CHAPTER 108
Primary Bone Tumours

Kant Shah
Kokila Lakhoo

Introduction

Bone tumours in childhood cause considerable anxiety to both the affected child and the parents. They may present with vague symptoms or a fracture and can easily be confused with osteomyelitis or some tumour-like lesions that may be developmental in origin. Benign lesions account for 50% of all bone lesions; some may be large enough to cause significant disability. Primary malignant tumours of the bone make up for 6% of all childhood malignancies[1] and are indeed the most common malignancy of adolescence after leukaemias and lymphomas. Overall diagnosis depends on factors such as age of patient, site of lesion, imaging (plain x-rays, computed tomography (CT), nuclear studies, magnetic resonance imaging (MRI)), and, if possible, the histopathology and immunohistochemistry. Thus, a multidisciplinary team approach is vital to the diagnosis and management of bone tumours.

The mainstay of treatment of benign lesions is surgery to limit disability, with reconstruction as needed. As chemotherapy has become more advanced with fewer side effects, the focus of treatment of bone malignancies has changed from surgery to neoadjuvant chemotherapy followed by wide excision and then chemotherapy or radiotherapy as appropriate.

The aim of this chapter is to acquaint the reader with the common lesions of the bone,[2] and the differential diagnosis, investigations, and management of the common malignancies. For simplicity in this chapter, the demographics, pathophysiology, clinical presentation, investigations, prognosis, and outcomes are listed together, and management of individual lesions is described separately.

Classification of Bone Tumours

Bone tumours are primarily classified according to the type of tissue they produce. Hence, they may be osteogenic, chondrogenic, etc. The World Health Organization (WHO) classification (Table 108.1) is extensive. The tumours that affect children and adolescents are marked with an asterisk (*) in the table.

Demographics

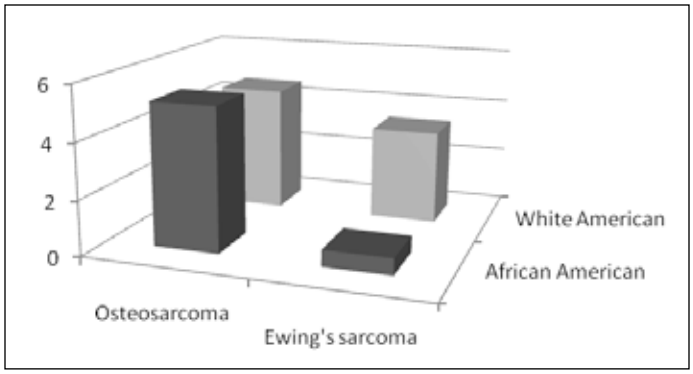
The common benign tumours of childhood are osteochondroma, enchondroma, osteoid osteoma, osteoblastoma, chondroblastoma, and haemangioma. In addition, tumour-like lesions such as nonossifying fibroma, simple bone cyst, and fibrous dysplasia are also common in the developing child. Primary bone malignancies are rare, however, with osteosarcoma (54%) and Ewing's sarcoma (34%) being the most common.[1] The overall age-adjusted incidence of bone malignancy increases with age and peaks at 20 cases per million at 15–19 years of age.

In North America, the overall incidence rate among caucasian American children was 8.8 per million compared with 6.8 per million for African American children. This racial difference is further highlighted as the two tumour types are compared[1] (Figure 108.1). The reason for this difference is not known. Males have a slightly higher and delayed peak of incidence of osteosarcoma compared to females, which correlates to their relative rates of growth.

Table 108.1: WHO classification of bone tumours.

Cartilage-forming tumours	
Benign:	Enchondroma;* osteochondroma;* periosteal chondroma; chondroblastoma;* chondromyxoid fibroma*
Malignant:	Chondrosarcoma: conventional; juxtacortical; mesenchymal;* dedifferentiated; clear cell
Bone-forming tumours	
Benign:	Osteoma, osteoid osteoma,* osteoblastoma*
Malignant:	Osteosarcoma: intramedullary* (conventional; telangiectatic; small cell; well differentiated); surface (parosteal; periosteal; high grade surface)
Fibrous/fibrohistiocytic tumours	
Benign:	Nonossifying fibroma;* desmoplastic fibroma;* myofibromatosis;* benign fibrous histiocytoma
Malignant:	Fibrosarcoma/malignant fibrous histiocytoma
Ewing's sarcoma/primitive neuroectodermal tumour of bone*	
Giant cell tumours of bone	
	Giant cell tumour of bone; giant cell reparative granuloma (GCRG) of jaw*; GCRG small bones*
Vascular tumours	
Benign:	Haemangioma*; lymphangioma; glomus tumour; angiomatosis;* Gorham-Stout disease*
Malignant:	Haemangiopericytoma; haemangioendothelioma; angiosarcoma
Other primary tumours	
	Smooth muscle tumours Lipogenic tumours Neural tumours Chordoma Adamantinoma of long bone
Miscellaneous tumour-like lesions	
	Simple bone cyst* Aneurysmal bone cyst* Fibrous dysplasia* Fibrocartilaginous dysplasia* Osteofibrous dysplasia* Langerhans cell histiocytosis* Mesenchymal hamartoma of chest wall*
Joint lesions	
	Synovial chondromatosis

* Childhood tumours



Source: United States Surveillance, Epidemiology and End Results (SEER) Program, 1975–1995. National Cancer Institute, 1999.

Figure 108.1: Age-adjusted incidence rates of bone tumours showing a remarkable dip in Ewing's sarcoma in the African American population

Pathophysiology

To date, no causative factors for bone tumours are known in general. However, associations have been found between osteosarcoma and retinoblastoma, osteosarcoma and Li-Fraumeni syndrome, and enchondroma and soft tissue and skin haemangiomas (Maffucci syndrome). These associations are uncommon, and the majority of tumours are isolated. A distinct feature of bone tumours is that many may be multiple in nature at the time of presentation (i.e., synchronous), such as osteosarcoma, Ewing's sarcoma, fibrous dysplasia (not a neoplasia), and enchondromatosis.[3] Another feature typical of bone tumours is that they have a predilection for certain bones and certain locations within the bones[4] (Table 108.2).

Table 108.2: Distribution of common bone tumours according to site.

Small tubular bones	Enchondroma Periosteal chondroma Osteoid osteoma Osteoblastoma Giant cell reparative granuloma
Long tubular bones	Most primary benign and malignant bone tumours and tumour-like lesions Metastasis (e.g., neuroblastoma)
Ribs/sternum	Benign/malignant cartilage tumours Fibrous dysplasia Mesenchymal hamartoma of the chest wall Eosinophilic granuloma Metastasis
Spine	Aneurysmal bone cyst Osteoblastoma Osteoid osteoma Haemangioma Metastasis
Skull/facial bones	Fibrous dysplasia "Fibro-osseous lesions" of the jaw Osteoma Giant cell reparative granuloma Haemangioma Eosinophilic granuloma Osteosarcoma Mesenchymal chondrosarcoma Metastasis
Pelvis	Osteochondroma Chondrosarcoma Ewing's sarcoma Metastasis

Presentation

History

Usually a child presents with nonspecific symptoms, such as limping, weakness, oedema of an extremity, or swelling of an associated joint, all of which make the diagnosis confusing. Pain is the most common symptom, and 50% of all malignancies are associated with minor trauma. Bone pain is typically dull, constant, severe at rest, and worse in the night. Fever may be present in Ewing's sarcoma, which is often confused with osteomyelitis.

Physical Examination

A swelling or mass is frequently present; however, lesions in the pelvis may be obscure. There may be venous engorgement or peripheral oedema, which points towards a malignancy. Benign lesions may cause a deformity or fracture.

Investigations

Blood investigations may show anaemia, a high erythrocyte sedimentation rate, and a high white cell count. Serum alkaline phosphatase and lactate dehydrogenase may be higher and associated with a poorer prognosis in malignancy.[5]

Primary radiological investigations may be inconclusive or confusing, and special or oblique view x-rays or CT may be needed. A high index of suspicion and careful review of radiology is adequate to pick up most malignancies. Multiple lesions may be present in multifocal osteosarcoma, and multiple primary lesions in Ewing's sarcoma or osteomyelitis apart from secondary malignancies. Hence, biopsy or further imaging may be necessary in the form of MRI or bone scintigraphy.

X-rays

Some features on a plain radiograph assist in differentiating benign from malignant lesions[4] (Table 108.3).

Table 108.3: Radiological features of benign and malignant bone tumours.

Feature	Benign	Malignant
Periosteal reaction	Variable	Common
Margin of lesion/zone of transition	Well-defined and sclerotic	Poorly defined
Cortical destruction	Rare	May be present
Pattern of osteolysis	Geographic	Expansile, moth-eaten, permeative
Soft tissue involvement	Variable	Common
Size	Variable	Usually extensive
Multiple lesions	Unlikely	May be present especially around the primary
Involvement of joint	Unlikely	Effusion may be present

Computed Tomography

CT scans help in the diagnosis of bone tumours as well as planning of biopsy, surgery, and chemotherapy. Information is obtained at various levels. Local disease extent is defined, the nature of the tumour is classified, and the amount of soft tissue involvement can be judged. In addition, neurovascular structures can be studied around the tumour; this information aids in the plan for reconstruction of the limb. Also CT of the chest can detect pulmonary metastases <3 mm, which have a significant prognostic value.

Magnetic Resonance Imaging

MRI is now the gold standard investigation for bone tumours in the Western world, mainly for its ability to pick up marrow extension and delineate the level of surgery. Also multiplanar and three-dimensional (3D) imaging allows the surgeon to accurately choose between wide excision and amputation because it gives details on neurovascular bundles, availability of soft tissue for cover, and it visualises skip metastases.

Bone Scintigraphy

Nuclear medicine has a vast beneficial diagnostic advantage both in primary and secondary bone lesions. Tecnitium-99m (Tc-99m) labelled scans are widely used in the Western world for identifying synchronous tumours as well as metastases of primary bone malignancies. Combined with CT, bone scintigraphy is a good tool to manage most primary bone malignancies.

Management

Great strides have been made in the past two to three decades in the management and survival of children with malignant bone tumours. This is attributable to worldwide unity in conducting research due to low numbers of malignant bone tumours in individual centres. 3D radiological investigations, advances in pathological understanding of tumours and their origins, newer chemotherapeutic agents, better reconstructive surgery, and a multidisciplinary approach have all contributed.

Staging

The Musculoskeletal Tumour Society staging system[6] (Table 108.4), originally developed by Enneking, depends on the tumour's histological grade, local extent, and metastasis.

Table 108.4: Musculoskeletal Tumour Society staging system.

Stage	Grade	Local extent	Metastasis
IA	Low	Intraompartmental	None
IB	Low	Extraxcompartmental	None
IIA	High	Intraompartmental	None
IIB	High	Extraxcompartmental	None
III	Any	Any	Present

The significance of staging for malignant tumours is as follows:

- *Stage IA tumours* are treated with wide excision and are usually amenable to limb salvage procedures.
- *Stage IB tumours* may be treated with wide excision, but the choice between amputation and limb salvage depends on the estimated amount of residual tumour left behind after a limb salvage procedure.
- *Stage II tumours* are high grade, are usually extracompartmental, and have significant risks for skip metastases. They usually are not amenable to limb salvage operations and require radical amputation or disarticulation in most patients. However, bone tumours responsive to chemotherapy may be treated successfully by using wide excision and adjuvant therapy.
- *Stage III tumours* are responsive to chemotherapy and may be treated with aggressive resection. Those that are not responsive to adjuvant therapy should be treated with palliative resection.

Individual Tumours

Benign

Osteochondroma

Osteochondroma is a cartilage-capped bony outgrowth arising from the external surface of a bone. It is the most common benign bone tumour, accounting for almost 60% of all bone tumours. A lesion may be asymptomatic, and hence may not need any treatment except for careful observation.

Enchondroma

Enchondroma is a benign bone tumour. Radiologically, enchondroma is metaphyseal in location and does not have a soft tissue mass, periosteal reaction, or bone destruction, which differentiates it from chondrosarcoma.

Osteoid osteoma

Osteoid osteoma is a benign tumour that occurs mostly in the second decade of life, affecting males at a rate twice that of females. It arises commonly in the femur and tibia, presenting with typical bone pain that is worse at night. X-rays show a radiolucent core with sclerotic margins, but this tumour is best seen on CT scan. Complete removal of the lesion is recommended with grafting and cementing.

Osteoblastoma

Osteoblastoma is an uncommon benign tumour in children slightly younger than those with osteoid osteoma. It may not have a sclerotic rim and may involve short bones as well. It may also have systemic symptoms such as fever and weight loss. A particular variety is aggressive and can resemble low-grade osteosarcoma radiologically and pathologically. Careful follow-up is needed.

Nonossifying fibroma

Nonossifying fibroma is a common fibrohistiocytic lesion that may be large and involve the medulla of metaphyses. Radiologically, it is a lytic lesion with a well-defined sclerotic border. If symptomatic or vulnerable to fracture, excision may be necessary.

Simple bone cyst

Although benign, a simple bone cyst has a tendency to recur as it affects the growth plate. It often presents as a metaphyseal fracture of tubular bones and hence needs excision. Radiologically, it is an osteolytic lesion with trabeculations.

Fibrous Dysplasia

Fibrous dysplasia is a relatively common benign fibro-osseous lesion that is not a true neoplasm. It is thought to be developmental and is composed of fibrous tissue with irregular woven bone trabeculae. Radiologically, this lesion is well defined, with a ground-glass appearance and a sclerotic rim. Surgical excision or curettage with careful follow-ups is necessary because this lesion tends to recur often. Polyostotic fibrous dysplasia affects multiple bones and can be crippling, even needing radiotherapy. A sarcomatous change to a fibrous, osteoid, or cartilage component may occur in this setting.

Malignant

Chondrosarcoma

Chondrosarcoma is the third most common primary bone malignancy. It can occur in the setting of a benign lesion, such as exostosis or enchondroma; also, it occurs in patients older than 30 years of age, compared to benign lesions that can occur in childhood. There may be cortical destruction or a soft tissue mass, which may be the only differentiating factor between a benign active lesion and a low-grade malignant chondrosarcoma. Histology shows chondrosarcoma can be clear cell, dedifferentiated, or mesenchymal in origin. The treatment of these lesions is primary surgical excision followed by chemotherapy for the mesenchymal variety and radiation for pain control.

Osteosarcoma

Classic high-grade osteosarcoma is a highly malignant osteoid-forming spindle cell sarcoma of the bone. It is the most common primary malignant bone tumour in children and is the third most common malignant disease after leukaemia and lymphoma in adolescence. The incidence in Africa may be lower, however, due to underreporting, as shown in a large study in Nigeria.[5] It is still a rare tumour, and there appears to be no race- or sex-related predominance in incidence. Prevalence is higher in patients affected with retinoblastoma (40% in bilateral disease)[7] and those who have undergone radiation therapy or Paget's disease (secondary osteosarcoma).

Osteosarcoma can occur in any bone, but is most common in the metaphyses of long bones (80–90% of tumours), with particular predilection for distal femoral metaphyses (35%), proximal tibial metaphyses (20%), and proximal humeral metaphyses (10%).[5] Pain and swelling or mass are the most common presenting features, along with fever, weakness, and limping. Pelvic masses may be obscured.

Investigations

Radiologically, osteosarcoma appears as a destructive lesion of a metaphysic of a long bone, exhibiting mixed lytic and blastic areas (Figure 108.2). There is cortical destruction and a wide transitional zone. There is often soft tissue involvement with irregular densities. At the margins there may be reactive periosteal bone formation forming Codman's triangles, which are the mark of an aggressive destructive process.

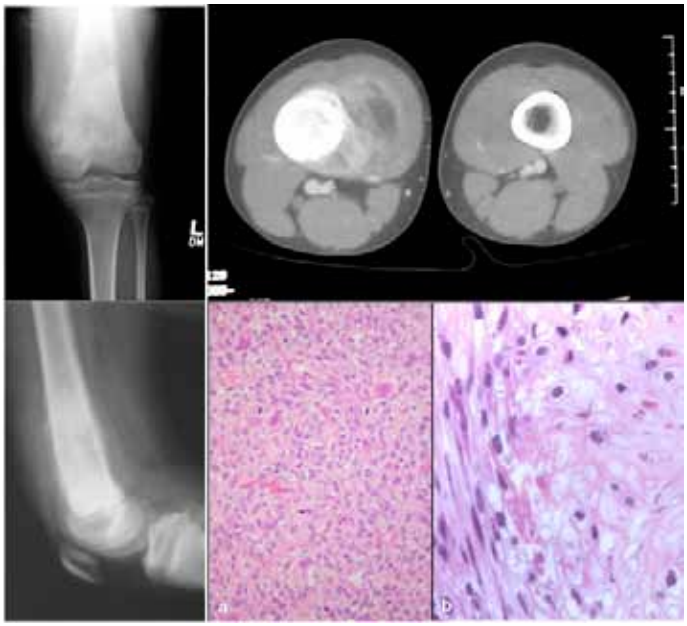


Figure 108.2: Osteosarcoma. X-rays (left panes) showing Codman's triangles, soft tissue invasion, and cortical destruction. The CT scan (upper right pane) shows a similar picture and is superior in defining the extent of the tumour. Histopathology (lower right panes, a and b) shows osteoid-forming highly mitotic cells.

The tumour is staged preoperatively by using oblique-view x-rays and CT. In the West, MRI is the gold standard because it shows accurate marrow extension, which helps in determining the surgical intervention. The multiplanar views of these instruments help in finding the appropriate surgical route for the biopsy as well as in identifying viable areas. A CT scan of the chest can identify small pulmonary metastatic lesions, which are of significant prognostic value. Bone scintigraphy, where available, helps in finding areas of skip metastases and sites of synchronous metastases.

Gross pathology of the tumour shows a heavily mineralised soft tissue mass extending from the marrow through the cortex to the soft tissues. Intraarticular extension typically occurs along ligaments. Microscopy shows frankly malignant pleomorphic cells producing osteoid. The background contains fibrous or chondroid stroma and many areas of necrosis (see Figure 108.2). The radiological and clinical correlation of histology is extremely important in differentiating malignant bone tumours from reactive, infective, and benign processes, as pure histology may be confusing.

Variants

High-grade central osteosarcoma is the classic type, described above. Surface or juxtacortical (parosteal, periosteal) osteosarcoma can be low to intermediate grade with variable response to chemotherapy, and wide surgical excision gives higher survival rates than for the classic type.

Treatment

In the past, surgery alone gave high metastatic rates with abysmal survival of less than 20%. Accurate clinical staging, vast strides in chemotherapy, and appropriate surgery have increased survival dramatically in the past few decades and also limited morbidity significantly. The current protocol for a suspected malignant bone tumour is radiology (x-rays, and, where available, CT, MRI, and bone scintigraphy); biopsy of the tumour; preoperative (neoadjuvant) chemotherapy; wide resection or amputation; and postoperative (adjuvant) chemotherapy.[7]

The benefits of neoadjuvant chemotherapy are manifold. It prevents the development of resistant clones, especially in the setting of the rapid doubling time in osteosarcoma, and it kills microscopic metastases and shrinks the primary tumour-inducing necrosis. The degree of necrosis thus induced is an important prognostic marker for long-term survival. The drugs commonly used are doxorubicin, cisplatin, and high-dose methotrexate. Recently, ifosfamide has been used.

Wide excision may be limb sparing and prevent morbidity; however, survival is not affected. Amputation may be particularly necessary in cases where tumour extent or grade are inadequately known, preoperative chemotherapy response is poor, or the surgical stump may not be adequate for prosthesis. Occasionally, reconstruction may be embarked upon by using allografts, metal prosthesis, or composites.

Prognosis

Concurrent to the improvement in strategy and introduction of neoadjuvant chemotherapy, the 5-year survival rates for osteosarcoma have gone up to 60–80% in different series.[8,9] In patients with apparent metastatic disease prior to surgery the survival is much poorer, at 10–20%. If the pulmonary metastases can be resected, this figure can go up to 40%.[7,10] The factors that affect or predict prognosis are tumour necrosis after neoadjuvant chemotherapy and presence or absence of metastases at time of presentation. A larger tumour size, raised lactate dehydrogenase and alkaline phosphatase levels, and tumours located in the pelvis and proximal femur or humerus are poor prognostic signs.[7]

In the future, antivascular growth factor antibodies and a vascular endothelial growth factor inhibitor may be beneficial as well as directed therapies against overexpressed tumour-related genes, such as Rb (retinoblastoma) gene and Her2/erb-2.

Ewing's sarcoma

Ewing's sarcoma is a malignant round-cell bone tumour of neuroectodermal origin. It accounts for 10% of all primary malignant bone tumours. Eighty percent of patients are younger than 20 years of age. This tumour is rare in Africa;[11–13] however, it is discussed in detail here because it is still the second most common tumour, and is probably the most common for children younger than 5 years of age.

The Ewing's sarcoma tumour presents usually in the lower limbs and pelvis, although it can occur in any bone. It belongs to a family of tumours of common neuroectodermal origin, along with primitive neuroectodermal tumour (PNET), atypical Ewing's tumour, and Askin tumour. This confers susceptibility of these tumours to chemotherapy, with increased survival noted in the past few decades .

Ewing's tumour frequently presents with a painful soft tissue mass and with fever, resembling osteomyelitis.

Investigations

Radiologically, Ewing's sarcoma appears as a soft tissue mass eroding through bone, and hence it may be confused with an acute reactive process or osteomyelitis. Indeed, a biopsy may show "pus", and it is important to send the biopsy material for histology or frozen section along with microbiology. Pathological fractures may occur. Rib involvement may cause malignant pleural effusion, and vertebral involvement may cause scoliosis due to the soft tissue mass. The primary tumour in the limbs may show a mottled, or "onion skin" appearance (Figure 108.3).

Special-view radiographs and a CT scan will help define the extent of the tumour as well as pulmonary metastases, if any. Bone scintigraphy may be particularly useful, as 10% patients may have multiple lesions. The scans are repeated after several cycles of chemotherapy; hence, MRI is more useful, especially in children.

Gross morphology shows a grey-white mass with extensive areas of necrosis and haemorrhage mimicking "pus formation". Microscopically the neuroectodermal origin is confirmed with numerous malignant

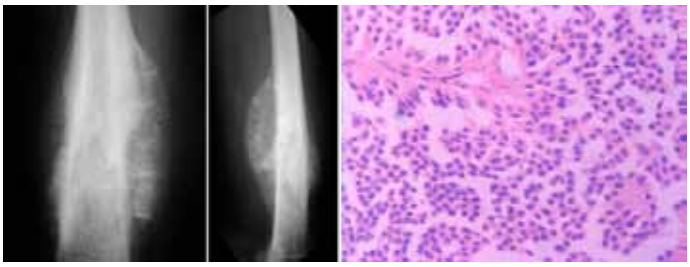


Figure 108.3: Ewing's sarcoma: x-rays (left) show onion-skin appearance (right).

small blue cells with sparse stroma. All such tumours also exhibit the MIC2 gene, which differentiates them from lymphomas and rhabdomyosarcoma. A commercial kit available for this investigation has a 95% sensitivity for detecting Ewing's sarcoma.

Treatment

Over the past two decades, the Intergroup Ewing Sarcoma Study has demonstrated a dramatic improvement in survival by modifying chemotherapeutic agents and the intensity of their dosage regimen. The society has recommended high-dose vincristine, actinomycin, cyclophosphamide, and adriamycin (VACA).[7,10] Recently, the Children's Cancer Group and the Paediatric Oncology Group have shown that the addition of ifosfamide and etoposide improved the morbidity of the survivors.

Surgical excision of the primary tumour, where possible, markedly improves the outcome, possibly due to the removal of chemotherapy-resistant clones. Radiotherapy may be added where surgical margins may not be adequate, but in sites where this is the only postoperative treatment possible, the outcome is poorer (34%). Indeed, the risk of radiation-induced malignancies and crippling disabilities are coming to light in this era. Patients who have received doses of more than 60 Gy have the maximum lifetime risk. Aggressive excision with reconstruction is now being favoured in difficult sites such as the proximal femur, pelvis, and spine.[3]

Prognosis

As with osteosarcoma, the presence of distal metastases at time of diagnosis of Ewing's sarcoma, initial tumour size >8 cm, and central lesions such as in the pelvis fare worse. The overall survival has increased from 5% in the 1980s to >70% currently.

Postoperative Complications

Surgical complications may be related to the amputation stump or the distal end of the limb. Additionally, functional inability to fit a prosthesis or adapt to a restricted lifestyle causes severe mental and emotional as well as physical disability. Implants have their own risk of wear and tear and can fracture, but this is certainly more acceptable than the risks of radiotherapy, which may be multiple. Radiotherapy has limited use in delimiting preoperative disease and treating tumours difficult to resect. It has a serious life time malignancy risk, and complications such as limb-length discrepancy or joint contracture are more pronounced in the skeletally immature. Chemotherapy risks are minimised by the addition of multiple agents and by worldwide consortiums offering research into newer molecules.

Ethical Issues

In Africa, the management of bone tumours is more complex, as specialist oncology, pathology, or radiology centres may not be available; surgical experience also may be limited in rural areas.[12] Of special note are patients who have a rather unusual story of osteomyelitis or those who have a sudden onset or presence of other systemic features and require a high index of suspicion and multiple radiological investigations to determine the nature of the tumour. Telemedicine and digital radiology are able to offer expert radiological opinions to many centres.

In addition, the balance between wide-excision surgery and limited resection to preserve function has greater meaning in Africa, where reconstructive surgery and rehabilitation are not always possible. Greater planning prior to surgery and the use of expert help can prevent many a disability, which, in turn, would save many disability-adjusted life years.[4]

Evidence-Based Research

Table 108.5 presents a detailed description of various bone lesions. Table 108.6 is a monograph on the incidence and prevalence of bone tumours, with an emphasis on racial differences.

Table 108.5: Evidence-based research.

Title	Radiological and pathological diagnosis of paediatric bone tumours and tumour-like lesions
Authors	Vlychou M, Athanasou NA
Institution	Nuffield Department of Pathology and Nuffield Department of Orthopaedic Surgery, University of Oxford, Nuffield Orthopaedic Centre, Oxford, United Kingdom
Reference	Pathology 2008; 40(2):196–216
Problem	Radiological and pathological diagnosis.
Comparison/ control (quality of evidence)	Benign with malignant tumours.
Historical significance/ comments	A detailed description of various bone lesions. The focus is on radiology and includes various modalities and their advantages. Its feature on pathology illustrates immune-histochemical differences and the basis for adjuvant therapy in malignancies.

Table 108.6: Evidence-based research.

Title	SEER paediatric monograph
Authors	Gurney JG, Swensen AR, Bulterys M
Institution	National Cancer Institute, Bethesda, Maryland, USA
Reference	Gurney J, Swensen A, Bulterys M. Malignant bone tumors. In: Ries L, Smith M, Gurney J, et al., eds. *Cancer Incidence and Survival among Children and Adolescents: United States SEER Program 1975–1995.* National Cancer Institute, SEER Program, 1999, Pp 99–110.
Problem	Incidence and prevalence of bone tumours.
Outcome/ effect	Racial differences in bone tumour incidence is highlighted.

Key Summary Points

1. Malignant bone tumours are the third most common malignancy in adolescence.
2. Presentation and radiological findings of benign and malignant bone lesions may be similar and be confused with reactive or infective processes.
3. The site of the tumour and age of the patient are the most important factors in differential diagnosis.
4. Accurate preoperative staging, aggressive neoadjuvant chemotherapy, and surgical resection are the cornerstones of management of primary malignant bone tumours.
5. Even though survival has increased in the Western world from 20% to >70% due to modern chemotherapy, the key factors to survival in Africa are the availability of chemotherapy, selection of patients, surgical complications, and rehabilitation.
6. Newer drugs, telemedicine, and the availability of mobile radiological services have tremendous roles to play in providing cancer services in Africa.

References

1. Gurney J, Swensen A, Bulterys M: Malignant bone tumors. In: Ries L, Smith M, Gurney J, et al., eds. *Cancer Incidence and Survival among Children and Adolescents: United States SEER Program 1975–1995.* National Cancer Institute, SEER Program, 1999, Pp 99–110.
2. Dorfman HD, Vanel D, Czerniak B, Park YK, Kotz R, Unni KK, WHO classification of tumours of bone: introduction. In: Christopher DM, Fletcher K, Unni K, Mertens F. Pathology and Genetics. Tumours of Soft Tissue and Bone. World Health Organization, 2006, Pp 226–232.
3. Heare T, Hensley MA, Dell'Orfano S. Bone tumors: osteosarcoma and Ewing's sarcoma. Curr Opin Pediatr 2009; 21(3):365–372.
4. Vlychou M, Athanasou NA. Pathology, radiological and pathological diagnosis of paediatric bone tumours and tumour-like lesions, J Bone Joint Surg Am 2008; 40(2):196–216.
5. Omololu AB, Ogunbiyi JO, Ogunlade SO, Alonge TO, Adebisi A, Akang EE. Primary malignant bone tumour in a tropical African University teaching hospital. West Afr J Med 2002; 21(4):291–293.
6. Musculoskeletal Tumor Society. Staging of musculoskeletal neoplasms. Skeletal Radiol 1985; 13(3):183–194.
7. Gibbs CP Jr, Weber K, Scarborough MT. Malignant bone tumors. Instr Course Lect 2002; 51:413–428.
8. Foster L, Dall GF, Reid R, Wallace WH, Porter DE. Twentieth-century survival from osteosarcoma in childhood. Trends from 1933 to 2004. J Bone Joint Surg Br 2007; 89(9):1234–1238.
9. Mariotto AB, Rowland JH, Yabroff KR, et al. Long-term survivors of childhood cancers in the United States. Cancer Epidemiol Biomarkers Prev 2009; 18(4):1033–1040.
10. Ilić I, Manojlović S, Cepulić M, Orlić D, Seiwerth S. Osteosarcoma and Ewing's sarcoma in children and adolescents: retrospective clinicopathological study. Croat Med J 2004; 45(6):740–745.
11. Stiller CA, Parkin DM. Geographic and ethnic variations in the incidence of childhood cancer. Br Med Bull 1996; 52(4):682–703.
12. Polednak AP. Primary bone cancer incidence in black and white residents of New York State. Cancer 1985; 55(12):2883–2888.
13. Bahebeck J, Atangana R, Eyenga V, Pisoh A, Sando Z, Hoffmeyer P. Bone tumours in Cameroon: incidence, demography and histopathology. Int Orthop 2003; 27(5):315–317.