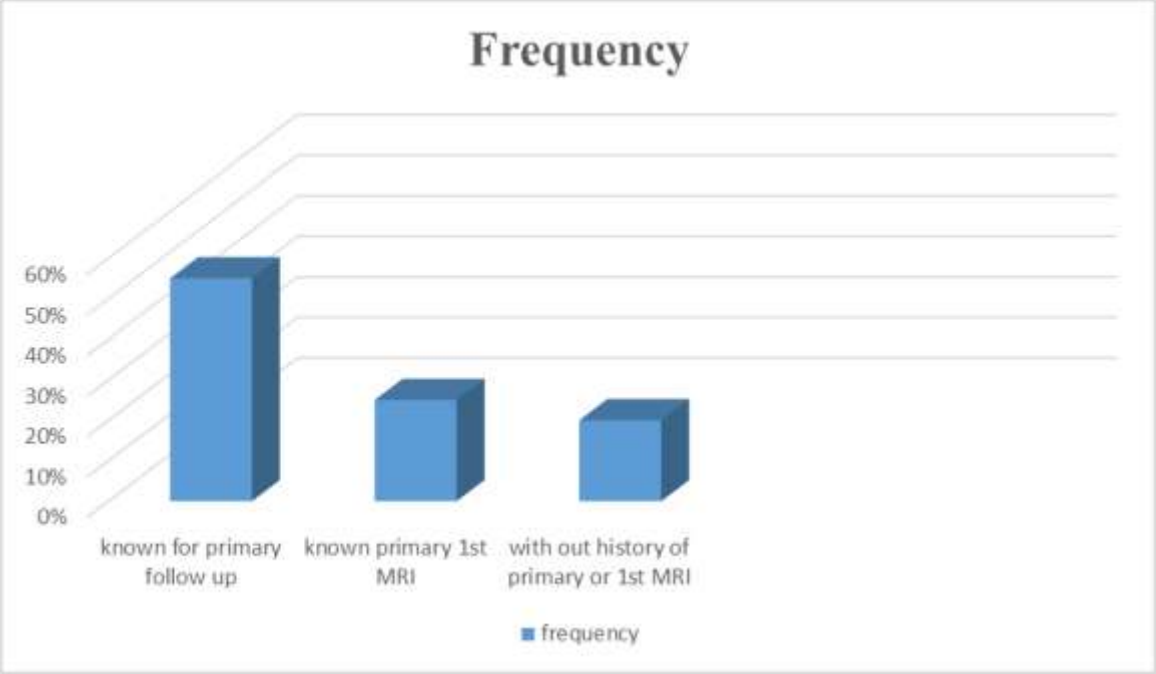

Figure. 9. The frequency of the type of cases.

Conclusion

From the results of this study, it is concluded that the overall accuracy of MRI for detection of spinal metastasis was 93%. The most frequent primary in females was CA breast while in male was Ca prostate. The dorso-lumbar and dorsal spinal levels were the predilections sites for spinal metastasis (85 %) and of those lesions (64%) were of contagious type with vertebral body involvement among all patients. The inter-vertebral discs were exempt in all patients. About (34 %) of patients showed vertebral collaps, and (24%) of patients had pathological thecal sac and/or spinal cord compression. The most common pattern of spinal lesions was of focal multiple lytic pattern (58%). Magnetic resonance imaging (MRI) is a golden standard method for detection and evaluation of spinal metastasis in patients with high risk of metastatic disease. Early diagnosis of spinal metastases helps to start treatment before the occurrence of any significant neurological and functional deficits, and so it improves health related quality of life.

Conflict of interests

None.

Authors' contributions

The authors are the same

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