Histopathological study of tumours of bones and joints

Gururajaprasad C[1,*], Damodaran A. M[2]

[1]Associate Professor, [2]Professor, Dept. of Pathology, [1]J.S.S. Medical College (J.S.S. University) Mysore, Karnataka, [2]Rajiv Gandhi University of Health Sciences, Bangalore, Karnataka, India

***Corresponding Author: Gururajaprasad C**
Email: geepee111@yahoo.co.in

Received: 22nd June, 2018 **Accepted:** 30th June, 2018

Abstract

Introduction: Tumours of Bones & joints are rare. The histogenesis of some of these is still uncertain. Unpredictable behaviour of undifferentiated tumours and some of the differentiated tumours, are a challenge.

Aims and Objectives: Cases of tumours of bones & joints were studied for their varied Histopathology. Tumour like conditions were not included.

Materials and Methods: Biopsies of 74 Patients with tumours of Bones & joints, admitted to J.S.S. Medical College Hospital and Dental College Hospital, from April 2015 to April 2018 were studied. Cases were clinically & radiologically examined & studied by routine Haematoxilin & Eosin stains after decalcification by 10% formic acid. Special stains & I.H.C were done when required.

Results: In this study, benign tumours of bone were 56.25% & Malignant were 43.75 %. Joints infiltrated by synovial sarcoma was 8.10%. Benign odontogenic tumours were 5.4% & malignant tumours were 6.75%. Male to female ratio in benign tumours was 2.65:1 & in malignancy, 1.35:1. Sex incidence of the commonest malignant tumour osteosarcoma was to 1: 1. Next commoner malignancy was synovial sarcoma infiltrating the joints with a sex ratio of 1:5. Giant cell tumours showed a sex ratio of 3:2.

Conclusion: Tumours of bones & joints are a real challenge to the pathologist, Radiologist & orthopedic surgeons because of their varied presentation, uncertain histogenesis in some & their behavior to treatment. A sincere effort is done to classify, study their varied histopathological features & rarities which definitely deepens our knowledge on this.

Keywords: Bone tumours, Osteosarcoma, Giant cell tumour, Joint tumours.

Introduction

Bone tumours are rare lesions and rarer still are tumours of joints. The histogenesis and behaviour of some tumours is enigmatic.

Ewing, Jaffe, Lichtenstein and Dahlin, Sindelar, Delbruk, Weatherby, Tucker, Bago-Granel, Wick, & Huvos have enlightened on the aetiological factors, and preexisting lesions of malignant bone tumours.

Unni and Dahlin, Enneking and associates, Mirra and associates & Salisbury and associates have extensively studied the staging & grading.

W.H.O has been doing a yeoman's work to classify, grade and stage the tumours of bones & joints.

Despite hi-techs like Computerised Axial Tomographic scanning, Magnetic Resonance Imaging and advances in Limb Salvage Surgery are throwing a silver lining, the pathologists' role in arriving at an accurate diagnosis is still the crucial determining factor. This problem is to an extent being solved by Immunohistochemistry.

Materials and Methods

Biopsies of 74 patients with tumours of Bones & joints who were admitted to J.S.S. Medical College Hospital and Dental College Hospital, from April 2015 to April 2018 were studied. Cases were examined clinically & radiologically. Amputated specimens were also received. Radiographs of some specimens were also studied.

Discussion

In this study, benign tumours of the bone were 56.25% & Malignant tumours were 43.75% & cases of joints infiltrated by synovial sarcoma being 8.10%. Benign odontogenic tumours were 5.4% & malignant tumours were 6.75%. Male to female ratio in benign tumours was 2.65:1 & in malignancy, 1.35:1. Incidence of the commonest osteosarcoma was equal, 1: 1 in both sexes and the next commoner malignancy was synovial sarcoma infiltrating the joints with a male to female ratio of 1:5. Giant cell tumours were in a sex ratio of 3:2.

In a study of 46 cases by by Saadvi Kethi Reddy et al,[21] non-neoplastic bone lesions were 18 (39.1 %) while that of neoplastic lesions were 28 (60.9%). Both neoplastic and non neoplastic lesions were more prevalent in < 20 years age group. Benign lesions were 54.3% and malignant lesions were 6.52%. Giant cell tumour (42.8%) was the common neoplastic lesion, followed by 2 cases of Chondroblastoma, 2 cases of Enchondromas, 3 cases of osteomas & 6 cases of osteochondromas. Among malignancies, out of 3 cases, 2 were osteosarcomas & 1 was Ewing's sarcoma (10.71%). Amongst benign tumours, sex ratio was 3:2 and in Malignant tumours all 3 were males & the commonest one was osteosarcoma.

In another study by Yopovinu Rhutso et al.[23] out of 98 histopathologically diagnosed bone lesions, 50 (51%) were males and 48 (49%) were females, with a sex ratio of 1.04:1. Age ranged from 7–74 years. Neoplastic lesions accounted for 63.3%. Out of 62 cases of bone tumors, benign tumors were 66.01% & the malignant tumors were

17.71%. Age ranged from 8–74 years, in which 34 (55%) were males and 28 (45%) were females with sex ratio of 1.2:1. Osteochondroma with 22 cases (35.2%) and osteosarcoma with seven cases (11.27%) were the most common benign and malignant tumors, respectively. The peak age incidence was in the 2nd (43.55%) and 3rd (32.2%) decades. Femur was the most common site with 19 (30.6%) occurrences followed by tibia with 18 (29%).

Table 1: The details of this study

	Male	Female	Total	Percentage
Osteoblastic tumours				
Benign				
Osteoma	1		1	1.3%
Osteoid osteoma	3		3	4.0%
Malignant				
Osteosarcoma	6	6	12	16.2%
Cartilage tumours				
Benign				
Chondroma	2		2	2.7%
Osteochondroma	10	2	12	16.2%
Chondroblastoma	1		1	1.35%
Malignant				
Chondrosarcoma	1	2	3	4.05%
Non osteblastic and non-cartilaginous tumours				
Benign				
Ossifying fibroma		2	2	2.70%
Calcifying fibroma		1	1	1.35%
Capillary haemangioma	1		1	1.35%
Cavernous haemangioma	1		1	1.35%
Angiofibrolipoma	1		1	1.35%
Giant cell tumour (Osteoclastoma)	3	2	5	6.75%
Malignant				
Ewing's sarcoma	2	2	4	5.40%
Fibrosarcoma	1		1	1.35%
Haemangiopericytoma	1	1	2	2.70%
Adamantinoma (tibia)	1		1	1.35%
Metastases	6		6	8.10%
Odontogenic tumours				
Benign				
Ossifying fibroma	1	2	2	2.70%
Calcifying fibroma		1	1	1.35%
Odontogenic fibroma	4		1	1.35%
Malignant				
Ameloblastoma		1	5	6.75%
Tumours Infiltrating Bones and Joints				
Synovial sarcoma	1	5	6	8.10%
Total			74	99.99%

Table 2: Osteoblastic neoplasms

S. No.	Age in Years	Sex	Benign	Malignant	Site
1.	29	M	Osteoma		Hard Palate
2.	17	M	Osteoid Osteoma		Upper (R) tibia
3.	40	M	Osteoid Osteoma		Lower (R) mandible
4.	22	M	Osteoid Osteoma		(R) Iliac bone
5.	18	M		Osteosarcoma	Upper (L) tibia
6.	18	M		Osteosarcoma	Upper (L) tibia
7.	21	M		Osteosarcoma	Upper (L) tibia
8.	18	F		Osteosarcoma	Lower (L) femur

9.	65	M		Osteosarcoma	Lower (L) humerus
10.	18	M		Osteosarcoma	Lower (R) femur
11.	17	F		Osteosarcoma	Lower (R) tibia
12.	16	F		Osteosarcoma	Lower (R) tibia
13.	45	F		Osteosarcoma	Extraosseous (R) breast
14.	14	F		Osteosarcoma	Upper (R) fibula
15.	17	F		Osteosarcoma	Upper (R) tibia
16	16	M		Osteosarcoma	Lower (L) femur

Osteoblastic Neoplasms

Osteoma: A lone case of Osteoma was found abutting from the hard palate. Osteomas are benign mature bony growths, seen almost exclusively in bones formed in membrane (e.g. the skull). Parosteal osteoma of bones other than of the skull and face have also been reported.[1]

Osteoid Osteoma: Osteoid Osteomas are benign neoplasms. Only 3 cases of Osteoid Osteomas are reported in the present series; one each from the surface of upper tibia, lower mandible and right iliac bone as painful, hard swellings that presented with clear cut margins surrounded by reactive osteoblastic tissue. The nidus composed of interlacing trabeculae with Osteoid matrix. They occur in any bone & even in vertebra.[2]

Osteosarcoma: Osteosarcoma is the commonest malignant tumour of the bone, particularly of long tubular bones. It usually occurs in patients between 10 and 25 years (Primary osteosarcoms) and is exceptionally rare in preschool children. Another peak age incidence occurs after 40 years.[3]

(Secondary osteosarcomas) following Paget's disease, radiation, chemotherapy or metallic implants.[6] In this study, 12 cases were observed. Our study showed a Male preponderance of 62.5% & in females the incidence was 37.5%. Among Osteosarcomas that occurred in the tubular bones; the age incidence of nine cases was 14-18 years, and only one case was in a young adult of 21 years. One case was metaplastic osteosarcoma in the breast in a female of 45yrs. (Fig. 5, B). A male of 65yrs who was radiologically opined as osteomyelitis / Paget's was diagnosed as osteosarcoma on histopathology. In the present series of cases, eleven cases were primarily intraosseous and invading the juxtacortical soft tissues.

The conventional osteosarcoma (Fig. 1,A) is the one which is intraosseous & an high grade neoplasm in which the neoplastic cells produce bone.[4] The histological types belonged to mainly Osteoblastic variant (8 cases), while Chondroblastic, Fibroblastic, Telangiactatic (Fig. 1,B), Giant cell rich type (Fig. 1,C) and Small Cell type (Fig. 1,D) variants were the other types. Most of the variants were of high grade type, with poor prognosis.

Immunohistochemistry of osteosarcomas is non specific with the tumour cells producing osteocalcin, osteonectin, S100, CD 99, Keratin, EMA and Desmin only to cause diagnostic difficulty.[5]

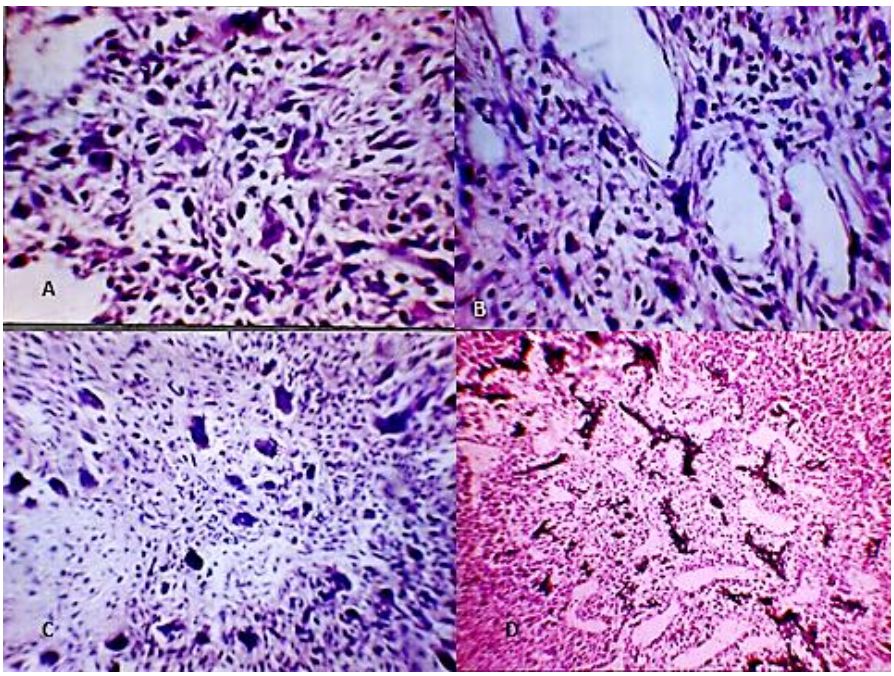

Fig. 1A: Osteosarcomaa - Classical- .H & E .10X; B: Osteosarcoma-Telangiactatic-H & E 10X; C: Osteosarcoma –Giantcell rich-H & E 10X; D: Osteosarcoma-Small cell type-H & E 10X

Table 3: Cartilaginous neoplasms

S. No.	Age in Years	Sex	Benign	Malignant	Site
1.	70	M	Osteochondroma		Anterior end of (R) 8th rib
2.	15	M	Osteochondroma		Upper posterior (L) tibia
3.	13	M	Osteochondroma		Multiple exostosis
4.	14	M	Osteochondroma		Lower (L) femur
5.	26	F	Osteochondroma		Outer (R) iliac bone
6.	18	M	Osteochondroma		Medial lower 1/3 (R) femur
7.	11	F	Osteochondroma		Upper (R) tibia
8.	9	M	Osteochondroma		Lower medial 1/3 (L) femur
9.	38	M	Osteochondroma		Middle phalanx, middle finger
10.	24	M	Osteochondroma		Inner (R) scapula
11.	14	M	Osteochondroma		Upper (L) tibia
12.	11	M	Osteochondroma		Lower (L) femur
13.	25	M	Chondroma		Mid (R) radius
14.	55	M	Chondroma		Head-2nd (R) metatarsal
15.	13	M	Chondroblastoma		Upper end (R) tibia
16.	51	F		Chondrosarcoma	Lower end (R) femur
17.	39	M		Chondrosarcoma	Inner (L) iliac bone
18.	24	F		Chondrosarcoma	Lower end (L) femur

Osteochondroma: It is a common benign tumour of the bone. In the present series, 8 cases of Osteochondroma occurred in the growing age from 9 years to 18 years, and all of them were found as exostoses from the long bones.[7] There were 2 cases in the flat bones- Scapula and inner surface of iliac bone in the ages of 24 years and 26 years respectively. A lone case of Osteochondroma of middle phalanx in a 38 year old male and anterior end of the 8th rib in a 70 years male were diagnosed.

Chondromas: Two cases of Chondromas were diagnosed in a male of 55 years in the metatarsal bone and a young male of 25 years in the radius. Radiologically, a well demonstrated radiolucent medullary cavity lesion with scalloping endosteum was seen in the latter case.

Chondroblastoma: These are benign tumours producing chondroid matrix. They occur in the epiphyses of skeletally immature patients with a slight male preponderance. One case of a 13yrs old boy was observed in the upper end of tibia. In older individuals, it occurs in other sites.[22] Microscopy showed chondroblast like cells admixed with giant cells and produced osteoid & cartilaginous matrix with chicken wire calcification.

Chondrosarcoma: (Fig. 2, B) Chondrosarcoma is the second most common malignant neoplasm after Osteosarcoma. Chondrosarcomas arising de novo in bone are designated as primary Chondrosarcomas. Those arising from previously benign cartilaginous lesions such as Osteochondromas, multiple Osteochondromatoses or multiple Enchondromas (Ollier's Disease) are referred to as secondary Chondrosarcomas & can have increased risk of developing chondrosarcomas.[8] Chondrosarcomas are subclassified as central, when located within medullary cavity, and peripheral, while being juxtacortical on the surface of the bone.

High grade chondrosarcomas are not difficult to diagnose. Low grade tumours present significant problems in interpretation as the most inoccuous histologic pattern is the common denominator for the lesions that show clinico-radiologic signs of benign lesions. But the lesions that show aggressive features like expansion of the bone with thinning of the cortex and scalloping of endosteum and the lesions that break through the cortex are interpreted as Chondrosarcomas.[9] Pain seems to be the commonest symptom in a majority of Chondrosarcomas.

However, malignancy of a lesion is characterised by the presence of high cellularity and pleomorphism. Appreciable number of plump cells with large / double nuclei and mitotic figures are frequent.

In the present series, 3 cases of Chondrosarcoma are reported, in which 2 were from the lower end of femur and 1 was from the inner surface of the ilium. Radiologically and grossly, these lesions showed characteristic appearance of popcorn like, punctate and stippled appearance.

Grossly, the tumours showed typical glistening and lobulated appearance in all the cases. Histologically, both the cases from the lower end of the femur were highly cellular and pleomorphic, with frequent mitoses. The tumour from the pelvis was moderately cellular with atypical chondroblasts and lobulated appearance.

Table 4: Non osteoblastic and non-cartilaginous neoplasms (Tumours of unknown origin, fibrous tissue, blood vessels and epithelium)

S. No.	Age in Years	Sex	Benign	Malignant	Site
1.	41	M		Giant cell tumour Gr. II	Middle shaft (R) humerus*
2.	60	F		Giant cell tumour Gr. II	Lower end (L) radius
3.	35	M		Giant cell tumour Gr. III	Lower end (L) femur
4.	28	F		Giant cell tumour Gr. I	Lower end (R) femur
5.	23	M		Giant cell tumour Gr. I	Lower end (R) radius
6.	25	F		Ewing's Sarcoma	Anterior (R) 8th rib
7.	15	M		Ewing's Sarcoma	Mid 1/3 (R) tibia
8.	12	F		Ewing's Sarcoma	Lower (L) mandible
9.	21	M		Ewing's Sarcoma	8th rib Posterior part
10.	30	M		Haemangiopericytoma	Neck (R) femur
11.	16	F		Haemangiopericytoma	Lower end (L) tibia
12.	35	M		Fibrosarcoma	Lower 1/3 (L) humerus
13.	40	F	Calcifying Fibroma		Lower (L) mandible
14.	6	F	Ossifying fibroma		(R) maxilla
15.	22	F	Ossifying fibroma		Lower (R) mandible
16.	22	F	Capillary haemangioma		(L) trochanter
17.	10	M	Intraosseous Ca v haemangioma		(L) ramus mandible
18.	18	M	Angio fibro - lipoma		(L) malleolus
19.	45	M	Adamantinoma		(L) tibia up.end

Giant Cell Tumours (Syn.: Osteoclastoma): Giant Cell tumours (Fig. 2,A) are uncommon tumours showing a predominence of occurrence in the long bones. They are locally aggressive tumours of still uncertain of histogenesis.[10] They show a range of biological behaviour from completely benign tumours to tumours producing pulmonary metastases; even though they appear histologocally benign.[11] Malignant transformation histologically is comparatively rare but reported.[12]

Out of 5 cases reported in the present series, 4 were in the age group of 23-41 years, and one case was in a 60 years old female. It is interesting to note that a 41 years male presented with pathological fracture of the shaft of the humerus with invasion into surrounding soft tissue and the patient ended fatally within one month in a cancer hospital.

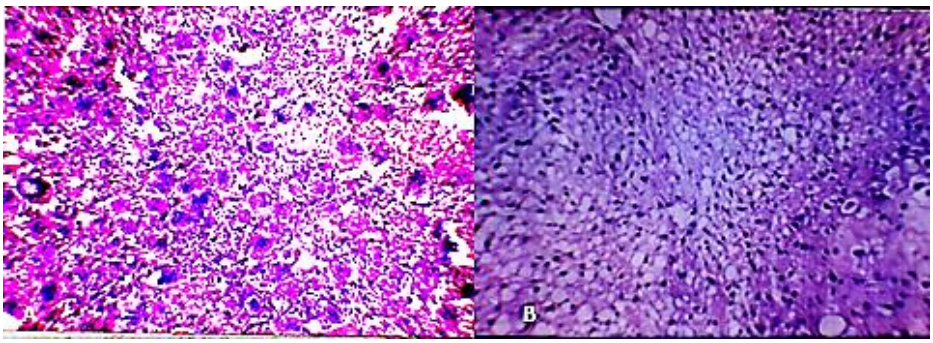

Fig. 2A: Giant cell tumour; B: Chondrosarcoma

Ewing's Sarcoma: Ewing's Sarcoma (Fig. 3,B) was first described by Sir J. Ewing in 1921. It is an uncommon neoplasm, accounting for 10% of all malignant tumours with a distribution predominantly in the long tubular bones. Histogenesis is still uncertain & clubbed with PNET as both share certain molecular features & viewed as variants of each other.[13] Majority of the cases occurred in the age group predominantly between 10 to 15 years of age.

The present study showed 4 cases of Ewing's Sarcoma (one each in tibia, mandible and two in Ribs). The age incidence was 12, 13, 25 and 28 years respectively. Patients presented with classical signs of low grade fever & raised erythrocyte Sediment Rate. Radiological features of layers of new bone formation classically was seen in the lower end of radius and moth eaten appearance in the mandible, and sclerotic pattern was evident in the ribs.

Histological examination did not show any controversial finding of Small Cell tumours of bone, as all the four cases showed diffuse and filigree pattern of uniformly small round cells, without prominent nucleoli or

prominent nuclear clumping. Three cases showed PAS positive intracytoplasmic granules.

Reports suggest that tumour size > 8 cm and the presence of metastasis appear strong predictors of negative outcome.[14]

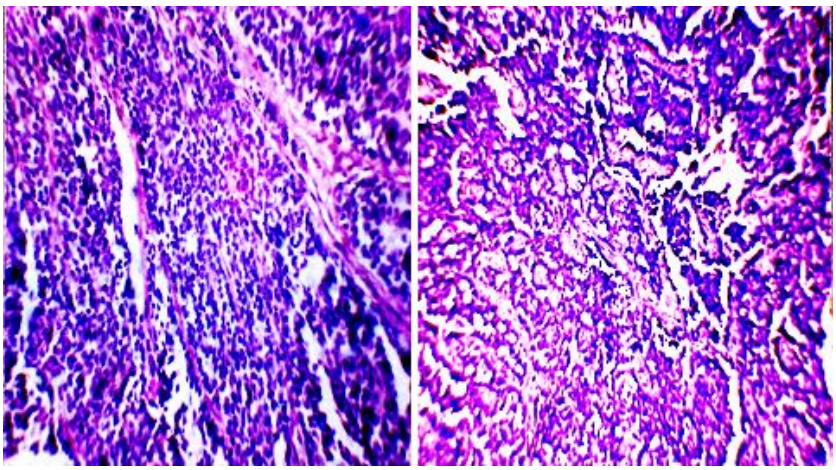

Fig. 3A: Hemangiopericytoma; B: Ewing's tumour

Spindle Cell Tumours- Fibrosarcoma: Fibrosarcoma is an exceptionally rare bone tumour. Age incidence is very wide from 6-88 years. However, the higher average of 56 years excludes the lesion from the Fibroblastic variant of Osteosarcoma. A close differential diagnosis is with Malignant fibrous histiocytoma.[15] The analysis of present study shows a lone case of fibrosarcoma in a 35 year old male from upper 1/3 of humerus, radiologically presenting as Osteolytic lesion invading the soft tissue. Microscopically, it turned out to be a malignant spindle cell tumour with many mitoses.

Haemangiopericytoma (Fig. 3,A)

Primary intraosseous haemangiopericytomas are very rare tumours and show the same histological picture as their soft tissue counterparts. The present study includes two cases from the neck of femur, which was highly vascular at the time of biopsy, and another one from the lower end of the tibia. Occurences in pelvic bones are also reported.[16] Both the cases showed typical arrangement of plump and round cells around thin-walled staghorn shaped vessels. The one from a male aged 30 years, shows pathological fracture of neck of the femur who bled profusely into the surrounding soft tissues after surgical resection.

Epithelial Neoplasms

Adamantinoma-(Fig. 4,A) Adamantinoma is a very rare epithelial bone tumour, and it resembles ameloblastoma of the jaw. Osteofibrous dysplasia progressing to adamantinoma are reported.[17] This lesion is slow growing expansile growth thinning the overlying cortical bone. Radiologically it presented as radiolucent defects of varying sizes with sclerotic bone in between. This study showed a case of Adamantinoma in the upper shaft of the tibia showing soap bubble appearance and histologically showed tubular and squamoid epithelial pattern among the proliferating spindle cells. This lesion recurred within a month after surgical resection.

Odontogenic Tumours

Ameloblastomas are the most common odontogenic tumours and they are locally aggressive & highly recurrent with an incidence of 1% of the tumours of jaw.[19] The age incidence is from 3rd-5th decade. Commonest site is mandible (80%) and rarely maxillary and other sites. Radiographically, showed multilocular destruction of bone, mostly in the molar-ramus area and rarely in premolar and incisor regions. Histological pattern varied greatly and showed patterns of follicular, plexiform, acanthomatous, basal cell type and granular cell type. The common factors are the ameloblastic epithilium enclosing varying amount of stellate reticular stroma.

The follicular variant has more chances of recurrence.[19] The present study contains 4 cases from mandible and 1 from maxilla. Lesions from the mandible showed histologically more than one pattern and the one from maxilla shows ademanotoid variant of ameloblastoma (Fig. 4,B). The rarer varieties of odontogenic tumours like Calcifying Fibroma, Odontogenic Fibroma (one each) and Ossifying Fibroma (2 cases) were diagnosed.

Table 5: Odontogenic tumours

S. No.	Age in Years	Sex	Benign	Malignant	Site
1.	40	F	Calcifying fibroma		Mandible
2.	6	F	Ossifying fibroma		Maxilla
3.	22	F	Ossifying fibroma		Mandible
4.	20	M	Odontogenic fibroma		Mandible

5.	15	F		Ameloblastoma	Mandible
6.	28	M		Ameloblastoma	Mandible
7.	38	M		Ameloblastoma	Mandible
8.	45	M		Ameloblastoma	Mandible
9.	21	M	Adenomatoid Odontogenic Tumour Odontogenic tumour		Maxilla

Metastatic Tumours in Bones: A pathological fracture occurring in a weakened bone excluding osteoporosis is due to Metastasis in the bone.[18] Seven cases of metastatic lesions occurred in the present study. Sites of lesions were identified in 2 cases in femur, 2 in the rib, one each from parietal bone, mandible and vertebra. The primaries were identified as Bronchogenic Carcinoma, Oropharyngeal Carcinoma, Prostatic Adenocarcinoma, Colonic Adenocarcinoma, Hepatocellular Carcinoma, and poorly differentiated Carcinoma.

Synovial Sarcomas: Synovial sarcomas are considered as soft tissue tumours. The present study shows 6 cases of synovial sarcoma; one each infiltrating upper tibia, femoral condyles, and both the bones of knee joint. One extensively infiltrated and destroyed tarsal bones, metatarsal bones, and lower ends of tibia and fibula (ankle joint). Another one also infiltrated tarsal bones and lower end of fibula. One case infiltrated the proximal interphalangeal joint of left 5th finger.

Histologically, they showed Spindle Cell variant (Fig. 4, C) and biphasic patterns (Fig. 4,D) consisting of sarcoma like Spindle Cells in sheets, fascicles and epithelial cells. Bcl2, CD 99& EMA were positive. There was also evidence of synovial fringes perched upon by malignant epithelial cells and sheets of sarcomatous cells.

Prognosis depends upon the size & the status of the margine.[20]

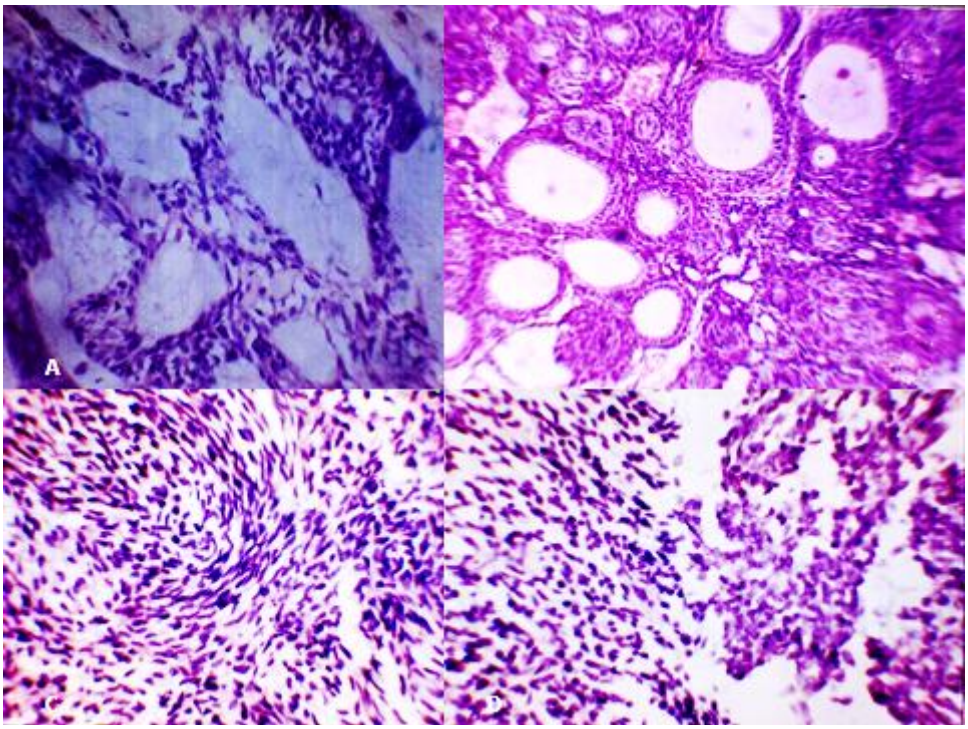

Fig. 4A: Adamantinoma; B: Ameloblastoma, Adenomatoid variant; C: Synovial sarcoma, monophasic; D: Synovial sarcoma, Biphasic

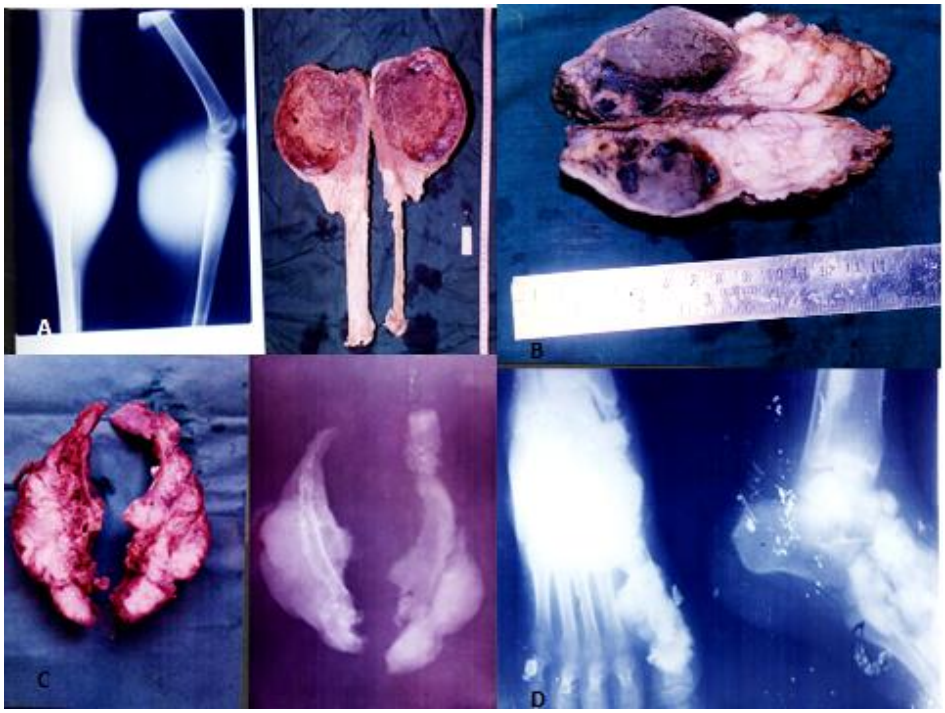

Fig. 5A: Osteosarcoma, fibula with x-ray; B: Extraskeletal osteosarcoma- Breast; C: Hemangiopericytoma, ribs with specimen x-ray; D: Synovial sarcoma infiltrating foot

Conclusion

A remarkable contribution to bone tumours was by Jaffe who emphasised combined approach. Mirra, Enneking, Unni, Bertoni & many have been contributing. In some tumours etilogy, histogenesis & behaviour remain enigmatic.

Tumours were diagnosed with clinical & radiological correlation. Oteosarcoma, giant cell tumour, chondrosarcoma, Ewing's tumour & metastases by Synovial sarcoma were in significant contribution.

A sincere effort is made to diagnose & help the patients. It is worth memorising that "you miss the diagnosis of a malignant bone tumour, you lose the life of the patient; you misdiagnose as a malignant lesion, you lose the limb of the patient'.

Conflict of Interest: None.

References

1. Bertoni F, Unni KK, Beabout JW, Sim FH. Parosteal osteoma of bones other than of the skull and face. *Cancer* 1995;75:2466–2473.
2. Loizaga JM, Calvo M, Lopez Barea F, Martinez Tello FJ, Perez Villanueva J. Osteoblastoma and osteoid osteoma. Clinical and morphological features of 162 cases. *Pathol Res Pract* 1993;189:33–41.
3. Kozakewich H, Perez-Atayde AR, Goorin AM, Wilkinson RH, Gebhardt MC, Vawter GF. Osteosarcoma in young children. *Cancer* 1991;67:638–642.
4. Fletcher CDM, Bridge JA, Hogendoorn OVW. WHO classification of soft tissue and bone. Lyon, France:IARCPRESS,2013
5. Sternberg's Diagnostic Surgical pathology, 6th edition, vol 1, chapter 8, 273 to316
6. Unni KK, Dahlin DC: osteosarcoma: pathology & classification. *Semin Roentgenol* 1989;24:143.
7. Mulder JD, Schutte HE, Kroon HM. Radiologic atlas of bone tumours. Amsterdam, The Netherlands: Elsevier,1993
8. Verdegaal SH, Bovee JVMG, Pansuriya TC. Incidence, predictive factors & prognosis of chondrosarcoma in patients with Ollier's disease & Muffucci syndrome.: an international multicenter study of 161 patients. *Oncologist* 2011:16;1771-1779
9. Geirnaerdet MJA, Hermans J, Bloem JL. Usefulness of radiographs in differentiating enchondroma from central grade I chondrosarcoma *Am J Roentgenol* 1997;169:1097-1104.
10. Meideiros LJ. Giant cells & mononuclear cells of giant tumour of bone resemble histiocytes. *Appl Immunohistochemistry* 1993;1:115.
11. Seethalakshmi Viswanathan, MD and N. A. Jambhekar, MD, DPB: Metastatic Giant Cell Tumor of Bone: Are There Associated Factors and Best Treatment Modalities?: *Clin Orthop Relat Res* 2010;468(3):827–833.
12. Franco Bertoni, Patrizia Bacchini. Eric L. Staals. Malignancy in giant cell tumor of bone. *Cancer*. 2003;97(10):2520-2529.
13. Kumar, Abbas, Aster; Robbins Basic Pathology: Bones, joints & soft tissues, 9th edition: page 780-781.
14. Annmeik M van Maldegem, Pancras CW Hogendoorn and Andrew B Hassan: Clinical Sarcoma Research 2012;2:7
15. Romeo S, Bovée JV, Kroon HM, Tirabosco R, Natali C, Zanatta L, Sciot R, Mertens F, Athanasou N, Alberghini M, Szuhai K, Hogendoorn PC, Dei Tos AP: Malignant fibrous histiocytoma and fibrosarcoma of bone: a re-assessment in the light of currently employed morphological, immunohistochemical and molecular approaches. *Virchows Arch* 2012;461(5):561-570.
16. Lester E. Wold, Krishnan K. Unni, Kay L. Cooper, David C. Dahlin: Haemagiopericytoma of bone: *Am J Surg Pathol* 1982;6(1):253-258.

17. Hzelbag HM, Taminiau AHM, Fleuren GJ. Adamantinoma of long bones. A clinicopathological study of thirty two cases with emphasis on histological subtype, precursor lesion & biological behavior. *J bone Joint Surg Am* 1994;76(10):1482-1499.
18. Roger M. Tillman: Metastatic tumours of bone. *Surg Oxford* 2006;24(11):397-401.
19. Laborde. A, Nicot. R, Wojcik. T, Ferri J, Raoul. G: Ameloblastoma of the jaws: Management and recurrence rate, European Annals of Otorhinolaryngology, Head and Neck Diseases. 2017;134(1):7-11.
20. Lewis JJ, Antonescu CR, Leung DH. Synovial sarcoma: A multivariate analysis of prognostic factors in 112 patients with primary localised tumours of the extremity. *J Clin Oncol* 2000;18:2087-2094.
21. Saadvi Kethireddy, K. Raghu, K.P.A Chandra Sekhar, Y. Srikanth Babu, Monalisa Dash. Histopathological Evaluation of Neoplastic and Non-Neoplastic Bone Tumours in A Teaching Hospital. *J Evolution Med Dent Sci* 2016;5(86):6371-6374.
22. Robert E, Turcotte, Anne- Marie Kurt, Franklin Sim, Krishnan Unni, Richard, McLeod. Chondroblastoma. Human Pathology: 1993;24(9):944-949.
23. Yopovinu Rhutso, Rajesh Singh Laishram, L Durlav Chandra Sharma, Kaushik Debnath Histopathological evaluation of bone tumors in a tertiary care hospital in Manipur, India, *J Med Society* 2013:27(2):135-139.

How to cite this article: Gururajaprasad C, Damodaran AM. Histopathological study of tumours of bones and joints. *Indian J Pathol Oncol* 2019;6(1):16-24.