WORLD JOURNAL OF PHARMACEUTICAL RESEARCH
SJIF Impact Factor 8.084
Volume 9, Issue 1, 1356-1367. Research Article ISSN 2277– 7105

THE ROLE OF STIR SEQUENCE IN MAGNETIC RESONANCE IMAGING EXAMINATION OF BONE TUMOUR

[1]*Dr. Kaniza Kabir, [2]Dr. Rashimul Haque, [3]Dr. Md. Ishtiaque Mazid, [4]Dr. Mashah Binte Amin, [5]Dr. Samar C. Sarker and [6]Dr. Tamanna Tabassum

[1,4,5]Associate Professor, Department of Radiology & Imaging Enam Medical College & Hospital, Dhaka.

[2]Professor and Head, Department of Neuro-Medicine Uttara Adhunik Medical College & Hospital, Dhaka.

[3,6]RI, Pi Research Consultancy Center.

Article Received on 27 Oct. 2019,
Revised on 17 Nov. 2019,
Accepted on 07 Dec. 2019,
DOI: 10.20959/wjpr20201-16465

***Corresponding Author**
Dr. Kaniza Kabir
Associate Professor,
Department of Radiology & Imaging Enam Medical College & Hospital, Dhaka.

ABSTRACT

Background: Short Tau Inversion Recovery (STIR) sequences of MRI, by its marrow fat suppression provides clearer image of intramedullary tumor extension than conventional method. Therefore, the study underwent with an aim to assess the role of STIR sequence in Magnetic Resonance Imaging examination of bone tumour. **Methods:** This study was conducted at the Department of Radiology and Imaging in Enam Medical College Hospital with collaboration with the Department of Orthopaedics and Pathology. Patients attending the orthopedic OPD with history suggestive of primary bone lesions were included in the study. Before enrollment, informed consent was ensured. Magnetic resonance imaging (MRI) at 1.5 T with both conventional spin-echo (SE) and STIR sequences were done to reach a radiological diagnosis. A comparative analysis of the results have been performed in order to investigate the specificity, sensitivity, accuracy of STIR and conventional SE sequences in the detection of tumours, assessment of intramedullary extension and soft-tissue involvement. The intraosseous neoplastic extent has been compared with histopathology reports of biopsy specimens. In this study, total 30 cases of histologically proven bone tumour was included. Data were recorded in a preformed case record form. Data analysis was done by SPSS 23. **Results:** Among 30 patients, 30% had benign tumours (n=9) and 70% (n=21) malignant neoplasms. Osteosarcoma (30%) and hemangioma (13.3%) were the most frequently encountered malignant and benign tumours, respectively. Vertebral column (40%) was the most common tumour site. The lesions were mostly oval and lobulated (26.7% each) with regular margin (60%) and 66.7% had mass effect and 30% showed calcification. On MRI, lesions demonstrated hyperintense lesion in 70% cases during STIR sequence. The latter showed more sensitivity (100% vs 66.7%) and accuracy (86.7% vs 76.7%) as compared to the usual SE method in detecting benign tumours from malignant ones. **Conclusion:** STIR sequencing has proved to be a better diagnostic modality with greater sensitivity, accuracy but similar specificity for bone tumour classification than SE method of MRI.

KEYWORDS: Bone tumour, Magnetic resonance imaging, Short tau inversion recovery, Short T1 inversion recovery, STIR sequence.

BACKGROUND

Novel imaging techniques are at a rise in use because of their increased sensitivity[1] to diagnose primary stage cancers. Though a rare entity (0.2% of all cancers)[2,3] evident by the low rate of newly diagnosed bone malignancies in males which is about eight per million populations in North America and Europe. Europe with higher incidence in Argentina, Brazil and Israel[4], early detection gives better chance to defeat it, as 5-year survival rate of primary bone cancers, considering all age categories, is about 70% and even better when diagnosed earlier (85%).[3]

The appreciation of bone tumours regarding anatomical extent, characteristics & pathological features often requires more than single approaches of imaging including radiography, bone scintigraphy, CT, MRI, PET and biopsy as the final step.[5,6] Among all the imaging facilities, while conventional radiography usually be the primary step in diagnostic approach to evaluate the bellicosity, site & edges of the lesion, bone matrix mineralization, cortical involvement and response of the host bone e.g. periosteal reaction[5]; MRI, however, is usually the most efficient to evaluate soft-tissue extension or bone-marrow involvement[7] with sensitivity of 100% and specificity more than 90%in differentiating benignity and malignancy[7,8] and it has an important advantage of being the only modality evaluating peri-tumoral bone marrow oedema[1] that may surround the three most prevalent bone cancers (osteosarcoma, chondrosarcoma and Ewing's sarcoma), constituting about 60-90% all together[2–4,9] and can be distinguished from tumour extension by the lack of mass-effect and by a slightly diminished signal intensity compared to the tumour on short tau inversion recovery/short TI inversion recovery (STIR)sequence[10,11] that cancel the fat signal of the bone marrow with a 180 inversion pulse with an inversion time TI = ln(2)·T1fat, where the fat signal is zero, thus elicits high tissue contrast.[12,13] It shows clearer views of bone tumour extension in intramedullary component in coronal or sagittal view[11], as its fat suppression is generally more homogeneous than T2Wfast spin-echo sequences.[12] As manifestation of motion-created phase-encoding errors is proportional to the signal-intensity of the moving object, harshness of artifacts also can be attenuated by fat suppression because fat is a key contributor to many motion artifacts. Along with fat suppression, STIR technique also suppresses the additive effects of T1 and T2 mechanisms on tissue signal redundancy.[14] Consequently, fast STIR technique is significantly effective than T1W fat-suppressed contrast-enhanced imaging in appreciation of all bone marrow structures[15] with 100% sensitivity that in turn makes it less specific in detecting bony neoplasm which again helps STIR sequence to discover normally undetectable minute neoplastic focus, that is smaller than the lowest limit of detectability of MRI modality by its proficiency to dig up peritumoural edema.[11]

The purpose of the study was to evaluate the role of STIR MRI sequence in depicting bone tumours with respect to their MRI characteristics and correlate and compare imaging findings with surgical and pathological observations wherever possible.

MATERIALS AND METHODS

This longitudinal study was carried out at Enam Medical College and Hospital (EMCH), Dhaka, Bangladesh for 8 months of period extending from March 2019 to October 2019. Total 30 patients with clinically and radiologically apparent bone tumour irrespective of age and gender were approached for the study. All the subjects were ensured that they are independent of giving necessary information in the whole interview procedure. They got no financial benefits from this study other than usual management. Informed written consent was taken from each subject. Ethical measures were followed in accordance to the Helsinki declaration and ethical clearance was taken from the ethical review board of the study place. Complete privacy of the patient during interview and strict confidentiality of the gathered information was maintained throughout the procedure. Following signing consent form within the time frame patients were interviewed.

Study instrument: A preformed questionnaire was used to assess the patients and data were also collected from hospital registry. The first part of the questionnaire contained the informed written consent form and the second part contained few questionnaires to collect socio-demographic data and rest of the questions focused on presenting complaints, radiological (MRI) and histopathological findings.

Procedure of data collection: EMCH provides outpatient Orthopedic care well equipped with modern investigations and imaging facilities. All MRI were performed on a PHILIPS 1.5- Tesla superconductive Magnetic Resonance MR system, with high-gradient performance. The patients were positioned supine in the magnet bore. The MR protocol consisted exclusively of the following sequences:
First, Coronal T1 spin echo -weighted images were obtained with the following parameters: repetition time (TR)/ echo time (TE), 583/8; number of signals acquired (averages), 2; matrix, 420 × 353; FOV, 210 × 210 mm; and section thickness, 3 mm.

Second, Coronal T2 weighted images, with short time inversion recovery (STIR) sequences. STIR images were obtained with the following parameters:3048/50; inversion time, 150 ms; echotrain length, 15; averages, 2; matrix, 232 × 165; FOV, 140 × 140 mm; and section thickness, 3 mm.

Third, Axial T1 spin echo weighted images were obtained with the following parameters: TR/TE, 458/8; number of signals acquired (averages), 2; matrix, 260 × 216; FOV, 130 × 130 mm; and section thickness, 3 mm, and this same sequence after intravenous gadolinium contrast media injection with focus on maintaining TR and TE on T1W images before and after Gd-CM.

Fourth, Axial T2 weighted images TR/TE, 4651/80; number of signals acquired (averages), 2; matrix, 320 × 260; FOV, 160 × 160 mm; and section thickness, 3 mm.

The radiographs were reviewed by a consultant radiologist. The same radiologist provided opinion on all occasions. Where appropriate, repeat plain radiographs were performed prior to MRI. Finally after thorough evaluation, those who were planned for surgery to excise the suspicious lesion of the bone by an orthopedician and also declared fit for the total surgical procedure considering the age and comorbidities by an anesthetist were included in the study. After successful excision of the lesion in all patients the tumour mass were sent for histopathology in a specific laboratory. In the laboratory soft tissue were fixed in 10% formalin while for bone 3 to 5 mm thick sections were made and adequately fixed in 10% buffered formalin and then decalcification was achieved by placing the specimens in nitric acid. After that all tissue were processed by increasing concentrations of alcohol and paraffin, blocks were prepared. Sectioned were stained with haematoxylin and eosin. After that all slides were examined under microscope by at least two experienced histopathologist independently, the final diagnosis was made into inflammatory, benign and malignant lesion accordingly. In selected cases immunohistochemistry was performed to confirm histopathological findings.

Statistical analyses

Before final analysis, all collected data were checked & verified to remove inconsistencies and then data were input into the statistical software. For data analysis, Statistical Package for Social Science (SPSS) 23 version was used. Descriptive statistics of median, frequencies, and percentage were used to present the continuous and categorical variables, respectively. Age, gender, educational qualification, monthly income, residence and family type were the independent variables.

RESULTS

Total 30 confirmed cases of bone tumor were included in the study. Among them 70% had malignant tumors and 30% had benign tumors (Figure 1).

Patients had a median age of 25 years with a range of 4 to 75 years. The most affected age group was Adolescent and Young Adult (33.3%). Malignant tumors were more common among children, AYA and elderly than adults. Majority patients were male (83.3%). About 80% female and 68% male had malignant tumors (Table 1).

The most frequent malignant tumor and benign tumour was osteosarcoma and hemangioma, respectively. Osteosarcoma and hemangioma constituted respectively 30 and 13.3% of all tumors. Other tumors with their relative proportion are as follows- multiple myeloma (16.7%), metastasis (16.7%), aneurysmal bone cyst (10%), Ewing's sarcoma (6.7%) and exostosis (6.7%). (Table 2).

Table 3 enlists the MRI features found in bone tumors. Majority tumor involved vertebral column (40%). Most common shaped of lesion was oval and lobulated (26.7% each). Sixty percent tumor had regular margin, 66.7% had mass effect, 30% were calcified and 13.3% had cystic change. In STIR sequence 70% had hyperintense lesion.

STIR sequence showed more sensitivity and accuracy but similar specificity in comparison to conventional SE method in the differentiation benign tumor from malignant ones (Table 4).

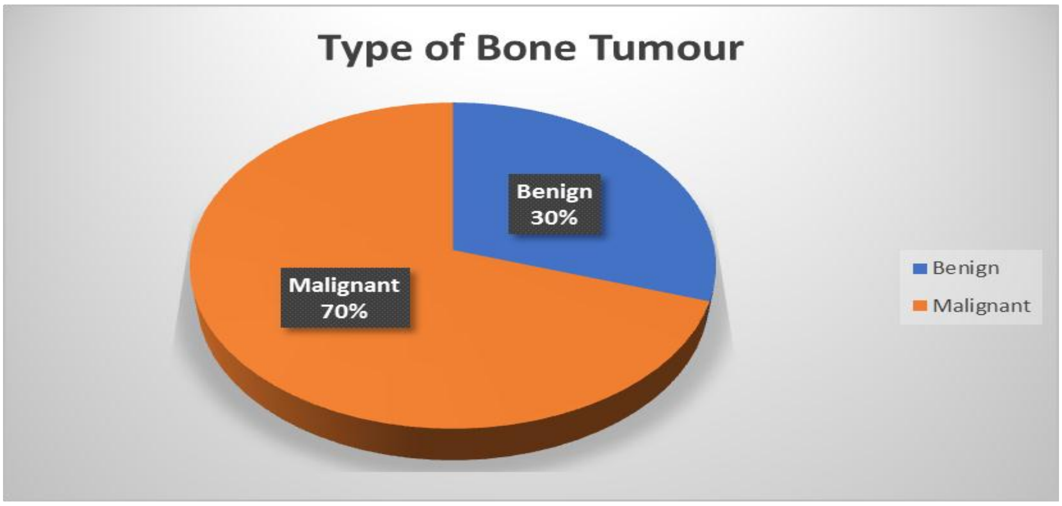

Figure 1: Type of bone tumours (n=30).

Table 1: Demographic profile of patients.

Variables	Benign (n=9)	Malignant (n=21)	Total (n=30)
Age (years)*	19 (13 – 45)	25 (4 – 75)	25 (4 – 75)
Age group			
≤ 15 (Children)	2 (33.3)	4 (66.7)	6 (20)
16 – 29 (AYA)	3 (30.0)	7 (70.0)	10 (33.3)
30 – 59 (Adult)	4 (80.1)	1 (20.0)	5 (16.7)
≥ 60 (Elderly)	0	9 (100)	9 (30.0)
Gender			
Male	8 (32.0)	17 (68.0)	25 (83.3)
Female	1 (20.0)	4 (80.0)	5 (16.7)

* Median (min-max)' Rest of the data shows row percentage among categories and column percentage within total' AYA: Adolescent and Young Adult.

Table 2: Histopathologic diagnosis of bone tumors (n=30).

Tumor	Frequency (n)	Percentage (%)
Benign	**9**	
Hemangioma	4	13.3
Aneurysmal bone cyst	3	10.0
Exostosis	2	6.7
Malignant	**21**	
Osteosarcoma	9	30.0
Multiple myeloma	5	16.7
Metastasis	5	16.7
Ewing's sarcoma	2	6.7

Table 3: MRI features of bone tumors.

Feature	Frequency	Percentage (%)
Location of tumor		
Vertebral column	12	40
Right Knee Joint	5	16.7
Right Elbow Joint	5	16.7
Left Knee Joint	2	6.7
Skull	2	6.7
Left wrist joint	1	3.3
Right humerous	1	3.3
Left leg	1	3.3
Right arm	1	3.3
Shape of lesion		
Oval	8	26.7
Lobulated	8	26.7
Round	7	23.3
Irregular	6	20.0
Elongated	1	3.3
Margin of lesion		
Regular	18	60.0
Irregular	12	40.0
Mass effect		
Present	20	66.7
Absent	10	33.3
Intensity (STIR)		
Hyperintense	21	70.0
Normal intensity	9	30.0
Calcification		
Present	9	30.0
Absent	21	70.0
Cystic changes		
Present	4	13.3
Absent	26	86.7

Table 4: Diagnostic accuracy of STIR sequence and SE method of MRI in differentiating benign from malignant tumors.

Method	Sensitivity	Specificity	PPV	NPV	Accuracy
STIR sequence	100%	80.9%	69.2%	100%	86.7%
SE method	66.7%	80.9%	60%	85%	76.7%

DISCUSSION

Histopathology is the confirmatory diagnosis for any tumor. But histopathology requires materials from affected tissue which can only be acquired through invasive procedures. This is often difficult to acquire prior to operative procedure in case of deep-seated tumors and if the tumor involves organ situated deep within the body. Therefore, various imaging modalities and serological markers are obtained to evaluate the character and extent of any tumor. In case of bone tumors, evaluation of lesions often requires more than one imaging modality.[16] Although radiographs are the primary screening technique, MRI can help narrow down the differentials of bone lesions.[17] Conventionally spin-echo (SE) method is used for characterization of tumor. But STIR sequences can suppress high signal from fatty bone marrow giving a clear depiction of tumor extent and was found to be superior to SE images.[11] Our study aimed to compare diagnostic accuracy of bone tumor by STIR sequences and SE method.

We included 30 confirmed cases of bone tumor. Patients' age ranged from as low as 4 years to highest 75 years and the median age was 25 years. This finding corresponds well with a previous study conducted in Bangladesh. In that study Begum and her team[18] documented a median age of 22 years with a range of 3 to 75 years among bone tumor patients. In concordance to their study children, adolescent and young adults were found to be mostly affected by bone tumors. Gayathri et al[19] and Jain et al[20] reported similar findings in their studies conducted in tertiary care hospitals in India. Male constituted majority of the patients in our study which is concordant with the findings of other studies.[18–20]

Among all patients, respectively 70 and 30% had malignant and benign tumors. This finding goes sharply in contrast to other studies[18–21] because our study only included operated and confirmed cases of bone tumor. While benign tumors often do not require any intervention[22] and therefore may have escaped diagnosis in this study.[22]

Osteosarcoma was the most common tumor among our patients and it was also the most frequent among malignant tumors. It was commonly found among children and adolescent, while multiple myeloma and metastasis was commonly found among elderly. Hossain et al[23] noted that incidence of osteosarcoma is increasing among children and adolescent in Bangladesh and recently bone tumor is the most common tumor noted among adolescent. This along with the fact that majority cases were adolescent explains the highest prevalence of osteosarcoma in our study population.

The most common location of tumor was vertebral column followed by involvement of bones around knee and elbow joint. Axial skeleton was the common location of involvement in multiple myeloma and metastatic bone tumors.[24] In our study almost all cases of multiple myeloma and metastasis were found in axial skeleton involving multiple vertebrae. While in case of osteosarcoma the metaphysis of the distal femur, proximal tibia, and proximal humerus were the most frequent sites of involvement explaining the localization of tumors around knee and elbow joint.[22]

Our study found a higher sensitivity and accuracy of STIR sequences than SE method in the differentiation of benign from malignant tumors replicating the findings of Golfieri et al.[11] But unlike them we found a similar sensitivity between these two methods. This was possible because we used T1W images in addition to STIR sequence in the interpretation of lesions to minimize the prolongation of T1 and T2 relaxation parameters caused by STIR. In this way we also could overcome other disadvantages of STIR sequence as listed by Tokuda et al.[16]

STIR sequencing has several advantages over conventional SE scans.[11,16] It is more sensitive in detecting spread of tumor beneath periosteum, into adjacent soft tissue and joint effusion. It allows good discrimination of tumor from intramedullary and soft-tissue fat by its enhanced ability to suppress fat images, producing increased intensity of abnormal tissue and eliminating chemical shift artifacts at the interfaces between fat and water. In addition, Tokuda et al[16] found that STIR scans show similar diagnostic accuracy when compared to contrast enhanced SE images of bone tumor. Therefore, we recommend using STIR sequence images while evaluation of bone tumor using MRI.

CONCLUSION

STIR sequencing has proved to be a better diagnostic modality with greater sensitivity, accuracy but similar specificity for bone tumour classification than SE method of MRI. However, the study was limited with very small sample size and less heterogenous data. Therefore, before any recommendation caution must be taken and further study with larger sample size is recommended.

List of abbreviations

EMCH	Enam Medical College Hospital
ERC	Ethical Review Committee
MRI	Magnetic Resonance Imaging
NPV	Negative Predictive Value
OPD	Outpatient Department
PPV	Positive Predictive Value
SE	Spin-Echo

SPSS	Statistical Package for Social Science
STIR	Short Tau Inversion Recovery
TE	Echo Time

Declarations

Ethical consideration

The researchers were duly concerned about the ethical issues related to the study. Ethical issues were maintained in according to the current Declaration of Helsinki.

Consent of Publication: All authors agreed to publish the article.

Availability of data and material: Data and materials supporting study findings in the manuscript will not be shared. It was not in accordance with participants' written informed consent. However, it can be shared with the reviewer team on request.

Competing Interests: The authors declare that there is no conflict of interests regarding the publication of this paper.

Funding: Self-Funded.

Author contributions

KK conceived and developed the concept of the study. Conception and design of this research were made by KK, MIM. TT analyze the data. MIM wrote the first draft of the manuscript and KK, TT, MBS, SCS reviewed the draft. All authors read and revised the article and KK approved the final manuscript.

ACKNOWLEDGMENTS

Author thanks to the 'Pi Research Consultancy Centre' **(www.pircc.org)** for data analysis and their valuable guide and assistance.

Supplementary Materials: Available on request.

REFERENCES

1. Bloem JL, Reijnierse M, Huizinga TWJ, Van Der Helm-Van Mil AHM. MR signal intensity: Staying on the bright side in MR image interpretation. RMD Open., 2018; 4(1): e000728.
2. ACS website. American Cancer Society. 2019. Available from: https://www.cancer.org/

3. Cancer Facts and Figures 2017: Special Section—Rare Cancers in Adults. American Cancer Society's (ACS) publication, 2017: 1-73.
4. Sisu AM, Stana LG, Petrescu CI, Tatu RF, Folescu R, Motoc A. On the Bone Tumours: Overview, Classification, Incidence, Histopathological Issues, Behavior and Review Using Literature Data. Histopathol – Rev Recent Adv, 2012; 65–80.
5. Miller TT. Bone tumors and tumor-like conditions: analysis with conventional radiography. Radiology, 2008; 246(3): 662–674.
6. Daniel A, Ullah E, Wahab S, Kumar V. Relevance of MRI in prediction of malignancy of musculoskeletal system-A prospective evaluation. BMC Musc Diso., 2009; 10: 125.
7. Baweja S, Arora R, Singh S, Sharma A, Narang P, Ghuman S, et al. Evaluation of Bone tumors with Magnetic Resonance Imaging and correlation with surgical and gross pathological. Ind J Radiol Im., 2008; 16: 611–8.
8. Bhuyan MH, Bhuyan RK. How accurate is MRI in prediction of musculoskeletal tumors - A prospective evaluation. Int J Biomed Res., 2015; 6(12): 942–6.
9. Marugame T, Katanoda K, Matsuda T, Hirabayashi Y, Kamo K, Ajiki W, et al. The Japan Cancer Surveillance Research Group, The Japan Cancer Surveillance Report: Incidence of Childhood, Bone, Penis and Testis Cancers. Jpn J Clin Oncol, 2007; 37(4): 319–23.
10. James SLJ, Panicek DM, Davies AM. Bone marrow oedema associated with benign and malignant bone tumours. Eur J Radiol, 2008; 67: 11–21.
11. Golfieri R, Baddeley H, Pringle JS, Souhami R. The Role of the STIR Sequence in Magnetic Resonance Imaging Examination of bone tumours. Br J Radiol, 1990; 63(748): 251–6.
12. Silva Jr JR, Hayashi D, Yonenaga T, Fukuda K, Genant HK, Lin C, et al. MRI of bone marrow abnormalities in hematological malignancies. Diagn Interv Radiol, 2013; 19: 393–9.
13. Sharma R, Niknejad, Mohammad Taghi et al. Short tau inversion recovery. Radiopaedia [Internet]. 2018; Available from: https://radiopaedia.org/articles/short-tau-inversion-recovery.
14. Tokuda O, Harada Y, Matsunaga N. MRI of soft-tissue tumors: Fast STIR sequence as substitute for T1-weighted fat-suppressed contrast-enhanced spin-echo sequence. Am J Roentgenol, 2009; 193: 1607–14.
15. Tokuda O, Hayashi N, Matsunaga N. MRI of Bone Tumors: Fast STIR Imaging as a Substitute for T1-Weighted Contrast-Enhanced Fat-Suppressed Spin-Echo Imaging. J Magn Reson Imaging, 2004; 19(4): 475–81.

16. Tokuda O, Hayashi N, Matsunaga N. MRI of Bone Tumors: Fast STIR Imaging as a Substitute for T1-Weighted Contrast-Enhanced Fat-Suppressed Spin-Echo Imaging. J Magn Reson Imaging, 2004; 19(4): 475–81.
17. Nascimento D, Suchard G, Hatem M, de Abreu A. The role of magnetic resonance imaging in the evaluation of bone tumours and tumour-like lesions. Insights Imaging, 2014; 5(4): 419–40.
18. Begum KNA, Ahmed SS, Ali MA, Mollah MAG, Amin MN, Ray S. Study of Bone Tumors in a Tertiary Care Hospital of Dhaka City. J Curr Adv Med Res., 2018; 5(1): 23–8.
19. Gayathri T, Shashikala V, Rekha S. Spectrum of tumour and tumour-like lesions of bone in a Tertiary Care Hospital in North Karnataka, India. Indian J Pathol Oncol, 2018; 5(1): 75–80.
20. Jain K, Sunila, Ravishankar R, Mruthyunjaya, Rupakumar CS, Gadiyar HB, et al. Bone tumors in a tertiary care hospital of south India: A review 117 cases. Indian J Med Paediatr Oncol, 2011; 32(2): 82–5.
21. Rhutso Y, Laishram RS, Sharma LD, Debnath K. Histopathological evaluation of bone tumors in a tertiary care hospital in Manipur, India. J Med Soc., 2013; 27: 135-9.
22. Busse JW, Bhandari M, Dunlop RB. Clinical and radiographic evaluation of bone tumors. Compr Ther., 2001; 27(1): 18–27.
23. Hossain MS, Begum M, Mian MM, Ferdous S, Kabir S, Sarker HK, et al. Epidemiology of childhood and adolescent cancer in Bangladesh, 2001-2014. BMC Cancer, 2016; 16(1): 1–8.
24. Macedo F, Ladeira K, Pinho F, Saraiva N, Bonito N, Pinto L, et al. Bone metastases: An overview. Oncol Rev., 2017; 11(1): 321.