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Original Research Article

A Study of Correlation between Histopathological and Radiological Diagnosis of Bone Tumours

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Abstract:

Background: Bone tumors and tumor-like lesions present diagnostic challenges due to their rarity, heterogeneous presentation, and overlapping radiological features, necessitating integrated histopathological confirmation for accurate management. Discrepancies often arise in non-specialized centers from limited exposure, underscoring the need to quantify agreement between provisional radiological diagnoses and definitive histopathology using metrics like Cohen's kappa. This study addresses these gaps in a tertiary care setting in Jodhpur, India.

Methods: A prospective observational study analyzed 81 bone lesion specimens (biopsies, curettage, excisions) from Jan 2023 to April 2024 at Dr. SN Medical College Pathology Department, including all ages/sexes with complete radiological data but excluding hematological malignancies or inadequate samples. Tissues underwent formalin fixation, nitric acid decalcification, paraffin embedding, H&E staining, and selective IHC; lesions were classified per WHO criteria. Cohen's kappa assessed diagnostic agreement, with $p<0.05$ significant via Excel-based statistics.

Results: Patients peaked in 11-30 years (49%), males predominated (70.37%, M:F 2.21:1); pain/swelling affected 92.2%. Osteogenic tumors (25.93%), giant cell tumors (24.69%), and cartilage tumors (17.28%) prevailed; osteosarcoma led malignancies (61.29%), GCT benign (57.14%). Ill-defined lytic lesions were common radiologically (33.33%); Cohen's kappa showed strong agreement (0.817, $p=0.001$), with 88.88% concordance and 11.12% discordance (e.g., osteosarcoma misdiagnosed as GCT).

Conclusion: Multidisciplinary clinico-radiological-pathological correlation achieves excellent diagnostic concordance for bone tumors, affirming histopathology's primacy with ancillary support. Representative sampling and clinical context minimize errors; this framework optimizes outcomes in resource-limited settings.

Keywords: Bone tumours, Histopathology, Radiological diagnosis, Cohen's kappa, Agreement.

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Introduction

Bone is a dynamic and heterogeneous tissue with major structural and vital physiological roles. In addition to providing mechanical support and safeguarding vital organs, it plays an active part in mineral regulation and the production of hematopoietic cells [1]. This intricate interplay of structural organization and cellular diversity makes bone vulnerable to a wide array of neoplastic and non-neoplastic disorders [2].

Lesions of bone exhibit considerable variation in size, gross appearance, and microscopic characteristics, and their clinical course may range from entirely benign to rapidly lethal [1]. The principal diagnostic challenge is the precise identification and staging of these lesions, followed by the institution of therapeutic strategies that optimize survival while maintaining the best possible functional integrity of the involved skeletal segments [1]. Accurate diagnosis is especially important in adolescents and young adults, in whom successful cancer therapy can still be associated with substantial long-term complications, including the risk of secondary malignancies [3]. The complex architecture of bone permits the development of primary malignant neoplasms of varied histogenetic origin, in addition to the metastatic deposits that commonly involve this tissue [2]. These tumors occur across all age groups and may arise in almost any bone, although most cases present within the first few decades of life [1]. This age distribution carries important implications for prognosis and therapeutic planning.

A major difficulty in the diagnosis of bone tumors is the frequent discrepancy between the initial pathological impression and the final diagnosis rendered after evaluation by subspecialists or at tertiary referral centers [4]. Owing to the overall rarity of bone tumors, clinicians and pathologists in non-specialized settings often have limited exposure, which significantly contributes to such diagnostic discordance [4]. Consequently, an accurate diagnosis requires a systematic and integrated assessment that combines clinical information, radiological findings, and histopathological features [5].

Objectives of Study

The primary objectives of this investigation were:

1. To establish the statistical significance of agreement between histopathological and radiological diagnoses.
2. To elaborate the comprehensive spectrum of bone tumours and tumour-like lesions using histopathological examination as the definitive diagnostic standard.

Materials and Methods

Study Design and Population: This was a prospective observational study conducted at the Department of Pathology, Dr. SN Medical College, and Jodhpur.

Bone lesion biopsies, curettage specimens, and excised tumour samples submitted from all sources (orthopaedic, general surgery, and other departments) were systematically evaluated over a 15-month period from Jan 2023 to April 2024.

Inclusion and Exclusion Criteria

Inclusion Criteria:

- Patients of all ages and both sexes
- Biopsy-proven primary bone tumours
- Metastatic lesions to bone
- Complete clinico-radiological and histopathological documentation

Exclusion Criteria:

- Hematological malignancies with bone marrow involvement
- Incomplete clinical or radiological information
- Cases without adequate tissue for histological assessment
- Degenerated or poorly fixed tissue samples.

Sample Collection and Preparation: Biopsy specimens and excised tissue were fixed in 10% neutral buffered formalin for 8-12 hours. Large bony pieces were sectioned into smaller fragments measuring 2-6 mm to facilitate processing. Specimens were subsequently treated with 5% nitric acid decalcification solution until tissue softened appropriately. Tissues were then processed using standard paraffin embedding methodology.

Histological Processing: All tissue samples were. Serial sections of 3-5 microns thickness were obtained using a rotator microtome. Standard haematoxylin and eosin (H&E) staining was performed on all slides. Special stains and immunohistochemical (IHC) markers were employed as clinically indicated based on initial H&E findings.

Statistical Analysis: Data were entered in Microsoft Excel and analyzed using descriptive and inferential statistics. Categorical variables such as age group, sex, tumour behavior, site, radiological pattern, and histopathological type were summarized as frequencies and percentages. The strength of agreement between the clinico-radiological diagnosis and histopathological diagnosis was assessed using Cohen's kappa statistic, and the kappa value with standard error and approximate P value were calculated to determine statistical significance, with P less than 0.05 considered significant.

Results

A total of 68 bone lesions were encountered in the study population. The age distribution analysis revealed peak incidence during the second and third decades of life. In the present study, the age distribution of the 81 participants showed that the majority belonged to the 11–20 years age group, which constituted the highest proportion with 23 individuals. This was followed by the 21–30 years age group with 17 participants and the 31–40 years group with 13 participants. Overall, the study population was predominantly concentrated in the second and third decades of life. [Fig 1]

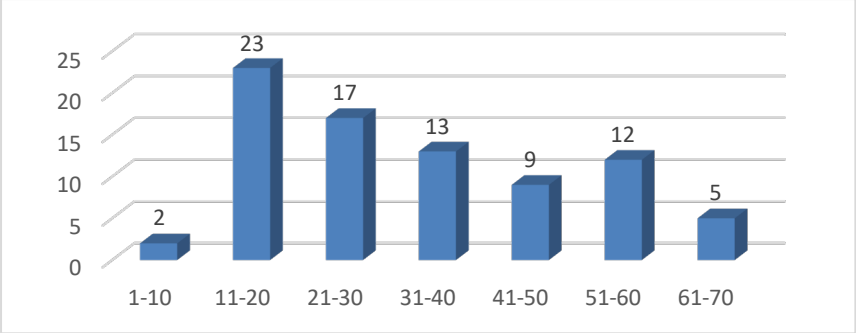

Figure 1: Age wise distribution of cases.

The study cohort consisted of 57 males (70.37%) and 24 females (30.7%), yielding a male-to-female ratio of 2.2:1.

This demonstrates significant male predominance across all categories of bone lesions. [Fig 2] Pain and swelling together constituted the most prevalent presenting complaint, observed in 43.21% of patients (n=35).

Pain alone was reported in 37.5% (n=24), while isolated swelling was documented in 10.9% (n=7). These three presentations accounted for 92.2% of all symptomatic cases. [Table 1]

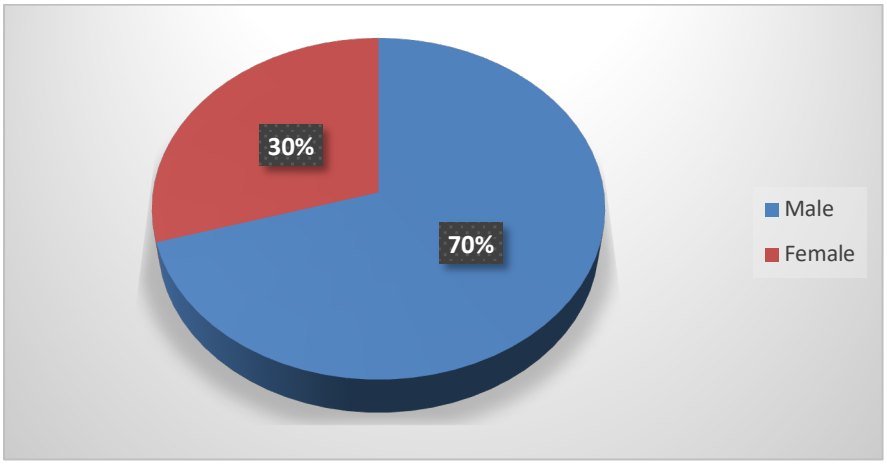

Figure 2: Gender distribution of cases.

Table 1: Distribution of presenting symptoms in the study cohort

Presenting Symptom	Frequency	Percentage
Pain alone	25	30.86%
Swelling alone	12	14.81%
Pain and swelling	35	43.21%
Inability to walk	2	2.47%
Constipation	1	1.23%
Pain, swelling, and walking difficulty	3	3.70%
Pain and movement restriction	3	3.70%
Total	81	**100.0%**

Table 2: Distribution of bone lesions according to WHO classification

WHO Classification Category	Frequency	Percentage
Cartilage tumours	14	17.28%
Osteogenic tumours	21	25.93%
Fibrogenic tumours	2	2.47%
Ewing sarcoma/PNET	3	3.70%
Haematopoietic tumours	3	3.70%
Giant cell tumours (GCT)	20	24.69%
Notochordal tumours	2	2.47%
Metastatic tumours	7	8.64%
Miscellaneous tumour-like lesions	9	11.11%
Total	**81**	100.00%

On histopathological examination the lesions were classified according to WHO classification of bone tumours into the categories as shown in table no. 2. Osteogenic tumours were the most common with 25.93% (n=21) cases followed by giant cell tumours comprising 24.69% of the cases. Cartilage tumours constituted 17.28%, and combined miscellaneous categories (metastatic tumours and tumour-like lesions) accounted for 19.75%.

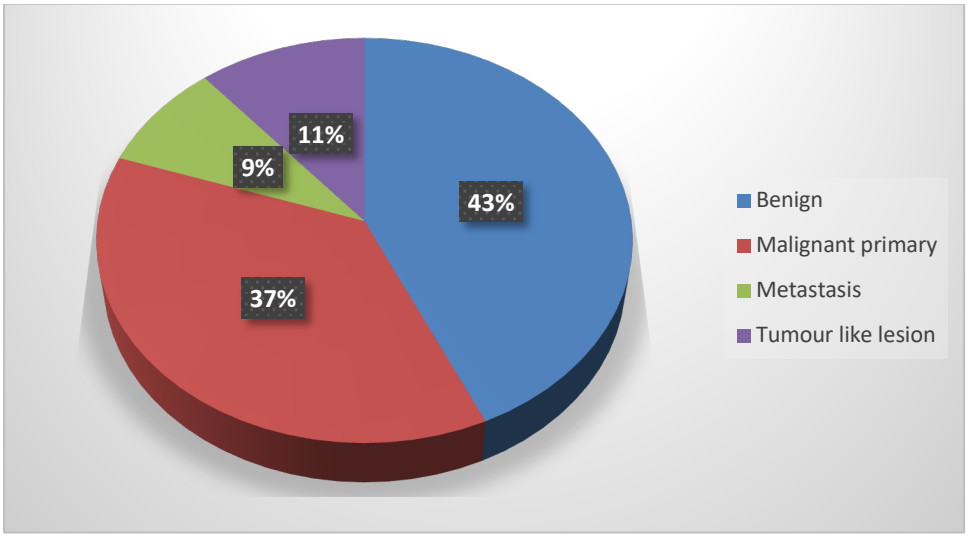

Figure 3: Graph showing distribution of cases according to type of lesion

Among the 35 benign tumours identified, giant cell tumour was overwhelmingly predominant at 57.14% (n=20), followed by osteochondroma (17.14%, n=6), chondroblastoma (14.28%, n=5), chondroma (5.71%, n=2), osteoid osteoma (2.85%, n=1), and desmoplastic fibroma (2.85%, n=1).

The 31 malignant primary lesions demonstrated the following distribution: osteosarcoma was the most common (61.29%, n=19), followed by chondrosarcoma (19.35%, n=6), Ewing sarcoma (9.68%, n=3), chordoma (6.45%, n=2), and primary malignant lymphoma of bone (3.23%, n=1). Seven metastatic lesions were identified (10.3% of total cases), representing secondary involvement from primary tumours elsewhere in the body. Nine tumour-like lesions (11.11%) were encountered, comprising aneurysmal bone cyst (44.4%, n=4), simple bone cyst (33.3%, n=3), fibrous dysplasia (11.11%, n=1), and Langerhans cell histiocytosis (11.11%, n=1). The tibia (upper half) was the most commonly affected bone, involved in 20.99% of cases (n=17). Femur (upper and lower regions) was involved in 24.69% of cases (n=6+14 = 20). Other commonly affected sites included the humerus upper half (11.11%, n=9), sacrum (7.41%, n=6) and radius lower half (6.17%, n=5). Other less commonly affected sites were Spine, Sacrum, Ilium, Maxilla, Scapula, Ischium, Sacrum and ilium, and Phalynx.

On analysis of the region involved revealed that the epiphysis was the most commonly affected site, seen in 25.93% (n=21) cases, followed closely by involvement of flat bones in 23.46% (n=19) cases and the metaphysis in 18.52% (n=15) cases. Diaphyseal involvement was observed in 6 cases. Diffuse involvement was noted in 4 cases, while apophyseal and meta-diaphyseal involvement were also seen in 4 cases each. Less commonly affected regions included the epi-metaphysis and multiple regions, each accounting for 3 cases, and meta-apophysis, which was the least frequent site, observed in only 2 cases.

Table 3: Distribution of radiological findings in bone lesions

Radiological Finding	Frequency	Percentage
Lytic with less sharp lesion	27	33.33%
Sclerotic lesion	18	22.22%
Lytic with very well limited lesion	9	11.11%
Lytic with specks of calcification	8	9.88%
Lytic with rim of sclerosis	7	8.64%
Permeative lytic lesion	6	7.41%
Pedunculated lesion	4	4.94%
Lytic and sclerotic lesion	2	2.47%
Total	**81**	100.00%

The most common radiological presentation was lytic lesions with less sharp definition (33.33%, n=27), which is characteristic of intermediate-grade lesions. Purely sclerotic lesions accounted for 22.22% (n=18), predominantly in benign and low-grade malignant lesions. Well-demarcated lytic lesions, indicative of benign processes, were observed in 11.11% (n=9). [Table 3] Among the 81 evaluable cases, clinico-radiological and histopathological diagnoses showed a strong correlation (p-value = 0.0001), with complete concordance observed in 72 cases (88.88%). Only 9 cases (11.12%) demonstrated discordance, indicating that in the vast majority of patients, the provisional radiological impression reliably predicted the final histopathological diagnosis. This high level of agreement reflects robust diagnostic integration between clinical assessment, imaging, and pathology in the evaluation of these lesions.

Seven cases of osteosarcoma initially misclassified as fibrous dysplasia (n=3), giant cell tumour (n=3), and dentigerous cyst (n=1). These misclassifications resulted from overlapping radiological features and the aggressive presentation mimicking benign entities in some instances. One case of desmoplastic fibroma initially diagnosed as aggressive giant cell tumour due to similar expansile lytic radiological presentation.

One case of primary lymphoma of bone initially considered Ewing sarcoma, requiring immunohistochemical confirmation (CD20 positive, CD3 negative). Our study show excellent concordance between histopathological and radiological diagnosis for bone tumors and tumor like lesions.

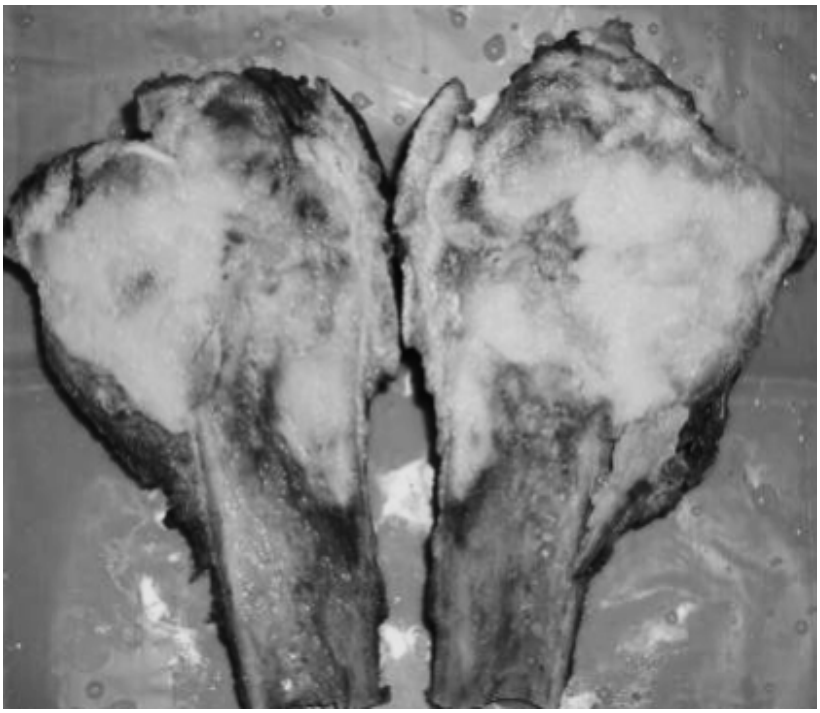

Figure 4: Gross specimen of left proximal tibia with irregular grey white mass.

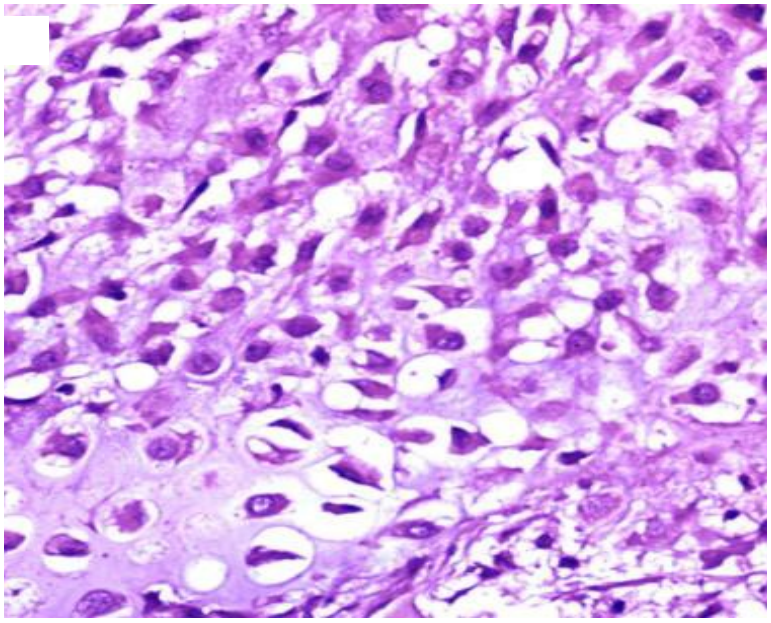

Figure 5: Pleomorphic chondrocytes against chondroid matrix (40x)

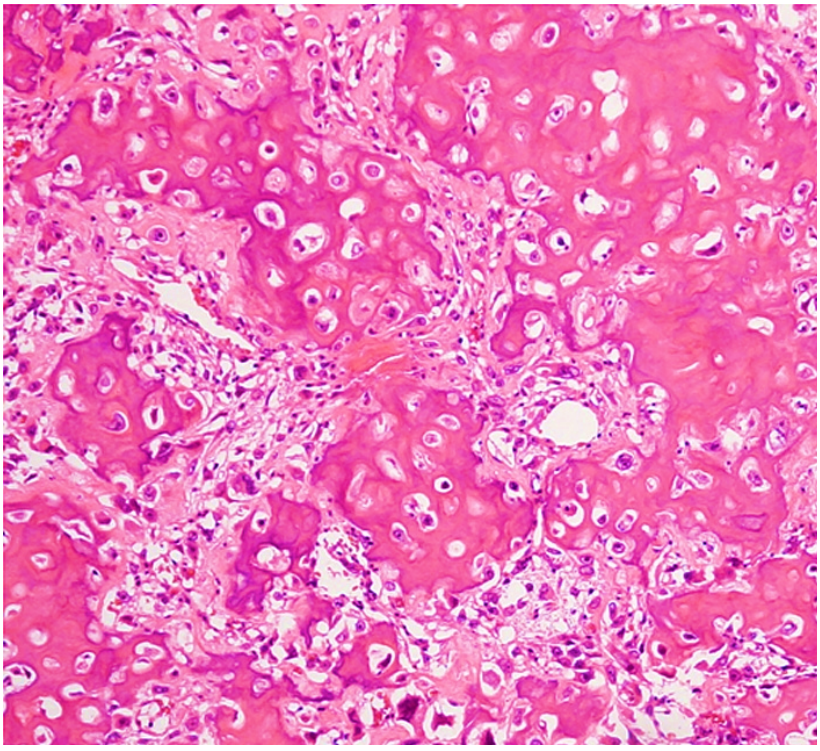

Fig ure6: Section showing tumor cells with hyperchromatic nuclei and eosinophilic amorphous osteoid suggestive of osteosarcoma. (H&E 40x)

Discussion

Histological examination of bone tumours remains one of the most challenging subspecialties in pathology [1]. The relatively low incidence of bone tumours and consequent limited diagnostic experience in non-specialized centers represents a major factor underlying the well-documented differences between initial clinico-radiological diagnoses and definitive histopathological conclusions [4].

The second and third decades of life represented the peak age of incidence for bone lesions in our study, accounting for around 53% of all cases. This age distribution pattern is well-established in the literature as also reported in study of Nayar M [6] and reflects the natural epidemiology of primary bone malignancies, which typically arise during periods of rapid skeletal growth.

Male predominance was evident in this series (male: female ratio = 2.2:1), consistent with published epidemiological data. Males

demonstrated slightly higher involvement in benign lesions (male: female = 4.2:1), malignant lesions (male: female = 1.8:1), and tumour-like lesions (male: female = 2.5:1).

Giant cell tumour dominated the benign category at 57.14% (n=20) in this series, which contrasts with previous studies where osteochondroma predominated. Nayar et al (1979) [6] reported osteochondroma in 54.3% of benign lesions, while this study found it in only 17.14%, a significant variation potentially reflecting patient population differences or referral bias. In the present study, malignant tumours comprised 37% of total lesions, compared to 52.5% reported by Chitale et al (1987) [7] and 66.4% by Nayar et al (1979) [6], the slight variation may be attributed to geographical conditions and differences in genetic and environmental risk factors.

In the present study, among the malignant tumors, osteosarcoma was the most common tumour (61.29%). This is similar to the observation of Rao VS [8] (45.7%) and Dorfman HD [9] (35.9%). Among tumour - like lesions, aneurysmal bone cyst was seen more frequently (42.9%) which is similar to the observations by Rao VS [8] (30.5%). Nayar M [6] in his analysis of large number of tumour-like lesions found fibrous dysplasia to be most common (33.3%) while aneurysmal bone cyst was the second most common tumour-like lesion (26.7%).

In the present study, very good agreement between clinico-radiological assessment and histopathological diagnosis was demonstrated (Cohen's kappa = 0.817, $p < 0.001$). This findings align closely with previously published data. Bayush et al (2009) reported similarly excellent agreement (kappa = 0.82) in their Ethiopian cohort, supporting the robustness of integrated clinico-radiological-pathological assessment [5]. Radiological evaluation is invaluable for assessing the aggressiveness, growth pattern, and possible differential diagnosis of bone lesions; however, it is rarely sufficient for definitive histological characterization. The present findings highlight that significant overlap exists between the imaging appearances of aggressive benign and malignant tumors, as exemplified by giant cell tumour mimicking osteosarcoma, leading to initial misclassification in several cases [10].

Accurate interpretation therefore requires correlation with clinical context, as demonstrated by the correct diagnosis of Langerhans cell histiocytosis when associated systemic features were considered.

Furthermore, reliable diagnosis depends critically on obtaining representative biopsy material, particularly in lesions with heterogeneous components or in small round cell tumours, where inadequate sampling may result in diagnostic error.

Conclusions

Bone tumours and tumour-like lesions pose significant diagnostic challenges that can be effectively addressed through integrated clinico-radiological-pathological correlation. The high level of agreement observed (Cohen's kappa 0.817; $p < 0.001$) confirms that a systematic, multidisciplinary approach yields excellent diagnostic accuracy.

Although imaging is indispensable for lesion characterization and guiding management, histopathology remains the definitive diagnostic gold standard on which therapeutic decisions are based. Accurate diagnosis further depends on obtaining representative biopsy material, particularly in heterogeneous tumours, and on the judicious use of ancillary techniques such as special stains, immunohistochemistry, and molecular studies in morphologically ambiguous cases. Incorporation of relevant clinical details, including age, symptoms, and associated systemic conditions, substantially enhances interpretative precision. Thus, routine light microscopy, when combined with thorough clinical and radiological correlation within a multidisciplinary framework, continues to form the cornerstone of reliable bone tumour diagnosis.

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