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RESEARCH ARTICLE

Epidemiological Landscape of Musculoskeletal Tumours at a Tertiary Centre in Yemen: A Retrospective Analysis

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Abstract

Introduction: Musculoskeletal tumours are diverse neoplasms that present significant diagnostic and therapeutic challenges, particularly in low-resource settings. Epidemiological data from Yemen remain limited, hindering the development of targeted oncological strategies. This study aims to characterise the distribution and clinicodemographic profile of musculoskeletal tumours at a major tertiary centre in Sana'a. **Materials and Methods:** A single-centre, retrospective descriptive analysis was conducted at Althawra Modern General Hospital, Yemen. We evaluated 172 consecutive patients with histopathologically confirmed musculoskeletal tumours admitted between January 2019 and March 2023. Demographic data, tumour classification, anatomical location, and histopathological subtypes were extracted from medical registries and analysed using descriptive statistics. This was a case series analysis; no comparative statistical testing was performed. **Results:** Benign neoplasms constituted the majority of the cohort (61.0%, n = 105), followed by primary malignant tumours (32.0%, n = 55) and secondary metastatic lesions (7.0%, n = 12). Among benign tumours, osteochondroma was the most prevalent (33.3%), followed by unicameral bone cysts (26.7%) and aneurysmal bone cysts (11.4%), with a marked male predominance (male:female ratio 2:1 for osteochondroma). In the primary malignant group, osteosarcoma was the predominant subtype (61.8%), followed by Ewing's sarcoma (10.9%) and chondrosarcoma (10.9%). Primary malignancies showed a bimodal age distribution, with a peak in the second decade of life. Notably, all secondary metastatic cases (100%) presented with pathological fractures of the long bones, indicating advanced disease at the time of orthopaedic consultation and highlighting significant systemic diagnostic delays. **Conclusion:** Musculoskeletal tumours in Yemen frequently affect children and young adults, with a high burden of primary malignancies such as osteosarcoma. Clinicians should recognise the higher rates of aggressive primary sarcomas and the near-universal presentation of metastatic disease with fractures, which reflects systemic healthcare challenges rather than a unique biological predisposition. These findings underscore the urgent need for improved oncological screening, established national referral pathways, and specialised orthopaedic oncology services to enhance early detection and limb-salvage opportunities in the region.

Keywords: Musculoskeletal Tumors- Osteosarcoma- Osteochondroma- Yemen- Epidemiology- Orthopedic Oncology

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Introduction

Musculoskeletal tumours (MSTs), encompassing a diverse range of benign and malignant neoplasms arising from bone and soft tissues, present a significant diagnostic and therapeutic challenge in orthopaedic oncology [1, 2]. Although these tumours are relatively rare compared to other systemic malignancies, their impact on morbidity and mortality is substantial, particularly in paediatric and adolescent populations [1]. Worldwide,

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the incidence and histological distribution of MSTs vary considerably by geographic region; however, comprehensive epidemiological data from low-resource settings – especially conflict-affected regions such as Yemen – remain critically limited [3, 4].

In high-income countries, robust oncological registries support early detection and the implementation of advanced limb-salvage protocol [5, 6]. In contrast, Yemen's healthcare infrastructure has been severely compromised by over a decade of socio-political instability [7]. This has created a severe "diagnostic vacuum" – a critical gap in early detection and specialised diagnostic services. In this context, many patients lack access to specialised musculoskeletal pathology services and advanced cross-sectional imaging, such as magnetic resonance imaging (MRI) and computed tomography (CT). As a result, clinical presentations in these settings are often marked by large tumour volumes, advanced local aggression, and a high incidence of pathological fractures, complicating surgical management and worsens the overall prognosis [8].

The epidemiological profile of MSTs typically shows a bimodal age distribution, with primary bone malignancies such as osteosarcoma and Ewing's sarcoma peaking during the adolescent growth spurt, while secondary metastatic disease and chondrosarcoma are more common in older adults [9]. Understanding these patterns in the local Yemeni context is essential for optimising resource allocation, improving referral pathways, and developing targeted screening programmes. Without baseline data, healthcare providers and policymakers cannot accurately address the disease burden or justify establishing specialised orthopaedic oncology units.

This study was designed to address this knowledge gap by analysing the clinicodemographic and histopathological characteristics of musculoskeletal tumours at Althawra Modern General Hospital, a major tertiary referral centre in Sana'a. By evaluating the distribution, age and sex distribution, and anatomical predilection of these tumours over a four-year period, we aim to provide a foundational epidemiological framework. Such data are vital for enhancing diagnostic accuracy, facilitating earlier interventions, and ultimately improving limb-salvage and survival rates for patients in Yemen.

Materials and Methods

Study Design and Setting

A single-center, retrospective, descriptive case-series analysis was conducted to investigate the distribution and clinicodemographic characteristics of musculoskeletal tumors at a major tertiary care center in Yemen. The study design was purely descriptive; no comparative statistical testing or causal inference was attempted. The research was performed at Althawra Modern General Hospital, Sana'a, which serves as a primary referral center for complex orthopedic and oncological cases.

Study Population and Period

The study population included all consecutive patients diagnosed with a musculoskeletal tumor who were admitted to the Orthopedic Department for surgical or medical management. The investigation covered a four-year period from 23 January 2019 to 22 March 2023. A total of 172 patients with histopathologically confirmed primary or secondary musculoskeletal neoplasms were included in the analysis.

Inclusion and Exclusion Criteria

• Inclusion criteria: All patients, regardless of age or sex, with a histopathologically confirmed diagnosis of a benign or malignant (primary or secondary) musculoskeletal tumour.

• Exclusion criteria: Patients with non-neoplastic musculoskeletal lesions, those with incomplete medical or histopathological records, and cases where tumours originated from non-musculoskeletal tissues were excluded from the final cohort (Figure 1).

Data Collection and Variables

Data were systematically extracted from hospital medical records, pathology registries, operative notes, and histopathology reports using a standardised data collection form. The following variables were recorded for each patient:

• Demographic data: Age at diagnosis and sex.

• Clinical characteristics: Anatomical location of the tumour and the presence of pathological fractures (specifically for malignant cases).

• Histopathological data: Tumor classification (benign or malignant) and specific histopathological subtype based on the histopathology reports available at the center; the diagnoses relied on routine morphology, as immunohistochemistry (IHC) and advanced molecular testing were not consistently available during the study period. This limited the application of the latest World Health Organization (WHO) criteria, particularly for the subclassification of chondroid and fibrogenic lesions.

Diagnostic Staging and Workup

To contextualise the diagnostic pathway in this resource-limited setting, data on the availability of key imaging modalities were collected. The use of Magnetic Resonance Imaging (MRI) for local staging and chest Computed Tomography (CT) for systemic staging in malignant cases was documented.

Operational Definitions

For the purposes of this study, tumours were classified based on histopathological findings:

• Benign tumours: Non-cancerous musculoskeletal growths.

• Malignant tumours: Cancerous musculoskeletal neoplasms, further categorised into primary (originating in bone or soft tissue) and secondary (metastatic) lesions.

• Prevalence: Calculated as the proportion of specific tumour types among the total sample during the defined study period.

Statistical Analysis

Data were tabulated and analysed using descriptive statistics in Microsoft Excel. Categorical variables (e.g., sex, tumour type, histological diagnosis) were expressed as frequencies and percentages. For key proportions, 95% confidence intervals (CIs) were calculated using the Clopper-Pearson exact method. Continuous variables, primarily age, were presented as median with interquartile range (IQR) in addition to ranges. Male-to-female ratios were used to describe sex distribution across different tumour subtypes. This was a case series analysis; no comparative statistical testing was performed.

Ethical Considerations

The study protocol was reviewed and approved by the Institutional Review Board (IRB) of the Yemeni Board for Medical Specialisations (Approval # IRB/YBM//2252, dated October 1, 2022). To ensure patient privacy, all data were anonymized during extraction and analysis. In accordance with the guidelines for retrospective research and the use of de-identified clinical records, the requirement for individual informed consent was waived. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Results

Overall Prevalence and Classification

Between January 2019 and March 2023, 172 cases of histopathologically confirmed musculoskeletal tumours were identified at our tertiary centre (Figure 1), representing an average of approximately 43 cases per year during the study period. This descriptive analysis summarises the clinicodemographic profile of this case series. Benign neoplasms comprised the majority of the cohort (61.0%, n = 105, 95% CI: 53.6–68.1%), while primary malignant tumours accounted for 32.0% (n = 55, 95% CI: 25.3–39.3%). Secondary (metastatic) malignant lesions, all presenting with pathological fractures, represented the remaining 7.0% (n = 12, 95% CI: 3.7–11.9%) of the study population. The age and sex distribution across these major categories showed a distinct bimodal pattern, with a particularly high prevalence of malignancies in the first and second decades of life (Figure 2).

Diagnostic Staging and Workup

In this resource-limited setting, the diagnostic pathway was constrained. Magnetic Resonance Imaging (MRI) for local staging was available for 68% (n = 117) of patients. A staging chest computed tomography (CT) to exclude pulmonary metastases was performed for 58% (n = 32) of patients with primary malignant tumours. Histopathological diagnosis was confirmed by core needle or open biopsy in all cases.

Benign Tumours: Clinicodemographic Profile

The benign cohort (n = 105) showed a peak incidence in children and adolescents. Osteochondroma was the most prevalent subtype, accounting for 33.3% of benign cases (n = 35, 95% CI: 24.8–42.9%), and showed a clear male predominance with a 2.0:1 male-to-female ratio (Table 1). The median age at diagnosis for osteochondroma was 14 years (IQR: 10–18). This was followed by unicameral bone cysts (UBC; 26.7%, n = 28, 95% CI: 18.9–35.9%) with a median age of 11 years (IQR: 8–15), and aneurysmal bone cysts (ABC; 11.4%, n = 12, 95% CI: 6.4–18.8%) with a median age of 16 years (IQR: 13–19). Other identified benign lesions included osteoid osteoma (9.5%, n = 10, 95% CI: 4.9–16.6%) with a median age of 17 years (IQR: 14–21) and giant cell tumours (GCT; 7.6%, n = 8, 95% CI: 3.6–14.3%) with a median age of 28 years

Table 1. Clinicodemographic Distribution of Benign Musculoskeletal Tumors (N=105)

Histological Subtype	Frequency, n (%) [95% CI]	Median Age (IQR) in Years	Male: Female Ratio
Osteochondroma	35 (33.3%) [24.8–42.9%]	14 (10–18)	2.0: 1
Unicameral Bone Cyst (UBC)	28 (26.7%) [18.9–35.9%]	11 (8–15)	1.8: 1
Aneurysmal Bone Cyst (ABC)	12 (11.4%) [6.4–18.8%]	16 (13–19)	1.4: 1
Osteoid Osteoma	10 (9.5%) [4.9–16.6%]	17 (14–21)	2.3: 1
Giant Cell Tumor (GCT)	8 (7.6%) [3.6–14.3%]	28 (22–35)	1.2: 1
Others*	12 (11.5%) [6.4–18.8%]	Variable	1.1: 1

*Includes chondromyxoid fibroma, osteoblastoma, and hemangioma.

Table 2. Profile of Malignant Musculoskeletal Tumors (N=67)

Tumor Classification	Type	n (%) [95% CI]	Sex (M: F)	Pathological Fracture (%)
Primary Malignant	Osteosarcoma	34 (50.7%) [38.8–62.6%]	1.9: 1	18.00
	Ewing's Sarcoma	6 (9.0%) [3.7–17.6%]	2.0: 1	12.00
	Chondrosarcoma	6 (9.0%) [3.7–17.6%]	1.1: 1	5.00
	Fibrosarcoma	5 (7.5%) [2.8–16.3%]	1.2: 1	10.00
	Others	4 (6.0%) [1.9–14.1%]	1.0: 1	0.00
Secondary (Metastatic)*	Metastatic Carcinoma	12 (17.8%) [9.9–28.2%]	1.1: 1	100.00

*Primary Sites: Breast (3), Prostate (2), Lung (2), Thyroid (1), Unknown (4)

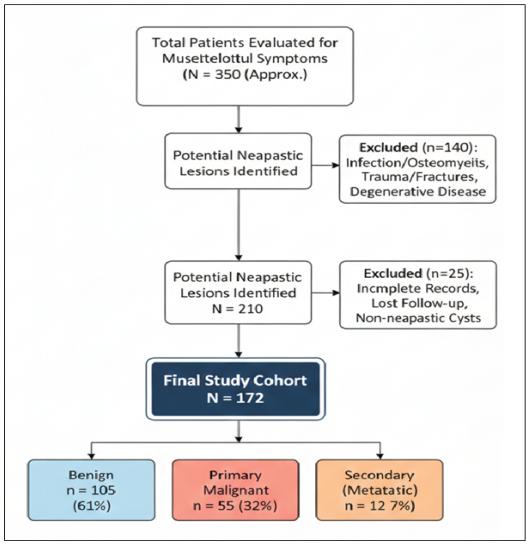

Figure 1. Patient Selection Process Flowchart.

(IQR: 22–35), both of which occurred more frequently in male patients (Table 1).

Malignant tumours: primary and secondary

Among the primary malignant tumours (n = 55), osteosarcoma was the most frequent diagnosis, representing 61.8% of primary malignancies (95% CI: 48.2–74.0%) and 19.8% of all cases (n = 34, 95% CI: 14.3–26.3%) (Table 2). Osteosarcoma predominantly affected patients in their second decade and showed a skeletal predilection for the metaphysis of long bones, particularly the distal femur and proximal tibia (Figure 3). Ewing's sarcoma and chondrosarcoma each represented 10.9% (n = 6 each, 95% CI for each: 4.5–21.2%) of the primary malignant group (Table 2). Fibrosarcoma accounted for 9.1% (n = 5, 95% CI: 3.4–19.0%).

High-grade lesions were frequently associated with male patients and showed significant local aggression. Notably, secondary metastatic lesions (n=12) were identified exclusively through pathological fractures of the long bones (100%, 95% CI: 75.8–100%), highlighting the late-stage presentation of systemic cancers in this setting (Table 2). Among these 12 metastatic cases, the primary cancer site was identified in 8 patients: breast carcinoma (n=3), prostate adenocarcinoma (n=2), lung carcinoma (n=2), and thyroid carcinoma (n=1). The primary site remained unknown in 4 cases.

Discussion

The Clinical Burden of Musculoskeletal Oncology in Yemen

This study outlining musculoskeletal oncology in Yemen shows a high burden of aggressive primary sarcomas in adolescents and often reports advanced metastatic disease. In our descriptive case series, we found that malignant tumors made up 39% of all musculoskeletal neoplasms, which is much higher than the 10–25% typically seen in Western populations [10, 11] and more similar to rates observed in other Middle Eastern countries like Turkey (48%) and Lebanon (64%) [12, 13]. However, we must interpret this high burden of malignancy with caution; it almost certainly reflects significant referral bias rather than a true epidemiological difference. In a fragmented healthcare system, patients with benign or slow-growing lesions may never make it to a specialized center, while those with aggressive, symptomatic high-grade disease are more likely to be included in surgical groups. This bias likely leads to the underrepresentation of indolent lesions and the overrepresentation of aggressive malignancies in our cohort. This selective referral pattern is evident from the alarming statistic that 100% of metastatic bone lesions in our study presented with pathological fractures, a finding that should be highlighted as a systemic failure in diagnostic oncology and palliative care. Tertiary referral centers in conflict zones deal with many advanced-stage cases compared to their counterparts in the West. Similar issues have been observed in other conflict areas, such as Syria and Iraq, where broken healthcare systems also result in late presentations and severe complications [14]. By outlining these trends, this study provides a foundational understanding necessary to address the "diagnostic vacuum" that currently limits orthopedic care and cancer treatment planning in Yemen.

Osteosarcoma and the Adolescent Burden

Osteosarcoma incidence has classically been described as having a bimodal distribution across regions, with primary peaks in the 10-19 age group and secondary peaks

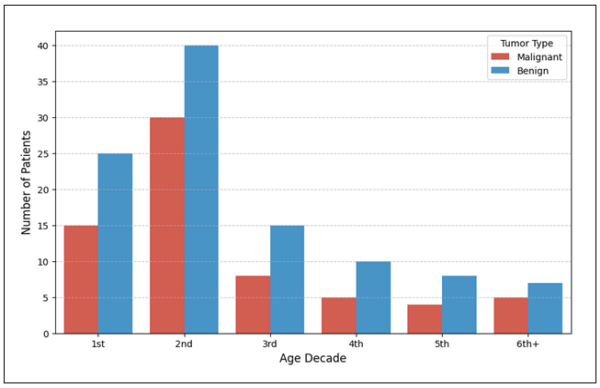

Figure 2. Age and Gender Distribution Among Main Tumor Types.

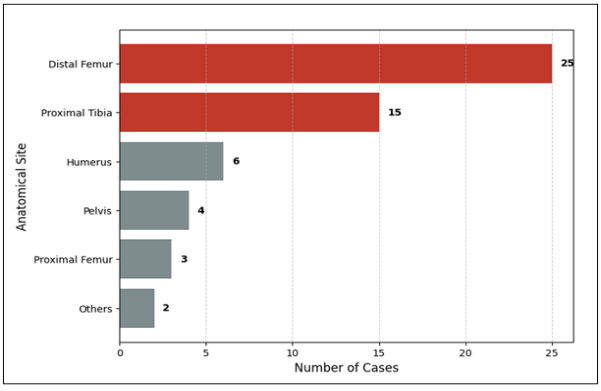

Figure 3. Anatomical Distribution of Primary Bone Cancers.

in older adults [15]. However, contemporary Western data suggests this bimodal distribution may be evolving, with a consistent first peak in adolescence but no consistent second peak in older populations [16, 17]. The most significant finding in our primary malignant group was the clear dominance of osteosarcoma, which accounted for 61.8% (95% CI: 48.4-73.8). This finding aligns with regional data from Tunisia, where osteosarcoma represented 60% of malignant bone tumors in children and adolescents [18], and mirrors data from Pakistan, where over 95% of osteosarcoma cases occur before age 40 [19]. Additionally, in one such analysis from Shiraz, no osteosarcoma patients were younger than 5 years, and the majority (82.1%) were under 25 years old [20]. A study in the Kurdistan Region of Iraq reported that soft tissue sarcomas exhibit significant regional variability, with a higher incidence observed in the Duhok governorate despite overall rates remaining below 2 per 100,000 [21]. This contrasts with traditional Western descriptions that showed a significant secondary peak in older adults, though recent US data suggests this secondary peak may no longer be consistently observed [16]. Certain scholars have elucidated that the elevated prevalence of sarcoma during adolescence can be attributed to the secretion of growth factors and sex steroids. These elements facilitate the proliferation of malignant cellular entities. A limited number of prenatal determinants have also been postulated to correlate with the onset of Ewing's sarcoma. Such determinants encompass rib malformations, diminished birth weight, and peri-conceptional engagement in agricultural occupations [22]. The absence of this secondary peak in our cohort may suggest either a younger population demographic or increased competing mortality risks that may mask cancer incidence in older people.

Moreover, the 18% rate of pathological fractures at presentation in our study indicates serious delays in diagnosis, though this is somewhat lower than the 28% prevalence reported in systematic reviews of osteosarcoma patients [23, 24]. In developing world contexts, studies have documented an average of 4.5 months elapsing before patients first present to specialized tumor units [25]. For many Yemeni children, a fracture is the first sign that leads to diagnosis, often closing the opportunity for limb-salvage surgery, as delayed diagnosis is associated with larger tumors, higher rates of amputation, and poorer functional outcomes [26, 27]. These findings highlight the urgent need for heightened awareness and structured diagnostic procedures in primary care. As an immediate, actionable step informed by experiences in other resource-limited settings [25], prompt plain radiography should be standard for any adolescent complaining of persistent bone pain lasting over two weeks.

Ewing's Sarcoma and Chondrosarcoma: Diagnostic Consistency and Challenges

Ewing sarcoma's occurrence in our cohort confirmed a consistent global biological profile, marked by a significant male predominance (with reported ratios of approximately 1.6:1) and a strong preference for the diaphysis of long bones [28, 29]. However, a notable deviation from recognized orthopedic oncology patterns is the considerable rate of chondrosarcoma among young adults in our series. This finding raises essential diagnostic and biological questions. In a setting with limited resources, where advanced molecular testing is not available, distinguishing between conventional chondrosarcoma and chondroblastic osteosarcoma; a subtype requiring different treatment (chemotherapy plus surgery for osteosarcoma versus surgery alone for conventional chondrosarcoma), remains difficult [30, 31]. Traditionally described as a malignancy of the fifth to seventh decades of life, its presence in younger patients may point to region-specific biological patterns or diagnostic errors due to a lack of specialized musculoskeletal pathology. Specifically, without IDH1/2 mutation analysis, which is unavailable in our setting, the possibility remains that some of these lesions could be misclassified chondroblastic osteosarcomas. Studies have demonstrated that IDH1/2 mutations are present in approximately 61% of chondrosarcomas but are absent in osteosarcomas, making this a valuable diagnostic biomarker in well-resourced settings [31, 32]. Similar patterns of chondrosarcoma occurring in younger patients were recorded in a South Asian study from Pakistan, indicating that in our region, chondrosarcoma may present earlier in life [19]. The authors reported that an overwhelming majority of osteosarcomas occurred in the second and third decades of life [19]. This finding calls for humanitarian academic partnerships, including telepathology networks with international centers for remote reviews and molecular testing, to ensure accurate diagnoses and the best care for these young patients. Successful telemedicine initiatives in other resource-limited settings, such as Armenia, Iran, and India, have demonstrated that virtual tumor boards and remote expert consultation can lead to diagnostic changes in over 30% of cases and significantly reduce management delays [33-36].

The "Diagnostic Vacuum": Metastasis as a Crisis in Palliative Care

The most urgent and striking finding of this study is that 100% of patients presented with metastatic bone disease through pathological fractures. In wealthier countries, skeletal metastases are usually found during proactive staging of a known primary tumor [37, 38], allowing for preventative measures like stabilization or palliative radiotherapy to avoid painful fractures [39]. Large contemporary database studies from the United States demonstrate that the most common primaries metastasizing to bone are lung (24.8%), breast (19.3%), and prostate (19.4%) cancers, and critically, these studies show significantly improved 90-day and 360-day survival in patients treated for impending pathological fracture compared to those treated after completed fracture [37]. Our data reveals a "diagnostic vacuum" in Yemen, where metastatic disease often remains undetected until it progresses to a severe mechanical problem requiring emergency intervention. This reflects the human toll of conflict, where a lack of advanced imaging, systematic staging, and palliative care transforms manageable

conditions into complex surgical emergencies with poorer outcomes [40, 41]. Similar challenges have been documented in other conflict-affected settings in the Middle East and North Africa region, where infrastructural collapse and health system fragmentation result in late presentations and severe complications [40]. Systematic reviews of cancer care in low- and middle-income countries have documented average delays of 7.4 months from symptom onset to diagnosis, with health system limitations including inadequate diagnostic services affecting over 55% of patients [42]. This situation calls for not only better cancer screening but also the swift creation of accessible palliative care pathways aligned with WHO recommendations for integrating cancer care into humanitarian responses [41]. This includes providing pain relief and establishing radiotherapy pathways to manage bone pain and prevent fractures in patients with known advanced cancers, utilizing evidence-based approaches such as single-fraction radiotherapy (8 Gy) which has proven as effective as multifraction regimens for pain palliation [43].

Benign Tumors: The Hidden Strain on Resources

In terms of benign tumors, osteochondroma was the most common lesion in our series, accounting for 33.3% of all benign neoplasms. This finding aligns closely with data from South Asian and Mexican studies, as well as recent regional data from Tunisia where osteochondroma represented 56.5% of benign bone tumors in children and adolescents [18, 44, 45]. The reported incidence of osteochondroma in the literature ranges from 20-35% of all pediatric benign tumors, consistent with our observations [46]. However, our figure is substantially higher than the 8% reported in a recent Lebanese study [12], a discrepancy that likely reflects differences in referral patterns, catchment populations, and the higher overall malignancy rate (64%) observed in the Lebanese cohort. The high occurrence of osteochondroma and bone cysts in our series; predominantly affecting young males with predilection for the lower limbs as seen in other regional studies [18, 46], suggests that these are significant sources of orthopedic morbidity requiring surgical consultation in Yemen. Osteochondromas, while often asymptomatic and incidentally diagnosed after trauma [18, 46], may become symptomatic due to mechanical irritation, mass effect, or secondary deformities, necessitating surgical intervention [45]. In a healthcare system already struggling to address both war-related traumatic injuries and advanced cancer cases, these benign but symptomatic lesions create an additional, often unappreciated, burden on limited surgical resources. Similar challenges have been documented in other conflict-affected settings such as Gaza and Ukraine, where orthopedic departments operate under extreme constraints, requiring rapid adaptation, fluidic triage systems, and repurposing of existing facilities to manage the combined influx of trauma and elective cases [47, 48]. These findings support the need for efficient, evidence-based triage protocols to allocate limited surgical resources effectively, prioritizing symptomatic lesions with high potential for complications while managing incidental findings conservatively [49].

Study Limitations

This study has several important limitations related to its design and setting. First, this is a retrospective, single-center review from Yemen's main national referral hospital. Therefore, the findings are likely influenced by referral bias and may not represent the true incidence or distribution of musculoskeletal tumors in the country. There is likely an overrepresentation of severe malignancies and surgically treatable benign lesions in this context.

Second, the diagnostic process faced limitations due to the lack of resources. The absence of advanced molecular profiling and specialized musculoskeletal pathology expertise increases the possibility of misdiagnosis, especially for histologically complex tumors like chondroid lesions and fibrogenic sarcomas. The diagnosis of fibrosarcoma is notable, as modern WHO guidelines have reclassified many such cases to undifferentiated pleomorphic sarcoma or fibroblastic osteosarcoma. Our diagnoses relied on the histopathological resources available, which may not have consistently followed the latest WHO classifications, and we acknowledge this as a key limitation.

Third, we often lacked complete staging and follow-up data; including details on chemotherapy, surgical margins, and long-term outcomes, due to the fragmented healthcare system, patient displacement due to conflict, and substantial financial barriers. As a result, this analysis cannot provide information on survival rates, recurrence, or the long-term effectiveness of treatments; important measures in oncology. This absence of survival data is a significant gap, though it was constrained by the high rate of patients lost to follow-up.

Finally, the lack of a functioning national cancer registry prevents us from validating our epidemiological data against a broader population-based benchmark. Despite these challenges, this cohort offers the first current glimpse into the severe disease burden and systemic issues at a tertiary center in conflict-affected Yemen. Its findings are essential for guiding humanitarian clinical planning and advocacy.

In conclusion, this study shows a clear pattern of musculoskeletal tumors in Yemen. It highlights a high burden of aggressive primary sarcomas in young patients and an almost universal late-stage presentation with pathological fractures. This pattern reflects severe delays in diagnosis within a healthcare system affected by conflict, rather than a unique biological risk.

To tackle this crisis, we urgently need a multi-layered response. First, a national diagnostic protocol should require prompt plain X-rays for adolescents and young adults with ongoing bone pain or swelling. Second, we must establish efficient referral pathways to speed up access to specialized orthopedic oncology. Finally, sustained investment is crucial for building local capacity through training, securing advanced imaging, developing telepathology networks, creating palliative and surgical pathways, and forming dedicated oncology units. Without

these focused efforts, improving survival and quality of life for Yemeni patients will remain a significant challenge.

Declarations

Ethics Approval and Consent to Participate

This study was performed in accordance with the ethical standards of the Declaration of Helsinki. The study protocol was reviewed and approved by the Institutional Review Board (IRB) of the Yemeni Board for Medical Specializations (Approval # IRB/YBM/2252, dated October 1, 2022). The requirement for individual informed consent was waived by the IRB due to the retrospective nature of the study and the use of de-identified clinical data.

Conflicts of Interest

The authors declare that they have no competing interests or financial disclosures related to this work.

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Data Availability Statement

The de-identified datasets analyzed during the current study are available from the corresponding author upon reasonable request.

Author Contributions

KS and MS were involved in the study conception and design. MSA and RAA performed the data collection. GAM and KS conducted the statistical analysis. All authors contributed to the interpretation of the results and the drafting of the manuscript. All authors have read and approved the final manuscript.

AI Declaration

During the preparation of this work, the authors used Gemini (Google) in order to improve the language, formatting, and readability of the manuscript. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

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