

CHAPTER 26

Musculoskeletal Neoplasms

CATHERINE C. GOODMAN

Neoplasm is defined as a new or abnormal growth of cells and is often used interchangeably with *tumor*, which means any swelling or mass. Neoplasms are divided into two broad categories: benign and malignant. Benign neoplasms show no tendency to metastasize, are noninvasive, and are usually slow growing. A malignant neoplasm is one that can be invasive or can metastasize (see further discussion, Chapter 9).

Although neoplasms represent a small portion of the spectrum of pathology seen in clinics, their severity and potential for serious consequences necessitate an understanding of their detection and treatment.

The purpose of this chapter is to review the characteristics of primary and secondary musculoskeletal neoplasms. Those that may be encountered by therapists are highlighted. It is hoped that by increasing awareness of the clinical manifestations, earlier detection will be possible.

PRIMARY TUMORS

Overview

Description

Primary musculoskeletal tumors are those that have developed from or within tissue in a localized area. Primary musculoskeletal neoplasms can be benign or malignant, soft tissue or bone. A soft tissue tumor may originate from muscle, cartilage, nerve, collagen, adipose, lymph or blood vessel, or skin (see Table 9-1). Common sites in the body and location within the bone vary depending on the type of tumor (Table 26-1; Fig. 26-1).

Modern classification of soft tissue tumors recognizes more than 200 benign and approximately 70 malignant (sarcomatous) lesions with a ratio of benign tumors to malignant sarcomas of 100:1. The focus of this chapter will remain on the most common bone and soft tissue tumors encountered in the physical therapist's practice.

Other soft or connective tissue tumors (e.g., skin, heart, myeloma, lymphatic, hematologic, neurologic) are discussed elsewhere in this text. An excellent comparison of soft tissue sarcomas in adults and children, including rehabilitation, is available elsewhere.⁴⁶⁻⁵⁹ A review of solid bone cancers occurring during adulthood and the implications for physical therapy is also available.³⁴

Benign Neoplasm

Benign tumors are well differentiated, resemble normal tissue, rarely invade locally, and have low potential for autonomous growth. However, benign does not necessarily mean innocuous. For example, osteoblastomas in the spine may produce serious neurologic problems requiring resection, with additional complications possible from the surgical procedure.

Some benign bone tumors pose difficult evaluation and management decisions and can result in a significant level of impairment. For example, large fibrous defects in weight-bearing bones can cause pathologic fractures. A *pathologic fracture* refers to bone that has been weakened by local destruction (osteoclastic resorption) from any cause; bone with this type of impairment is more readily fractured than normal bone. This complication is referred to as a *pathologic fracture* because it occurs through an area of abnormal or pathologic bone.

Although rare, some benign lesions can develop into a malignancy. Benign lesions usually do not cause the constant, severe pain that is commonly associated with progressive malignant disease, but benign tumors can impair blood supply or compress nerve tissue.

Malignant Neoplasm

Malignant primary tumors of bone by definition have the capacity to spread to other sites and often do so aggressively by invading locally and destroying adjacent tissues and by metastasizing to distant sites. Skeletal neoplasms often metastasize to the lungs through the bloodstream.

Fortunately, malignant tumors are not as common as benign lesions; however, this rarity has made it difficult to standardize treatment interventions and management. For this reason, most individuals with malignant primary tumors are referred to regional centers, where valuable experience concerning evaluation and treatment can be gained and then applied to future cases.

Incidence

Primary tumors of the musculoskeletal system are uncommon, although the incidence is difficult to determine because these lesions often escape diagnosis (Table 26-2). Excluding myeloma and skin cancer, as few as 2400 new cases of primary bone tumors and 9200 cases of soft tissue sarcomas are detected annually in the United States with a 3:1 ratio of men to women affected.⁵⁴ This does

Table 26-1 Classification of Soft Tissue and Bone Tumors

Tissue of Origin	Benign Tumor	Malignant Tumor
Connective Tissue		
Fibrous	Fibroma	Fibrosarcoma Malignant fibrous histiocytoma
Cartilage	Chondroma Enchondroma Chondroblastoma Osteochondroma	Chondrosarcoma
Bone (osteogenic)	Osteoma; osteoblastoma (giant osteoid osteoma)	Osteosarcoma (osteogenic sarcoma)
Bone marrow (myelogenic)		Leukemia Multiple myeloma Ewing's sarcoma Hodgkin's lymphoma of bone Liposarcoma Synovial sarcoma
Adipose (fat)	Lipoma	
Synovium	Ganglion, giant cell of tendon sheath	
Muscle		
Smooth muscle	Leiomyoma	Leiomyosarcoma (uterus, gastrointestinal system)
Striated muscle	Rhabdomyoma	Rhabdomyosarcoma (can occur anywhere)
Endothelium (Vascular/Lymphatic)		
Lymph vessels	Lymphangioma	Lymphangiosarcoma Kaposi's sarcoma
Blood vessels (angiogenic)	Angioma Hemangioma	Lymphosarcoma (lymphoma) Angiosarcoma Hemangiosarcoma
Neural Tissue		
Nerve fibers and sheaths	Neurofibroma Neuroma	Neurofibrosarcoma Neurogenic sarcoma (also known as neurosarcoma or schwannoma)
Glial tissue	Neurinoma (neurilemmoma) Gliosis	Glioma
Epithelium		
Skin and mucous membrane	Papilloma Polyp	Squamous cell carcinoma Basal cell carcinoma
Glandular epithelium	Adenoma	Adenocarcinoma

Table 26-2 Relative Frequency of Primary Bone Tumors***Benign**

Osteochondroma	35% of benign tumors; 10% of all bone tumors
Osteoid osteoma	10%-12% of benign bone tumors
Enchondroma	10% of benign bone tumors; some report as high as 24%
Osteoblastoma	1%-2% of benign bone tumors
Chondroblastoma	<1% of all bone tumors
Hemangioma	<1% of all bone tumors

Malignant

Metastatic neoplasm	Most common form of bone malignancy; secondary neoplasm of bone
Multiple myeloma	Most common primary neoplasm of bone; plasma cell malignancy (bone marrow)
Osteosarcoma	35% of all malignant bone tumors; 15%-20% of primary sarcomas (excluding multiple myeloma)
Chondrosarcoma	25% of malignant bone tumors (excluding multiple myeloma)
Ewing's sarcoma	16% of malignant bone tumors; second most common in children; fourth overall primary bone tumor for adults and children (after myeloma)
Malignant fibrous histiocytoma	2%-5% of malignant bone tumors (excluding multiple myeloma)
Chordoma	1%-4% of all malignant bone tumors; slow growing but locally aggressive
Angiosarcoma	1.4% of malignant bone tumors (excluding multiple myeloma)

Data from Dorfman HD, Czerniak B: Bone cancers, Cancer 75(1 suppl):203-210, 1995; Dorfman HD, Czerniak B: Bone tumors, St Louis, 1998, Mosby.

*Listed by decreasing order of frequency; with the exception of metastatic neoplasm listed, these statistics refer to primary bone tumors.

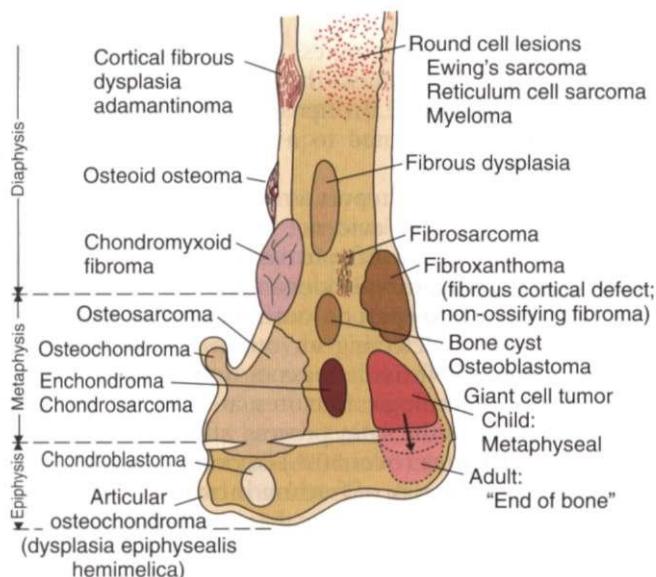


Figure 26-1

Composite diagram illustrating frequent sites of bone tumors. The diagram depicts the end of a long bone that has been divided into the epiphysis, metaphysis, and diaphysis. The *epiphysis* refers to the articular end of the long bones, which is primarily cartilaginous in the growing child. The *metaphysis* is the wider part of the shaft of the long bone. The *diaphysis* refers to the shaft itself. The typical sites of common primary bone tumors are labeled. (From Madewell JE, Ragsdale BD, Sweet DE: Radiologic and pathologic analysis of solitary bone lesions: I. Internal margins, *Radial Clin North Am* 19:715, 1981.)

not mean that they are unimportant. A great deal of time is devoted to research, reporting, and educating physicians in the proper management of people with primary tumors. These efforts are indicative of the serious nature of the problem rather than the frequency.

Risk Factors

Little progress has been made in our knowledge of the risk factors involved in the etiopathogenesis of malignant bone tumors. Although bone tumors may have a predilection for certain sites, age groups, and gender, most causes of osteosarcoma are unknown. The main factors implicated are Paget's disease, Li-Fraumeni syndrome, antineoplastic drugs, ionizing radiation, and hereditary retinoblastoma.³⁶

Exposure to alkylating chemotherapeutic agents such as cyclophosphamide, used in the treatment of acute lymphocytic leukemia, has been associated with subsequent development of osteosarcoma in a small percentage of cases.

Several genetic conditions are related to the development of soft tissue sarcoma (e.g., neurofibromatosis, tuberous sclerosis, basal cell nevus syndrome), but this is only a small number of cases.¹⁰³ Soft tissue tumors also may be associated with high doses of radiation or exposure to toxic chemicals in the workplace (herbicides, dioxin, preservatives, and so on).

Etiologic Factors and Pathogenesis

The histogenesis of tumors is generally poorly understood, although significant progress has been made toward understanding tumor development as a biologic

phenomenon. For a detailed description of the molecular biology of bone formation, apoptosis and its role in bone cancer, and molecular and oncogenetic concepts of bone neoplasia, the reader is referred to Dorfman and Czerniak, 1998.³⁰

Bone Tumors. To grasp the concepts of tumor formation, one must understand that bone metabolism is a balancing act of bone formation and resorption. The coupling of these two processes usually results in a balance of bone resorption and formation. When metabolic bone disease and neoplastic formations occur, this balance is upset.

Under normal circumstances, bone remodeling involves a fine balance between osteoblast activity, which promotes new bone synthesis, and osteoclasts, which stimulate bone resorption. This balance is disrupted by the presence of malignant cells, resulting in uncoupling of the process of remodeling.

Bone remodeling is a structured process governed by highly specialized cells. Osteoblasts are derived from mesenchymal fibroblast-like cells and are responsible for bone formation. Bone formation is accomplished by synthesizing various collagens, alkaline phosphatase, and other chemicals. A variety of paracrine factors, including tumor necrosis factor α , tumor necrosis factor (3, interleukin-1, and prostaglandins are released during the remodeling process and may ultimately contribute to growth of the metastatic cells.³³

Cortical bone is most abundant in the outer walls of the shafts of long bones and is quite dense. The haversian canal system, which refers to the concentric rings of lamellae, is found in cortical bone. Cortical bone surrounds the trabecular or cancellous bone, which is the honeycomb-like bone found in the ends of long bones. Trabeculae are aligned with applied stresses in the bone. The metabolic activity is higher in cancellous bone than cortical bone, which accounts for why many disorders that create disturbances in metabolic activity are first noted in cancellous bone.

Bone tumors are considered to be either osteoblastic or osteolytic, although most have characteristics of both processes. The osteoblastic process can be preceded by tumor cells or by normal cells in the host bone reacting to the tumor. Since the host bone continues with the normal process of resorption and bone formation, there will likely be a variety of cell types within the lesion. This makes histologic interpretation difficult.

Neoplastic cells do not themselves destroy bone, but their presence incites local osteoclastic resorption of bone. The cells of certain neoplasms also incite local osteoblastic deposition of normal bone, referred to as reactive bone. The neoplastic cells of the osteogenic group of neoplasms are capable of producing osteoid (young bone that has not undergone calcification) and bone, which are then referred to as tumor bone or neoplastic bone. The radiographic appearance of lesions affecting bone reflects varying proportions of bone resorption (osteolysis) and bone deposition (osteosclerosis)—some of the latter being reactive bone, and some being neoplastic bone.³⁴

Soft Tissue Tumors. Four types of genetic disorders underlying soft tissue sarcomas have been identified:

translocations, gene amplifications, mutations, and complex genetic imbalances. Detection of these molecular changes can guide treatment and may predict response to treatment. Techniques used to detect translocations are very sensitive and in some cases may be used to detect microscopic metastasis.¹³

Soft tissue sarcomas have a predictable growth pattern, beginning as small masses and often growing in a centripetal pattern. The leading edge of the tumor (reactive zone) contains edema, fibrous tissue, inflammatory cells, and tumor cells. Uncontrolled growth often causes loss of blood supply at the center of the tumor.

Benign soft tissue tumors also have a centripetal growth pattern, but the expansion is more controlled and much slower. Benign lesions tend to be more superficially located compared with malignant lesions, which often grow within tissues under the deep fascia.⁹⁴

Clinical Manifestations

The clinical features must be well understood to ensure that the diagnostic evaluation proceeds expeditiously. Unfortunately, many tumors are not diagnosed on their initial presentation. This is due to the ambiguous presentation of most tumors in their early stages; rarely does one actually find the case that is described as typical for a given lesion. This may be true regarding benign or malignant tumors, the initial presentation, and the appearance of the lesion.

Pain. Pain is a hallmark of tumor development, especially with malignant lesions. With bone tumors, intense pain is more likely to occur with rapidly growing lesions caused by pressure or tension on the sensitive periosteum and endosteum. Constant pain that is not dependent on position or activity and is increased with weight-bearing activities is a red flag symptom. The presence of night pain is considered an additional important finding. When the client reports night pain, further questioning is required.

The therapist should ensure that the client is reporting true night pain, which awakens the person from sleep, rather than a pain that makes it difficult to fall asleep. Ask the individual if rolling onto the involved side or painful area awakens him or her. Ascertain whether the pain subsides with movement and change in position, possibly indicating mechanical ischemia or positioning as the cause of the night pain. Determine the effects of eating on pain, as this may be an indicator of gastrointestinal (GI) involvement.

It is also important to remember the common referral patterns for pain. These may give important clues to the origin of symptoms. The varied pain pattern is a result of the nature, site, and rate of growth of the tumor.

Since pain is the overriding symptom in many people who seek treatment, a great deal of information should be obtained concerning the pain. The onset, progression, nature, quality, intensity, and aggravating factors are just some of the factors that may be important in identifying a tumor in the early stages.

Keep in mind that with cancer, pain is not always a measure of disease progression. Some tumors can progress to advanced stages without causing significant pain. Soft tissue tumors can occur in any anatomic region,

although most develop in the extremities, usually the legs. These tumors may progress with relatively little pain because the soft tissue allows the growth to occur without putting undue pressure on nerve endings. Any swelling present is often attributed to a minor injury, delaying medical examination.

In fact, clients often report a recent history of trauma, although no scientific evidence directly connects such injury to the inception of soft tissue or bone sarcomas. Instead, such traumatic episodes are thought to call attention to a specific body part or location, thereby increasing the likelihood of detecting an otherwise painless and often innocuous soft tissue mass or bone lesion.¹⁰³

Fractures. Pathologic fractures are rare in primary neoplasms, but if the lytic process affects a significant portion of the cortex (over 50%) or occupies 60% of the bone diameter, the risk of fracture increases. A relatively small lytic lesion in the femoral neck that destroys the inferior cortex of the femoral neck also places the client at increased risk. In benign lesions, no other symptoms may warn of the impending fracture.

A history of sudden onset of severe pain may be an indication of a pathologic fracture. Solitary bone cysts, fibrous dysplasia, nonossifying fibroma, and enchondromas may only be detected after presentation with a pathologic fracture. In addition to the tumor itself, other factors such as disuse, treatment (biopsy, radiation), and other health problems (osteoporosis) may increase the risk of pathologic fracture.

Miscellaneous. Other signs and symptoms often encountered include swelling, fever, and the presence of a mass. Other factors that are useful in screening for serious pathology include unexplained weight loss, failure of rest to provide relief of pain, age, and history of cancer. The history will often give more meaningful information regarding the possibility of skeletal neoplasms than the physical examination.

Swelling. Swelling surrounding a tumor may not be detectable in a bone tumor, but with soft tissue tumors close to the skin surface, swelling may be one of the first presenting signs. The nature of swelling, including the location, amount, temperature, and tenderness, is somewhat dependent on the vascularity of the lesion.

Mass. A careful physical examination may reveal a mass or other signs of an inflammatory process. The presence of a mass should raise questions concerning the location, mobility, tenderness, dimensions, and recent changes in any of these factors. As with pain, the size of the mass is not indicative of the severity of the lesion but is one factor to consider. Any change in size, appearance, or other characteristics of a lump, local swelling, or lesion of any kind within the previous 6 weeks to 6 months should be reported to the physician.

Metastases. Sarcomas spread by hematogenous routes rather than through the lymphatics. The most common site of metastases for individuals with extremity sarcomas is the lung, followed by liver and other bone sites. Anyone diagnosed with soft tissue sarcoma has an approximately 50% chance of local recurrence, since these tumors spread along tissue planes and involve adjacent tissue. Lymph node involvement is uncommon and is often associated with poor prognosis.⁵⁷

MEDICAL MANAGEMENT

DIAGNOSIS. Physical examination, imaging studies (e.g., x-rays, computed tomography [CT], magnetic resonance imaging [MRI]), and biopsy are the primary diagnostic tools.

Physical Examination. Many tumors cannot be observed or palpated during the physical examination, but if a mass is present its characteristics must be noted. The presence of cafe au lait spots (associated with neurofibromatosis), skin ulceration, or neurologic findings (e.g., footdrop, calf pain) may be significant.

Since synovial sarcoma, rhabdomyosarcoma, and epithelioid sarcoma can metastasize via the lymphatics, examination of the lymph nodes is essential.⁴⁴ A tumor overlying bone and muscle can be evaluated by contracting the muscle and checking for movement or change in consistency of the tumor.

Radiographic Examination. Radiographs also help differentiate between bone and soft tissue involvement. Plain radiographs are a mainstay in the detection and evaluation of many skeletal tumors. In many cases, skeletal tumors are found incidentally on routine radiographs for associated injuries. The radiograph provides unique information concerning skeletal tumors. MRI has emerged as the most useful imaging tool for evaluating soft tissue tumors, although biopsy is essential for a definitive histologic diagnosis.

The location of the tumor will give many clues to the type of lesion (see Fig. 26-1). Some tumors develop exclusively in the epiphysis, whereas others develop in the diaphysis of long bones. Bone tumors tend to predominate in those ends of long bones that undergo the greatest growth and remodeling and hence have the greatest number of cells and amount of cell activity (shoulder and knee regions).

When small tumors, presumably detected early, are analyzed, preferential sites of tumor origin become apparent within each bone, as shown in Fig. 26-1. This suggests a relationship between the type of tumor and the anatomic site affected. In general, a tumor of a given cell type arises in the field in which the homologous normal cells are most active. These regional variations suggest that the composition of the tumor is affected or may be determined by the metabolic field in which it arises.

The effect that the tumor has on bone is described as destructive or lytic if the normal bone pattern is disrupted. Approximately 50% of the bone must be destroyed before the lesion can be detected. This may be evident by an irregular, erosive border surrounding the lesion; loss of trabeculae; or disruption of the cortex.

The response of surrounding bone to the tumor is another important feature to note on plain radiographs. Sclerotic borders give an indication of the growth characteristics of the tumor. A well-defined border with definite sclerotic margins is seen with a slow-growing lesion.

A tumor with a permeated or moth-eaten appearance (i.e., an area with multiple holes with irregular edges randomly distributed) with an expansive cortical shell indicates an aggressive malignant lesion (Fig. 26-2). Codman's triangle, a triangular-shaped area of reactive bone, is formed when the neoplasm has eroded the cortex, ele-

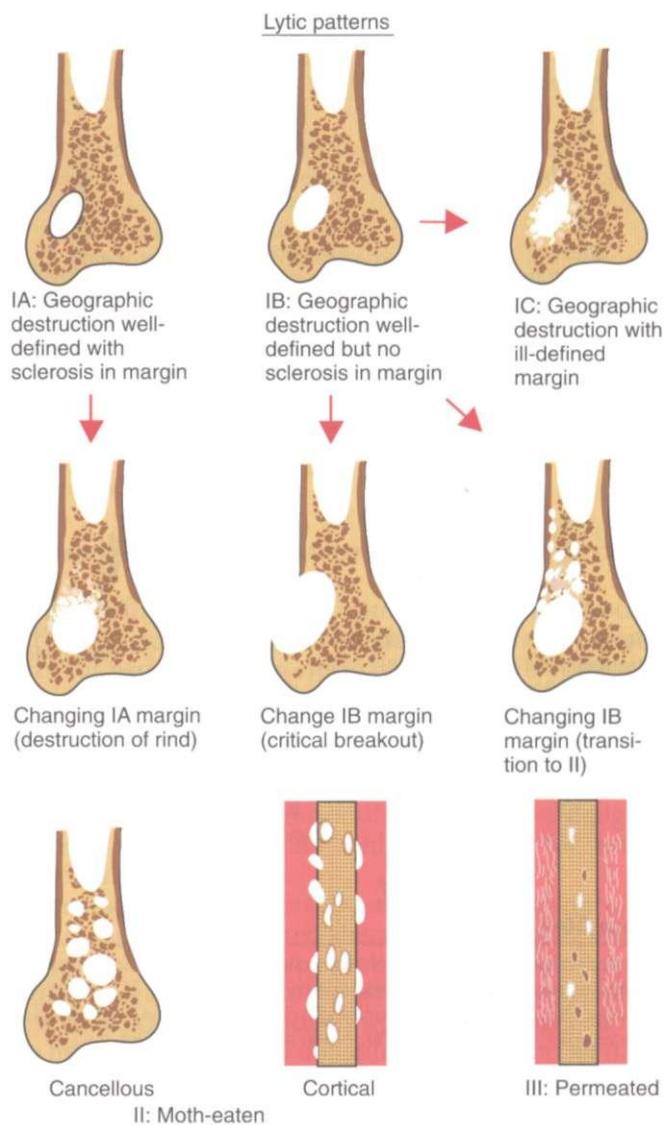


Figure 26-2

Schematic diagram of patterns of bone destruction (types IA, IB, IC, II, and III) and their margins. Arrows indicate the most common transitions or combinations of these margins. Transitions imply increased activity and a greater probability of malignancy. [From Madewell JE, Ragsdale BD, Sweet DE: Radiologic and pathologic analysis of solitary bone lesions: I. Internal margins, *Radiol Clin North Am* 19:715, 1981.]

vating the periosteum and producing reactive bone in the angle where it is still attached (Fig. 26-3).

The tumor's location, its effect on bone, and the local bone response to the lesion are just some of the radiographic features to be noted and will help in planning the rest of the evaluation.

Imaging. Radionuclide bone scan (scintigraphy), CT, MRI, angiography, and ultrasonography all have a place in the evaluation of bone lesions. *Bone scans* help locate skip metastases and the presence of bone metastases as well as metastatic bone lesions, and they assess tumor activity by the amount of radioisotope uptake in and around the tumor. Greater uptake indicates a more aggressive and malignant tumor.

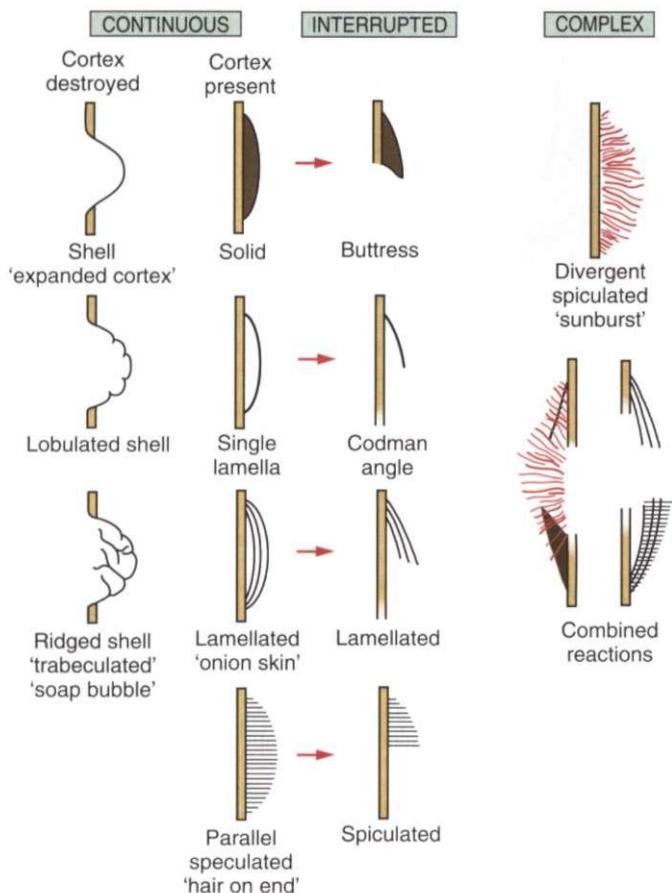


Figure 26-3

Schematic diagram of periosteal reactions. The arrows indicate that the continuous reactions may be interrupted. (From Ragsdale BD, Madewell JE, Sweet DE: Radiologic and pathologic analysis of solitary bone lesions: II. Periosteal reactions, *Radial Clin North Am* 19:749, 1981.)

CT scans are the most sensitive technique in detecting pulmonary metastases and also provide detailed information about the interaction between the tumor and various components of the bone (e.g., bone cortex, cancellous bone, reactive bone).

MRI is valuable in determining the extent of the marrow involvement and soft tissue masses outside the bone. The surgical team uses the information provided by an MRI to help visualize the involvement of the tumor and to plan limb salvage techniques.

Angiography plays an important role when limb-sparing surgery is being considered by providing information regarding the neovascularity of the tumor and mapping the vascular anatomy. **Ultrasonography** is a noninvasive imaging method that can be used to determine the size and consistency of a soft tissue mass. It may be used to establish intraarterial access for subsequent chemotherapy.⁵⁶

Biopsy. A biopsy is the definitive diagnostic procedure in both bone and soft tissue tumors and is usually performed after physical examination and imaging. This procedure can take many forms. The decision to do an open or incisional, core needle or fine-needle biopsy, or exci-

sional biopsy is based on the location and type of tumor.

Laboratory Tests. Various laboratory studies are used to detect, diagnose, and differentiate musculoskeletal neoplasms. Laboratory tests that may be of value include the complete blood count (CBC), urinalysis, erythrocyte sedimentation rate (ESR) (elevated in Ewing's sarcoma), serum calcium (elevated in metastatic bone disease), phosphorus (decreased with "brown tumors" associated with hyperthyroidism), alkaline phosphatase (elevated in osteosarcoma and Paget's disease), and serum protein electrophoresis (abnormal in metastatic bone disease).

Serum levels of alkaline phosphatase and calcium are often elevated with metastatic disease. Elevated alkaline phosphatase and lactic dehydrogenase (LDH) also occur with osteosarcoma (see Table 40-5).

STAGING AND GRADING. The purpose of much of the extensive workup once a tumor is identified is to determine the grade and stage of the tumor. Grading determines the histologic characteristics, such as the extent of anaplasia or differentiation of the cells from grade I, indicating cells that are very differentiated, to grade IV, those that are undifferentiated.

Staging of a tumor is concerned with the extent of its growth, both local and distant. The tumor-node-metastasis (TNM) staging system (see Box 9-2) reflects the degree of local extension at the primary tumor site, involvement of local nodes, and presence of metastasis. This classification group is strongly correlated with survival.

No universally accepted staging system for musculoskeletal neoplasms exists because of the low incidence of such tumors, their heterogeneous nature and unpredictable behavior, and disagreement as to the relative importance of prognostic factors.⁷⁶ The surgical staging system of Enneking is used for soft tissue and bone tumors and includes prognostic variables such as the histologic grade of the tumor, location of the tumor, and presence or absence of metastases (Table 26-3).³³ The American Joint Committee on Cancer (AJCC) also provides staging for soft tissue sarcomas.³ Staging helps in planning and standardizing the intervention strategy for these rare lesions.

Grading sarcomas has been one of the most important contributions pathologists have made to the treatment of sarcomas. There is not one single, individual grading scheme that works well for all sarcomas. Outcomes do not always correspond to grades, and some tumors are "ungradable." Diagnosis and grading are increasingly based on tissue obtained by core needle biopsy, which presents its own challenges.²⁹

TREATMENT. Once a tumor has been identified and staged, decisions about management and intervention can be considered. Treatment ranges from *observation* in the case of some benign bone tumors to *surgical intervention*. Principles of treatment are similar for some of the malignant bone tumors such as Ewing's sarcoma and osteosarcoma. Chemotherapy or surgery alone cures few people. Multimodal measures are needed for a long-term successful response.⁴

Complete tumor resection is the best surgical strategy and is attempted whenever possible. A marginal excision

Table 26-3 Enneking Staging System for Bone and Soft Tissue Tumors

Stage	Grade	Site
Stage 0	G ₀ (benign neoplasm)	
Stage IA*	G ₁ (low grade; locally inactive or latent tumor with low probability of metastases)	T ₁ (tumor is contained within the bone and involves only one compartment; i.e., single compartment = individual bone with its medullary cavity)
Stage IB	G ₁ (low grade; active, slow growth)	T ₁ (tumor extends into soft tissue)
Stage IIA	G ₂ (high grade; aggressive tumor with high metastatic potential)	T ₁ (tumor is contained within the bone)
Stage IIB	G ₂ (high grade; aggressive)	T ₂ (tumor extends beyond cortex into adjacent soft tissue, joint, epidural space, or other bone)
Stage III	Any grade	Metastases present

For staging according to the American Joint Committee on Cancer (AJCC), see National Comprehensive Cancer Network (NCCN) *Practice guidelines in oncology: soft tissue sarcoma*, vol 2, 2007. Available at www.nccn.org [page 28]. Accessed May 30, 2008.

From Dorfman HD, Czerniak B: *Bone tumors*, St Louis, 1998, Mosby.

*The suffixes A and B in this system indicate A, intracompartmental or B, extracompartmental lesions.

removes the tumor at its border, resulting in some of the tumor remaining. A wide excision (sometimes referred to as an en bloc incision) removes some of the normal surrounding tissue, leaving none of the tumor. Soft tissue sarcomas often require wide excision to reduce the recurrence rate. Radical resection may be required in which the entire involved bone and all the tissue compartments adjacent to the tumor are removed.

The spine, sacrum, pelvis, ankle, hand, mediastinum, and chest wall are just a few examples of bone cancer locations that make surgery difficult. When local excision has positive margins (not all the cancer was removed), local control may be increased with radiation and chemotherapy regimens. Immunotherapy and biotherapy are additional treatment methods used to prevent cancer recurrence.⁴

Limb salvage or limb-sparing procedures have largely replaced amputation as the principal method to eradicate primary sarcomas. The three phases to any limb-sparing procedure are (1) resection of the tumor, (2) reconstruction of the skeletal area involved, and (3) soft tissue and muscle transfer to complete the reconstruction.

Obtaining a wide surgical margin while preserving limb viability and function remains the challenge to the medical team, requiring close coordination of surgical, medical, and oncologic staff. Often, soft tissue reconstruction is necessary to provide wound coverage after tumor removal.

The use of *radiation* is recommended for some tumors such as Ewing's sarcoma and myeloma, but many malignant tumors are not affected by radiation. For some soft tissue tumors, adjunctive radiation is used in an attempt to limit the degree of surgical excision needed. In general, radiation is not recommended for benign conditions. Irradiation creates a suboptimal tissue bed susceptible to wound breakdown, seroma, and hematoma formation and infection, which may complicate the success of soft tissue reconstruction.¹⁰³

Because hematogenous spread occurs early in musculoskeletal tumors, *chemotherapy* is also used to help eradicate malignant tumors. For example, combination chemotherapy has resulted in increased survival rates in clients with Ewing's sarcoma and rhabdomyosarcoma as well. When chemotherapy is combined with other modal-

ties such as surgery and radiation, less toxic doses can be used.

Future improvements in treatment may come about as a clearer understanding of cellular and molecular pathways of pathogenesis is elucidated. The development of less toxic, more specific therapies remains an important challenge. Newer strategies under investigation include stem cell transplantation, gene therapy, biotherapy such as biologic response modifiers, antibody targeting of immunotoxins to tumor cells, and vaccines designed to elicit T-cell immunity with specificity for tumor peptides.

As discussed in Chapter 9, modern clinical oncology is moving toward tailored therapy according to genetic profiling. Treatment can be stratified with different intensities prescribed based on the genetic characteristics of the individual cancer. Individuals with a poor prognosis may do better with aggressive therapies such as stem cell transplantation for an improved cure rate. Gene silencing techniques may make it possible for the development of specific drugs that will target malignant cells without causing damage to normal tissue.⁷

PROGNOSIS. The prognosis is based in part on the type of tumor and whether it is benign or malignant. Survival is influenced by the grade of malignancy, tumor stage, and achieved surgical margins. A high grade and evidence of metastasis are associated with a poor prognosis for all neoplasms of bone or soft tissue regardless of the staging system that is used.⁷⁶ Tumor extension into both anterior and posterior columns of a vertebra is correlated with a poor outcome. Incomplete resections are more likely to result in tumor recurrence with subsequent surgeries and increased risk for complications and poor outcome.¹⁰⁶

Slow-growing tumors should be followed for prolonged periods, to determine the natural history and to identify the ultimate prognosis. Prognosis can vary from 3- to 5-year survival rates for clients with sarcomas and myeloma, to tumors that are asymptomatic. Successfully treated individuals may develop severe late effects, including second cancers (e.g., radiation-induced sarcomas or treatment-related leukemia), particularly after high-dose therapy with an alkylating agent, and chemotherapy-induced cardiomyopathy.⁹

RECURRENCE. People with recurrent disease generally have a poor prognosis but need to undergo a complete reevaluation of the extent of the disease to determine this more specifically. The prognosis depends on the type of therapy given previously, duration of remission, and extent of metastases. Recurrence or progression of tumor during initial therapy is generally incurable.⁶ The lung is the most common initial site of distant metastases for the majority of soft tissue and bone sarcomas. Other sites may include distant osseous sites, bone marrow, and lymph nodes.

the differential diagnosis of clients who have continued pain despite appropriate rest and treatment, further medical evaluation may be recommended, which may help reveal other pathology.

Rehabilitation

Currently, an achievable goal for the majority of people with soft tissue and bone sarcomas is freedom from disease with long-term resumption of nearly normal function. Therapists are key to the successful attainment of this goal for individuals who are undergoing treatment for primary musculoskeletal neoplasms. A comprehensive approach should be used to ensure that both psychosocial-spiritual aspects and physical problems are addressed. Occupational status, family structure, and age are all important factors.⁴⁶

Communication among the team members such as social workers, rehabilitation counselors, physicians, nurses, and therapists cannot be overemphasized. Communication is essential to coordination and follow-through in the treatment and rehabilitation program. A detailed approach to evaluation and treatment of clients with cancer should be formulated.⁷⁷

Therapists must understand the pathology of the tumor to understand the entire management plan. Specific interventions and goals can be developed with a thorough understanding of the pathology and the medical treatment being undertaken.

Early postoperative mobilization is essential to prevent complications such as pressure ulcers, deep venous thrombosis, lymphedema, pneumonia, muscle wasting, and generalized weakness associated with prolonged bed rest. Surgical procedures will have an effect on multiple organ systems, as will chemotherapy and radiation therapy. A detailed assessment and description of pain is always indicated, as described in Chapter 9, because pain control is a critical component in successful acute rehabilitation.

Many other factors to consider before implementing a treatment plan following orthopedic procedures include controlling compressive forces and weight bearing. Wolff's law demonstrates bone strength to increase in response to imposed mechanical stress, such as the pulling force of muscles and the pressures of weight bearing. When bone resorption exceeds bone formation, osteopenia develops.

After excision of cancerous bone (sometimes accompanied by muscle resection), mechanical weakening and resultant bone instability may limit or contraindicate weight bearing and use of the involved extremity.³⁴ Remaining muscles should be strengthened and substitution patterns of muscle control implemented and encouraged where necessary.⁴⁶

Other considerations in the rehabilitative process may include rehabilitation for the amputee, evaluation of adaptive equipment needs, ambulation devices, use of orthoses to support involved extremities, wound care management, environmental adaptations (e.g., access ramps, accessible doorways, bathroom grab bars), work site modifications, and quality-of-life issues. Client education is essential regarding proper body mechanics, energy conservation, side effects of

SPECIAL IMPLICATIONS FOR THE THERAPIST 26-1

Primary Tumors

PREFERRED PRACTICE PATTERNS

- 4B:** Impaired Posture
- 4C:** Impaired Muscle Performance
- 4G:** Impaired Joint Mobility, Muscle Performance, and Range of Motion Associated with Fracture
- 4I:** Impaired Joint Mobility, Motor Function, Muscle Performance, and Range of Motion Associated with Bony or Soft Tissue Surgery
- 4J:** Impaired Motor Function, Muscle Performance, Range of Motion, Gait, Locomotion, and Balance Associated with Amputation
- 5A:** Primary Prevention/Risk Reduction for Loss of Balance and Falling
- 5F:** Impaired Peripheral Nerve Integrity and Muscle Performance Associated with Peripheral Nerve Injury
- 6H:** Impaired Circulation and Anthropometric Dimensions Associated with Lymphatic System Disorders
- 7A:** Primary Prevention/Risk Reduction for Integumentary Disorders

See also discussion of various Special Implications for the Therapist in Chapter 9.

Screening Assessment

A therapist's involvement with clients with musculoskeletal neoplasms should begin with increased efforts directed toward early detection and education. Although many musculoskeletal tumors produce symptoms that are also present with more mundane conditions, careful examination and monitoring of a client's response to intervention may lead to earlier detection and treatment.

Assessing for past history of cancer, family history, and risk factors may alert the therapist to the need to screen further for medical disease. This is especially true in the case of musculoskeletal symptoms of unknown cause or when the individual does not respond to physical therapy intervention as expected for a musculoskeletal problem.

The presence of suspicious lymph nodes or aberrant soft tissue masses can be identified by the therapist but must be further evaluated by a physician. By including the possibility of a primary musculoskeletal tumor in

treatment (see Chapter 9), and prevention and recognition of complications such as infection (see Box 8-1), deep vein thrombosis (see Chapter 12), skin breakdown (see Chapter 10), lymphedema (see Chapter 13), scar formation, and the loss of flexibility, strength, balance, or endurance.

Prescriptive Exercise

As discussed, treatment of tumors can result in amputation (sometimes as extensive as a hemipelvectomy¹⁰), prolonged immobilization, bone or muscle resection, or extensive surgical reconstruction, all of which require consideration of postoperative complications (e.g., ischemia, infection) and the involvement of many different types of rehabilitation.

An individualized program of exercise that takes into account the diagnosis, underlying pathology, physical condition of the individual, effects of various interventions, strength deficits, structural instability, and so on is essential.

Toward this end, the therapist should be aware that studies are under way concerning the long-term effects of prosthetic knee replacement after wide resection, risk factors for prosthetic failure, and the most effective rehabilitative strategies after limb salvage procedures for bone tumors. Access to reports of early results and keeping abreast of this type of research effort will help therapists in making clinical decisions in the decade ahead. For example, for people undergoing quadriceps excision, long-term recovery is enhanced when closed kinetic chain knee extension exercises are performed.¹¹

Limb-sparing techniques (instead of amputation and/or disarticulation) such as the endoprosthetic replacement (distal femoral replacement with rotating hinge device; expandable for pediatric population) continue to undergo modification and refinement. Surgeons are attempting to minimize muscle resection, maintain mechanical function, and successfully reattach the muscles to the endoprostheses or to surrounding soft tissue structures, thereby reducing functional impairment.

Rehabilitation techniques for these clients remain conjectural. Despite loss of range of motion (ROM) and muscle power, most clients report good limb function (depending on their definition of "good"). Early gait training and weight bearing with active assisted range are indicated, and isometric exercises about the joint are recommended.¹²

General principles regarding energy conservation (see Box 9-8) and exercise for the person with cancer, especially following chemotherapy or radiotherapy, are discussed in Chapter 9. Additionally, the therapist must keep in mind safety guidelines for the use of laboratory values as discussed in Chapter 40 (see Tables 40-8 and 40-9) and Special Implications for the Therapist; Metastatic Tumors later in this chapter.

PRIMARY BENIGN BONE TUMORS

Bone Island

Overview and Incidence

Bone islands are oval, usually small, sclerotic lesions of bone. They are one of the most common benign bone lesions. Bone islands have been observed in all bones and may present as solitary or multiple lesions. The lesion is well defined and made up of cortical bone with a well-developed haversian canal system. The borders blend in with the surrounding bone. The presence of spicules of cortical bone extending from the margins to the surrounding trabeculae is characteristic. A prevalence of 14% has been reported for spinal bone islands.¹³

Clinical Manifestations

Bone islands are always asymptomatic. They are seen on radiographs as incidental findings.

MEDICAL MANAGEMENT

When the bone islands are small (less than 1 cm), diagnosis with plain radiographs is adequate. They are usually oblong and align themselves with the axis of the bone. A bone scan is usually normal, confirming the absence of malignancy. The emphasis is not on intervention but on the judicious use of diagnostic tools. Biopsies should be avoided, as they are usually unnecessary. Although some bone islands can enlarge, they do not transform into malignant lesions.

SPECIAL IMPLICATIONS FOR THE THERAPIST 26-2

Bone Islands

Bone islands are seen in radiographs of clients with a variety of musculoskeletal traumas. If clients are aware of these lesions, they should be reassured that they pose no significant health concern. Many physicians do not inform clients that bone islands are present. Care must be taken not to alarm the client. The word *tumor* is foreboding and should be used sparingly.

Osteoid Osteoma

Overview, Incidence, and Etiologic Factors

Osteoid osteoma is a rare benign vascular osteoblastic lesion. It is often found in the cortex of long bones such as the femur and tibia but may occur in almost any bone except the skull. The tumors occur near the end of the diaphysis (Fig. 26-4). Osteoid osteoma accounts for about 10% to 12% of benign bone tumors. Most of these lesions are found in men under the age of 25. The cause of osteoid osteoma remains unknown.

Pathogenesis

Pathologic study shows areas of immature bone surrounded by prominent osteoblasts and osteoclasts. The lesion is vascular, but no cartilage is present. Osteoid

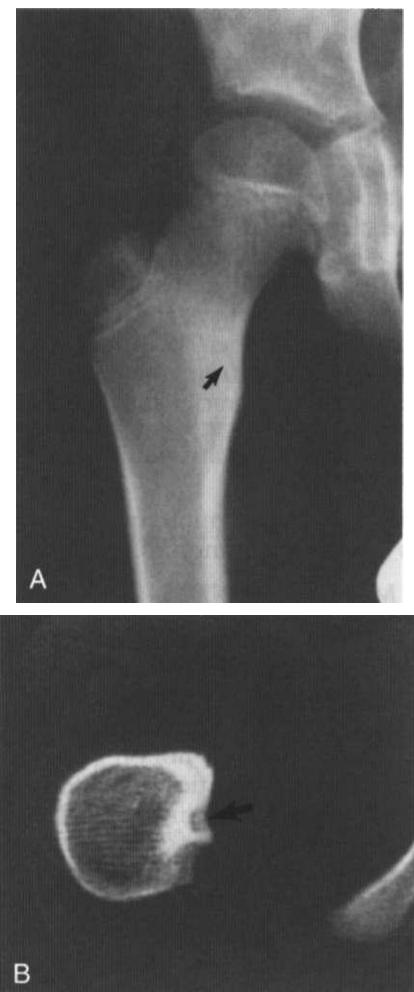


Figure 26-4

Osteoid osteoma. **A**, Bony sclerosis with cortical thickening is seen in this person with pain in the proximal femur. A faint lucency (arrow) can be seen in the area of sclerosis, which is the nidus of an osteoid osteoma. **B**, A computed tomographic (CT) scan through the nidus shows it to lie just dorsal to the lesser trochanter (arrow). This is a characteristic appearance of an osteoid osteoma with CT. (From Helms C: *Fundamentals of skeletal radiology: benign cystic lesions*, Philadelphia, 1989, WB Saunders.)

osteoma is probably a "reactive" bone-forming lesion rather than a true neoplasm, consisting of a small, round nidus (nest) of osteoid tissue surrounded by reactive bone sclerosis.

The zone of sclerosis is not an integral part of the tumor and represents a secondary reversible change that gradually disappears after the removal of the nidus. Osteoid osteomas are not progressive and rarely grow larger than 1 cm in diameter. They are uncalcified and therefore radiolucent.

Clinical Manifestations

Gradually increasing and persistent local pain in the area of the tumor, described as a dull ache, is the primary complaint. The pain is often worse at night and is characteristically relieved by aspirin and other nonsteroidal antiinflammatory drugs (NSAIDs). Pain relief may be due

to the inhibitory effect on prostaglandins produced by osteoid osteomas. Systemic symptoms are uncommon.

When the lesion is located near a joint, synovial effusion may develop and interfere with joint function, with local muscle atrophy developing.⁸⁴ A significant leg length discrepancy can occur, caused by the increased growth rate of affected bone in young individuals with open growth plates.

Though they occur rarely in the spine, if present, they are found in the lower thoracic or lumbar spine located in the posterior vertebral arch. The tumor can lead to joint pain and dysfunction, often delaying the diagnosis by masquerading as a more common problem such as an overuse syndrome.¹⁰⁵

Spine involvement may result in an unexplained backache or painful type of scoliosis with unilateral spasticity of spinal muscles. Some people with vertebral lesions may have clinical symptoms suggestive of a neurologic disorder, lumbar disc disease, or both.³⁰ In the case of spine involvement, neurologic deficits can be caused by extradural compression.¹⁰⁵

MEDICAL MANAGEMENT

DIAGNOSIS. Radiographs can be diagnostic for osteoid osteoma, although these are often normal early in the course. Later, a small (less than 1 cm) translucency or nidus forms, surrounded by sclerotic bone. When the tumor is not easily identified on radiographs (e.g., vertebral nidus), further testing is required, such as a bone scan (scintigraphy), which will show a focal uptake of the radiotracer. Plain films may not be adequate when the tumor is intraarticular; in such cases, CT or MRI can be used to accurately locate the nidus.

TREATMENT AND PROGNOSIS. In those tumors that are symptomatic, surgical excision of the nidus may be indicated. Since the tumor is small, excision is usually sufficient, although bone grafting may be needed depending on the size and location of the tumor. Recurrence is rare, and a full recovery is common. Osteoid osteomas have no potential for malignant transformation.¹⁰⁵ Differences in the expected rate of recovery may occur depending on the location of the tumor and the extent of excision required.

SPECIAL IMPLICATIONS FOR THE THERAPIST 26-3

Osteoid Osteoma

PREFERRED PRACTICE PATTERNS

See previous discussion and Special Implications for the Therapist: Primary Tumors earlier in this chapter.

The size and extent of the resection may mandate some activity restrictions or weight-bearing limitations if the risk of fracture exists. Monitoring bone healing with serial radiographs may help guide the weight-bearing progression. Intraarticular lesions certainly require more extensive rehabilitation for restoration of normal function.

Osteoblastoma

Overview

Osteoblastoma is another reactive but benign bone lesion similar to osteoid osteoma, only larger, with a tendency to expand. Some aggressive forms of osteoblastoma have been recognized. Unlike osteoid osteoma, osteoblastomas are often found in the spine, sacrum, and flat bones. Osteoblastomas involve the spine in approximately 35% of affected individuals, with the cervical spine affected in up to 39% of those people.²⁶

Those found in the long bones are usually in the diaphysis, although as with most tumors, they can be seen elsewhere (Fig. 26-5). The histologic makeup of osteoblastoma is very similar to that of an osteoid osteoma. In fact, sometimes it is size alone that differentiates the two, with osteoblastoma being the larger. The lesions are osteolytic and have a sclerotic border.

An aggressive osteoblastoma represents a borderline lesion between benign osteoblastoma and osteosarcoma. It is very rare and not discussed further in this text.

Incidence

Osteoblastoma occurs most often in men less than 30 years old, but cases have been reported in children as young as 2 years old and adults in their seventies.¹⁰⁵ Osteoblastoma is a rare osteoblastic tumor that makes up only 1% to 2% of all benign bone tumors.

Clinical Manifestations

When the tumor is located in the spine, the pedicles are often affected. Pain is the common presentation; it is not relieved with aspirin as occurs with osteoid osteoma. In general, the pain of osteoblastoma is not as severe as with osteoid osteoma, especially at night. Tenderness over the lesion is expected. With a spinal location, a functional scoliosis may be observed. In some cases a neurologic deficit may be present, which can mimic other, more common causes of nerve compression. Metastases and even death have been reported with the aggressive variant, which can behave in a fashion similar to that of osteosarcoma.

MEDICAL MANAGEMENT

DIAGNOSIS. Osteoblastoma is seen on plain radiographs, but when it is located in the spine, other imaging techniques are also useful. The lesion can have variations in its appearance. Often it looks like a large osteoid osteoma with a well-defined radiolucency in the central portion and a thin, sclerotic border. It also can be similar to an aneurysmal bone cyst that is expansile, lytic, and has a soap bubble appearance (see Fig. 26-3). CT and MRI are valuable in localizing the tumor and determining the extent of tissue involved. An aggressive lesion can expand beyond the cortex and involve soft tissue.

TREATMENT. In the long bones, curettage (scraping to remove the contents of the bone cavity) is often adequate. A wider excision is sometimes recommended because of the unpredictable nature of osteoblastoma and high recurrence rate (up to 15%). Recurrence is often attributed to incomplete resection.

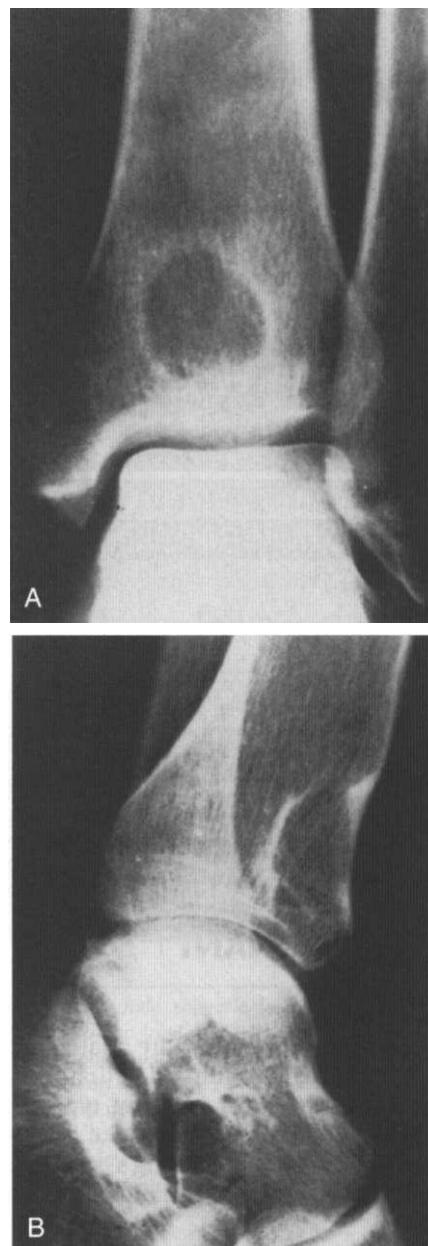


Figure 26-5

Genuine (conventional) osteoblastoma of the tibia in a 24-year-old woman. Anteroposterior (**A**) and lateral (**B**) radiographs show a round radiolucent lesion with slightly sclerotic borders at the lower and anterior aspect of the tibia. (From Gitelis S, Schajowicz F: Osteoid osteoma and osteoblastoma, *Orthop Clin* 20:320, 1989.)

Extramarginal excisions can result in the need to perform reconstructive procedures using autografts or allografts and internal fixation when the tumor is located in the diaphysis of long bones. If the joint is affected, implants may be needed. In the spine, removal of the tumor may lead to instability, which may require fusion and internal fixation.

In the cervical spine, their presence so close to neurovascular structures (e.g., vital blood vessels and the spinal cord) makes treatment of this problem very complex. Embolization (either partial or complete) may be done

first before surgery. Embolization is a nonsurgical, minimally invasive procedure using metal sponges or other devices to purposefully block blood flow. Surgery to remove the tumor is then done within 24 hours of the embolization. When necessary, bone defect filling and instrumented fusion may be done.²⁶

PROGNOSIS. Ninety percent to 95% of osteoblastomas are cured by the initial treatment,³⁵ but even with careful removal of the tumors, they recur in about 10% of affected individuals.³⁷ There is a risk of malignant transformation into an osteosarcoma, which can sometimes be determined early. Appropriate intervention with adjunctive chemotherapy or radiation is the current standard of care. Embolization before marginal resection may reduce the rate of recurrence.²⁶

SPECIAL IMPLICATIONS FOR THE THERAPIST 26-4

Osteoblastoma

PREFERRED PRACTICE PATTERNS

See previous discussion and Special Implications for the Therapist: Primary Tumors earlier in the chapter.

Surgical excision may be extensive. In the long bones the risk of pathologic fracture is often present. The use of external fixation, allografts, immobilization, and limited weight bearing is common.

PRIMARY MALIGNANT BONE TUMORS

Primary malignant bone tumors are relatively rare, representing about 6% to 7% of all pediatric neoplasms. Osteosarcomas are the most frequent type, followed by Ewing's sarcoma. Osteosarcomas make up over half of all malignant bone tumors; Ewing's sarcomas account for one-third of all primary malignant bone tumors (Table 26-4).³⁶

Osteosarcoma

Overview

Osteosarcoma, also known as *osteogenic sarcoma*, is an extremely malignant tumor with destructive lesions and

abundant sclerosis, both from the tumor itself and from reactive bone formation. A characteristic of osteosarcoma is the production of osteoid by malignant, neoplastic cells. This is seen on photomicrographs and is one of the features used to help differentiate this tumor. Resected specimens usually show that the cortex has been broken by the destructive tumor. Although various types of osteosarcoma exist, including parosteal, periosteal, telangiectatic, and small cell, only the most common, conventional intramedullary osteosarcoma, is discussed here.

Incidence

Osteosarcoma is the second most frequent malignant condition of bone, accounting for 15% to 20% of all primary bone tumors; only myeloma is seen more often. Osteosarcoma occurs most often in male children, adolescents, and young adults under the age of 30, with a peak frequency during the adolescent growth spurt and another smaller peak in people older than 50 years.³⁰

Osteosarcoma can develop in many bones but is more common in long bones, the site of the most active epiphyseal growth. The distal femur (knee) is the most common site, followed by the proximal tibia and proximal fibula (50% are located in the knee region), proximal humerus, pelvis, and occasionally the mandible, vertebrae, or scapula.

Etiologic and Risk Factors

Osteosarcomas can be primary or secondary. Certain genetic or acquired conditions increase the risk of osteosarcoma (e.g., retinoblastoma, Paget's disease of bone, enchondromatosis, ionizing radiation). Alterations of multiple chromosomes and their extra copies have been demonstrated but only in distinct clinical subsets of osteosarcoma. Secondary osteosarcomas are those that develop from other lesions such as Paget's disease, chronic osteomyelitis, osteoblastoma, or giant cell tumor.

Pathogenesis

The mechanisms involved in the development of osteosarcomas are still obscure. Osteosarcoma originates from primitive (poorly differentiated) cells from the osteoblasts of the mesenchyme. This suggests that early osteoprogenitor cells with the ability for chondroblastic differentiation are affected in the development of osteosarcoma. Whether a protective mechanism in the process of bone development is turned off (suppressed) or differentiation activity is altered remains unknown.

Table 26-4 Malignant Bone Tumors*

Tumor	Age (yr)	Sex Ratio (M/F)	Common Sites	Location
Osteosarcoma	10-25	2:1	Long bones of extremities (knee joint), jaw	Metaphysis
Ewing's sarcoma	10-20	2:1	Long bones; multiple sites	No predilection for specific part of the bone; diaphysis most common
Chondrosarcoma	50+	2:1	Pelvis, ribs, vertebrae, long bones (proximal)	Diaphysis or metaphysis
Chordoma	65+	1:1	Skull, sacrum, spine (cervical, lumbar)	Axial skeleton, medullary canal
Giant cell tumor	20-40	1:1	Long bones (knee joint)	Epiphyses

Adapted from Damjanov I: *Pathology for the health professions*, ed 3, Philadelphia, 2006, Saunders.

*In order of descending frequency.



Figure 26-6

Osteosarcoma. An extremely sclerotic lesion in the proximal tibia of a child is noted, which is characteristic of an osteogenic sarcoma. (From Helms C: *Fundamentals of skeletal radiology: benign cystic lesions*, Philadelphia, 1989, WB Saunders.)

Osteosarcoma grows rapidly and is locally destructive. It may be osteosclerotic (producing considerable neoplastic or tumor bone), or it may arise from more primitive cells and remain predominantly osteolytic, eroding the cortex of the metaphyseal region and resulting in pathologic fracture. As it continues to grow beyond the confines of the bone, the tumor lifts the periosteum, resulting in the formation of reactive bone in the angle between elevated periosteum and bone called *Codman's triangle* (see Fig. 26-3).

Clinical Manifestations

Osteosarcoma seems to appear in bones undergoing an active growth phase and appears at the epiphyseal plate of rapidly growing bone in adolescents. The long bones such as the distal femur, proximal humerus, and proximal tibia have a relatively more active growth period than other bones, which makes them more vulnerable (Fig. 26-6).

Pain that has continued for several weeks to months is the presenting complaint. The tumor is often located in the metaphysis but does not cross the physis. Even so, joint pain and tenderness can be present as the lesion penetrates the cortex and invades the joint capsule, also spreading to other nearby structures (e.g., tendons, fat, muscles).

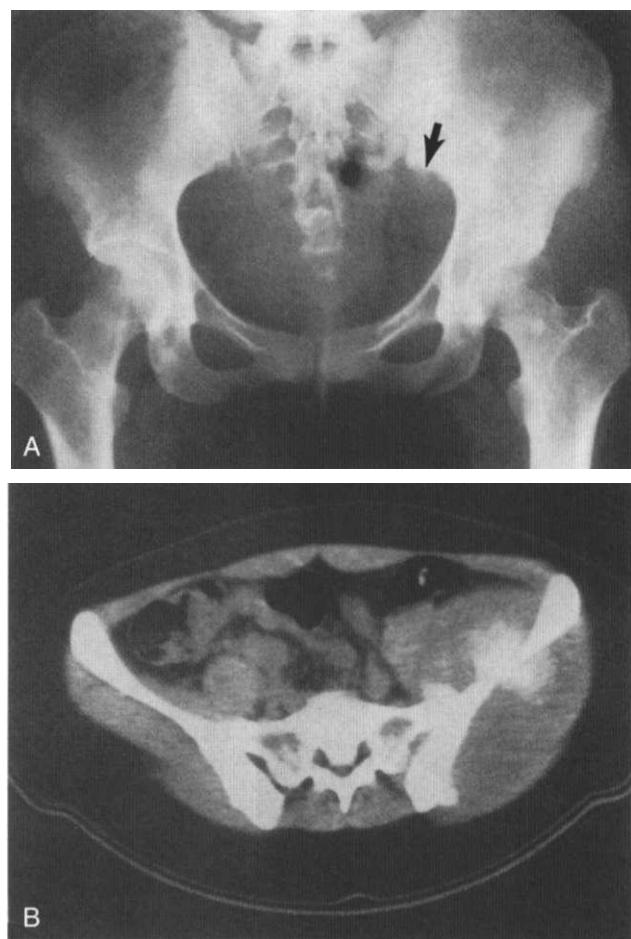


Figure 26-7

Osteosarcoma. **A**, A subtle sclerotic lesion is seen in the left ilium adjacent to the sacroiliac joint that was initially diagnosed as osteitis condensans illi, a benign entity. Because of persistent pain, the person returned for a follow-up visit, and a small amount of cortical destruction on the pelvic brim was noted (arrow). **B**, A computed tomographic scan was performed, which showed a large tissue mass and new bone tumor around the ilium, which is characteristic of an osteogenic sarcoma. (From Helms C: *Fundamentals of skeletal radiology: benign cystic lesions*, Philadelphia, 1989, WB Saunders.)

Since osteosarcoma can be a rapidly destructive tumor, the pain increases, and swelling may develop in just a few weeks, accompanied by some limitation of motion. Systemic symptoms are rare, although occasional fever may occur. This aggressive neoplasm is very vascular, and the overlying skin is usually warm. Metastases appear in the lungs early in 90% of cases and occur in 20% to 25% of cases at the time of presentation.⁴

MEDICAL MANAGEMENT

DIAGNOSIS. Diagnosis is often delayed, especially when swelling is minimal, as is often the case in early stages.⁴ X-rays should be done with any complaint of bone pain, especially around the knee. Plain radiographs often reflect dramatic changes and obvious tumor formation, but important findings can also be subtle.

CT scans and especially MRI are used to evaluate the extent of disease. In Fig. 26-7 plain films of a pelvis demonstrate minimal changes that could easily be dismissed

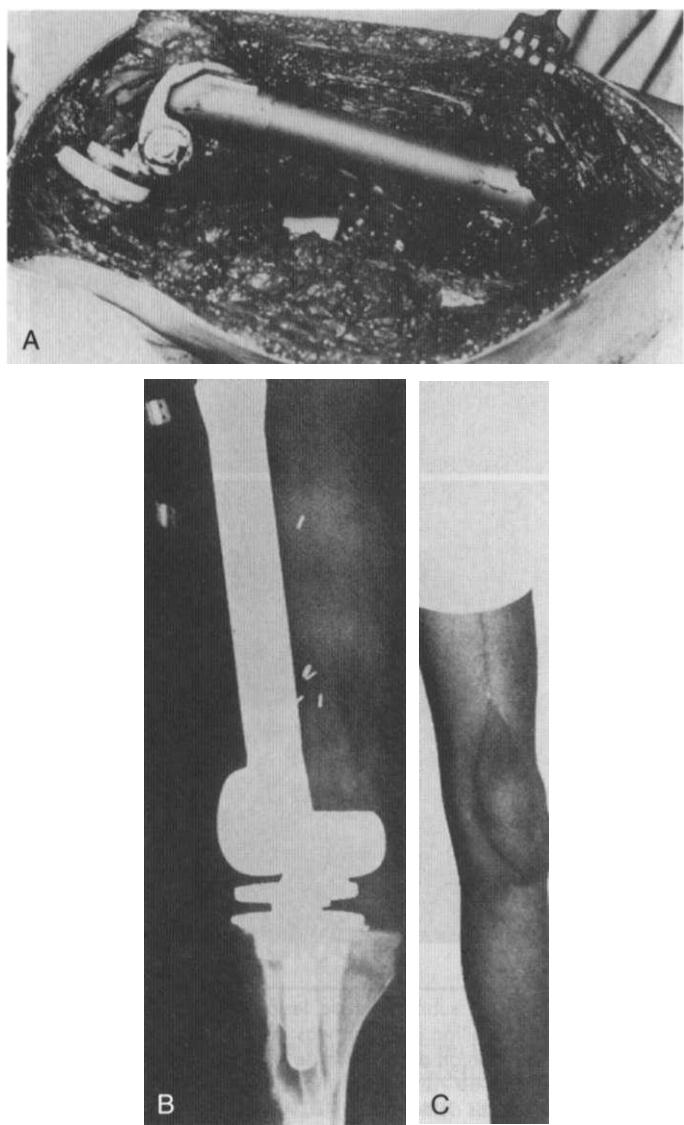


Figure 26-8

Osteosarcoma of the distal femur in a 17-year-old boy. **A**, Intraoperative photograph following resection of the distal femur. **B**, Postoperative radiograph of custom-made, rotating-hinge prosthesis. **C**, Follow-up clinical photograph (3 years after surgery). Soft tissue coverage of the prosthesis by latissimus dorsi myocutaneous free flap with acceptable cosmesis. (From Klein M, Kenan S, Lenis M: Osteosarcoma: clinical and pathologic considerations, *Orthop Clin* 20:343, 1989.)

as insignificant. The CT scan, however, reveals a large osteosarcoma involving the ilium. More commonly, radiographs show a rapidly growing lesion with poorly defined margins, and a permeated or moth-eaten appearance in the lytic area.

A biopsy is performed to determine the histologic makeup of the lesion. Serum alkaline phosphatase level is often elevated, but this is not diagnostic.

TREATMENT. Because osteosarcoma is relatively resistant to radiation therapy, complete surgical removal of the primary tumor and any metastases is essential to cure.⁶ The current surgical thinking is to use limb-sparing techniques (segmental resection and replacement with bone graft or implant) whenever possible (Fig. 26-8).

The use of a noninvasive expandable prosthesis for skeletally immature children and adolescents following limb salvage for malignant tumors in the leg has been reported. The Repiphysis prosthesis for pediatric osteosarcoma is an expandable metal rod that replaces the bone and does not require repeated procedures to lengthen as the child's other leg grows. Painless electromagnetic rays are used to expand the rod slowly without compromise to the surrounding skin and muscle.⁴³

Another creative procedure called *rotationplasty* removes the cancerous portion of the bone below the knee then uses the remaining bottom segment of the leg and ankle joint as a new knee. The surgeon removes the affected bone, rotates the lower portion of the leg 180 degrees so the foot faces the opposite direction, and reattaches it to the upper femoral area. Nerves, muscles, and blood supply are preserved. The posterior-facing ankle now functions as a weight-bearing knee joint in a specially fitted prosthesis (Fig. 26-9). Although the outcome is visually unusual, such a procedure improves gait and knee function and prevents amputation.¹⁰⁰

When the child takes off the prosthesis, the cosmesis of seeing a foot turned backward may not be acceptable. In such cases, children and families may still prefer endoprosthetic reconstruction or even amputation. Younger children (less than 10 years old) seem better able to adapt psychologically and physically to the rotationplasty.⁶⁴

The tibia turn-up is another important procedure that is an option in cases of osteosarcoma (Fig. 26-10). The leg is amputated above the knee, and the tibia bone from the lower leg is inverted, or turned up, making it possible for the ankle end of the tibia to be fused to the bottom of the femur. The muscles are then sutured back onto the tibia.^{19,20}

Tibia turn-up is an alternative that people may consider when the appearance of a rotationplasty seems too extreme. Tibia turn-up is also an option when cancer occurs in the thigh that might otherwise require a high-level above-knee amputation (Fig. 26-11). By having the tibia fused to the femur, these individuals now have a long residual limb that will be easier to fit with a prosthesis, providing them with increased function. Although these individuals will wear an above-knee prosthesis with a mechanical knee, their comfort and mobility will usually exceed that of above-knee prosthesis users with a short residual limb.¹⁹

Rotationplasty and tibia turn-up techniques both make allowances for the natural process of growth that extends into young adulthood. Before surgery, x-rays and other tests are performed to determine how much growth will occur in the sound leg. Growth plates at the hip account for 30% of growth in the femur, while plates at the knee contribute the remaining 70%. In the lower leg, plates at the ankle account for 40% of growth in the tibia and fibula, while those at the knee contribute the remaining 60%. Therefore, if the growth plates on either side of the knee are completely removed during amputation, the surgeon may choose to make the residual limb a little longer to compensate. Oftentimes, however, a growth plate can be salvaged, enabling the femur to grow naturally. If, in the future, the amputated side begins to grow

**A****B****Figure 26-9**

Rotationplasty for osteosarcoma. The primary reason for rotationplasty is to enhance the person's mobility as a prosthesis user. Placing the ankle joint in the position of the knee creates a functional, natural knee, and the toes provide important sensory feedback to the brain. **A**, Rotationplasty removes the cancerous portion of the femur (proximal to the midshaft of the femur), then rotates the lower portion of the leg 180 degrees so the foot faces the opposite direction. The proximal tibia is fused to the distal femur; the remaining bottom segment of the leg and ankle joint function as a new knee. **B**, Standing on the prosthesis with the cover on it. (Courtesy Kevin Carroll, Hanger Prosthetics and Orthotics, Orlando, FL.)

**Figure 26-10**

Tibia turn-up procedure. Sarcoma just below lesser trochanter in a 7-year old girl. There were three surgical options for this client: (1) transtrochanteric amputation (major loss of limb), (2) tibia turn-up procedure (shown here), or (3) rotationplasty (see Fig. 26-9). The tibia turn-up procedure was chosen for cosmetic reasons with excellent functional outcomes with the use of a prosthesis. The tibia turn-up procedure avoids high-level transfemoral amputation and provides an outcome similar to that of a knee disarticulation amputation. (Courtesy Kevin Carroll, Hanger Prosthetics and Orthotics, Orlando, FL.)

**Figure 26-11**

Rotationplasty or tibia turn-up can be a good alternative to high-level above-knee amputations such as this. (Courtesy Kevin Carroll, Hanger Prosthetics and Orthotic, Orlando, FL.)

more than desired, the surgeon can stop the growth by suturing the growth plate.¹⁹

Many factors such as age, remaining growth, expected functional outcome, and prognosis are considered in making the best treatment choices for osteosarcoma. Chemotherapy often precedes surgery. Chemotherapy is evaluated by its effect on the client and tumor. Chemotherapy may also help lessen the chance of skip lesions, or multiple foci of tumor that can cause recurrence of the tumor after surgery. New discoveries about the molecular genetics of osteosarcoma eventually may lead to effective gene therapy for osteosarcoma.

PROGNOSIS. Until the 1970s, surgery for osteosarcoma consisted of amputation or disarticulation. The 5-year survival rate at that time was about 20%, with frequent pulmonary micrometastasis.²⁵ Today the use of adjunctive (preoperative) chemotherapy with surgery results in 5-year cure rates of 70% to 80%. The majority of affected individuals (more than 90%) have limb-sparing surgery.¹⁰¹ Surgery alone will probably allow pulmonary metastasis to occur. Individuals who develop lung metastases have a 20% to 30% 5-year survival rate.

Even with chemotherapy, the outcome is dependent on the stage at diagnosis and the ability of the surgeon to achieve a tumor-free margin. Local recurrence is a poor prognostic sign. Local recurrence of craniofacial lesions after treatment is 50% for mandibular tumors and even higher for maxillary and skull lesions (80% and 75%, respectively); metastases occur in about one third of craniofacial osteosarcomas.³⁰

In older people, osteosarcoma may develop as a complication of Paget's disease, in which case the prognosis is extremely grave.⁸⁴

SPECIAL IMPLICATIONS FOR THE THERAPIST 26-5

Osteosarcoma

PREFERRED PRACTICE PATTERNS

See previous discussion and *Special Implications for the Therapist: Primary Tumors* earlier in the chapter.

Malignant neoplasms usually necessitate aggressive intervention, and therefore rehabilitation is more intensive, prolonged, and individualized. Extensive surgery, such as limb-sparing techniques, has provided therapists with an opportunity to assist these clients in maximizing their function (Fig. 26-12). When musculoskeletal structures are involved, it is important to be aware of reduced tensile strength of malignant tissue as compared with uninvolved bone tissue.

Preoperative Assessment¹⁹

People who have been diagnosed with cancer and are faced with the impending amputation of a leg find themselves in a state of shock and grief. Parents of children who are born with a lower limb difference experience similar emotions. Under these circumstances, it is difficult to talk openly with a surgeon about amputation and to meet with a prosthetist to discuss future prosthetic needs. The fact that the major-

ity of these clients are children, teenagers, and young adults only increases the level of anxiety. Yet beneath the surface of these painful conversations are seeds of hope: amputation can save a person's life, preoperative consultations can help people make better decisions, and children who are fitted early with a prosthesis can lead very active lives.¹⁹

Knowing what the options are before surgery can enable individuals and their families to make the best choice for each specific situation. Not all surgeons are aware of limb-sparing procedures, some of which involve bone replacement with human or laboratory-grown bone, or prosthetic implants. Some surgeons may make what they consider the most "conservative" recommendation: a standard above-knee amputation at a point significantly higher than the site of the cancer. To be as informed as possible, the best course of action is to consult with one or more orthopedic oncologists at a comprehensive cancer center. Parents of children with congenital lower limb differences should seek the advice of a pediatric orthopedic physician. Treatment of these conditions requires highly specialized physicians and medical facilities.¹⁹

The therapist can be instrumental in discussing the Van Nes rotationplasty and tibia turn-up, two surgical procedures that may increase client mobility as prosthesis users. At first glance, both procedures appear somewhat extreme and are difficult for people to visualize. However, the long-term positive results experienced by most people are impressive. Ideally, rotationplasty gives the affected individual a level of function that may be equivalent to that of a below-knee prosthesis user, even though he or she has experienced an above-knee amputation. The goal of tibia turn-up is to provide the person who faces a high-level, above-knee amputation with a longer, stronger residual limb onto which the prosthetic socket can lock.¹⁹

Postoperative Rehabilitation

Since these tumors are treated at regional medical centers, the initial phases of rehabilitation may be implemented by therapists with a great deal of experience working with clients with malignant neoplasms and those who have undergone various reconstructive surgical procedures.

When the client returns home a local therapist may be called on to continue the rehabilitation program. Communication with the therapist at the regional medical center to confirm initial management plan, progression, and prognosis is recommended.

The use of a new tool, Functional Mobility Assessment (FMA), has been examined in clients with lower extremity sarcoma. FMA requires the individual to physically perform functional mobility tasks and provides a reliable and valid measure of objective functional outcome and may help therapists guide children and adolescents in returning to daily activities.⁶⁴

As might be expected, rehabilitation following limb-sparing surgery or rotationplasty focuses on retraining muscles and increasing weight bearing and balance, ROM, and strength.

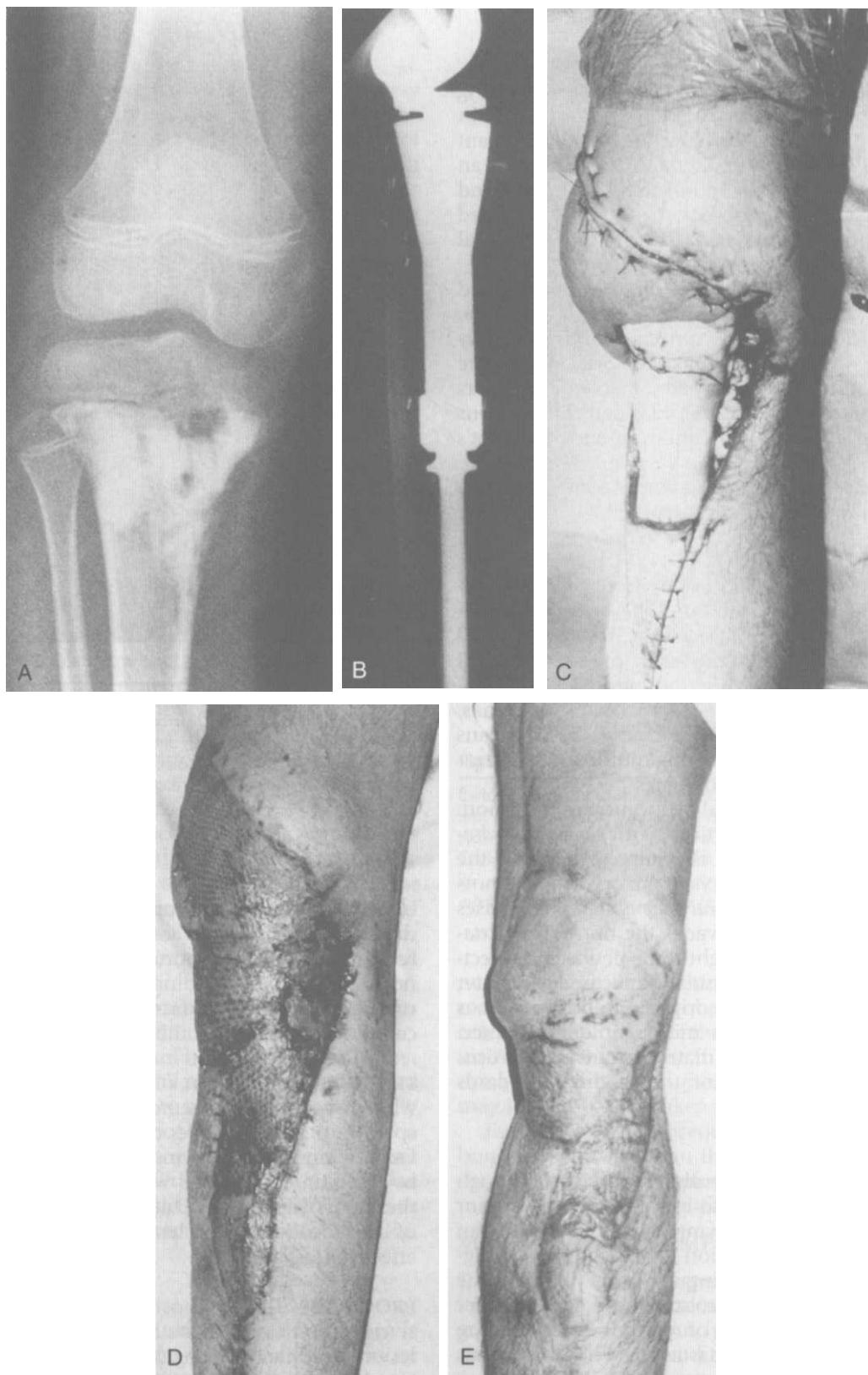


Figure 26-12

Use of a free muscle transfer to salvage an infected massive prosthesis. **A**, Preoperative radiograph of a 9-year-old boy with an osteosarcoma. **B**, After radical resection, an expandable prosthesis was inserted. **C**, When infection occurred, with subsequent breakdown of the wound, the prosthesis was removed, and the area was widely débrided. A spacer of antibiotic-impregnated methacrylate was inserted. **D**, Infection was controlled, and the knee was reconstructed with another prosthesis and a free latissimus transfer. **E**, A satisfactory result was obtained, sparing the leg. (From Hausman M: Microvascular applications in limb-sparing tumor surgery, *Orthop Clin* 20:434, 1989.)

Chondrosarcoma

Overview and Incidence

Chondrosarcoma is usually a relatively slow-growing malignant neoplasm that arises either spontaneously in previously normal bone or as the result of malignant change in a preexisting nonmalignant lesion, such as an osteochondroma or an enchondroma. The pelvic and shoulder girdles are common sites of tumor and related pain, as are the proximal and distal femur, proximal humerus, and ribs.

Chondrosarcoma is the second most common solid malignant tumor of bone in adults (after osteosarcoma, third after myeloma). These tumors can be primary or secondary. Primary chondrosarcomas are more common, but their origin is idiopathic. Secondary tumors are those that arise from previously benign cartilaginous tumors or from a preexisting condition such as Paget's disease.

Men in their forties to sixties are those most likely to be affected by primary chondrosarcoma.

Pathogenesis

In general, chondrosarcomas develop from cells committed to cartilaginous differentiation. The neoplastic cartilaginous cells produce cartilage rather than the osteoid seen with osteosarcoma. Alterations of programmed cell death (apoptosis) may play a significant role in the pathogenesis of low- to intermediate-grade chondrosarcomas, whereas high-grade lesions most likely develop by means of a multistep mechanism involving multiple transforming genes and tumor suppressor genes.³⁰

Chondrosarcoma is classified by location of the lesion: central, peripheral, or juxtacortical. With *central chondrosarcoma*, the neoplastic tissue is compressed inside the bone, and areas of necrosis, cystic change, and hemorrhage are common. *Peripheral chondrosarcoma* arises outside the bone and then invades the bone. The *juxtacortical chondrosarcoma* is thought to be periosteal (affecting the periosteum) or parosteal (affecting the outer surface of the periosteum) in origin. Chondrosarcomas can be graded based on their microscopic appearance. The presence of a chondroid matrix, extent of necrosis, and type of cells are some of the grading standards used.

Clinical Manifestations

Pain is the most common presenting complaint, although this is a slow-growing tumor, so in some cases the tumor can exist for years without symptoms. The lesion can range from a slow-growing lesion to an aggressive malignancy capable of metastasizing to other organs. The metastatic potential of chondrosarcoma is less than for osteosarcoma. The majority of chondrosarcomas are grade I or II, which rarely metastasize. When metastasis occurs, it is via the hematogenous route to the lungs, others bones, or organs.

MEDICAL MANAGEMENT

DIAGNOSIS. On radiograph the tumor often shows an expansile lesion in the diaphysis of long bones with cortical thickening and destruction of the medullary

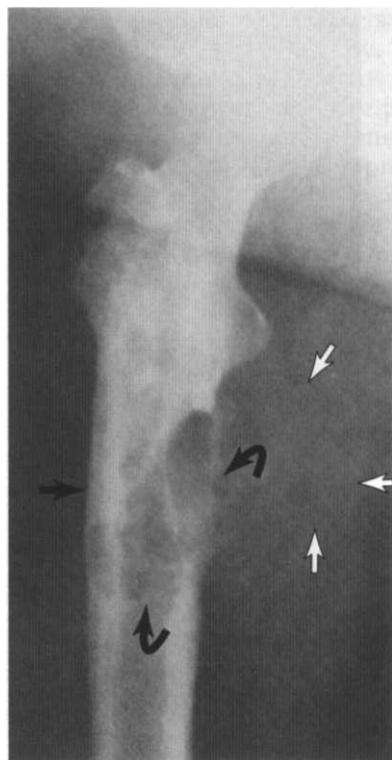


Figure 26-13

Characteristic radiographic features of chondrosarcoma include thickening of the cortex (closed arrow); destruction of the medullary and cortical bone (curved arrows); and soft tissue mass (open arrows). Note the characteristic punctate calcifications in the proximal part of the tumor. (From Greenspan A: Tumors of cartilage origin, *Orthop Clin* 20:359, 1989.)

bone (Fig. 26-13). The appearance is somewhat variable depending on the rate of growth and the host bone response. Biopsy is important not only for accurate diagnosis but also for guiding treatment. Chondrosarcoma can develop on the surface of bone or present as multicentric, involving several bones.

TREATMENT. Treatment of chondrosarcoma is surgical, with complete tumor removal. Wide resections or limb-sparing procedures are often required, and internal fixation after tumor removal to prevent fracture may be recommended. As with osteosarcoma, radiation therapy is ineffective. Due to the slow-growing nature of this malignancy, chemotherapy is limited in its effectiveness.

PROGNOSIS. The prognosis is dependent on the aggressiveness and stage of the lesion. For example, a grade I lesion is unlikely to metastasize, and if it is completely resected, a good prognosis follows with 80% chance of cure. A grade III lesion is much more likely to metastasize. Undifferentiated lesions found in the pelvis or any bone where complete resection is difficult have a poorer prognosis. Secondary chondrosarcomas are usually of a low-grade malignancy and have a good prognosis with adequate intervention.

Ewing's Sarcoma

Overview and Incidence

Ewing's sarcoma is a malignant nonosteogenic primary tumor that can arise in bone or soft tissue.⁴⁴ It is the second most common primary malignant bone tumor of children, adolescents, and young adults and the fourth most common overall, although it only accounts for approximately 3% of all pediatric malignancies.⁵¹ Most tumors of this type (80%) occur in young people under the age of 20; approximately 225 new cases are diagnosed each year in the United States.⁹ Ewing's sarcoma has been reported in children as young as 5 months, but occurs rarely in the black population.

Although this type of bone tumor was noted as early as 1866, it was not until 1921 that James Ewing described his experience with the lesion. The pelvis and lower extremity are the most common sites. Unlike with many tumors, no predilection for a certain part of the bone is evident.

Risk Factors, Etiologic Factors, and Pathogenesis

Based on different levels of scientific evidence, the main risk factors related to Ewing's sarcoma include Caucasian race, parental occupation (exposure to pesticides, herbicides, fertilizers), and parental smoking.³⁶

Cytogenetic studies show that 95% of these tumors are derived from a specific genetic translocation between chromosomes 11 and 22, although the molecular oncogenesis remains unknown. The formation of the EWS-FLI1 fusion protein from the chromosomal translocation contributes to the pathogenesis of Ewing's sarcoma by modulating the expression of target genes.

Ewing's sarcoma is composed of islands of small, uniformly round cells of neural origin characterized by strong membrane expression of CD99.^{9,27} It is the least differentiated tumor in a group of neuroectodermally derived lesions in bone and soft tissue. These morphologic features are characteristic enough to serve as useful diagnostic markers.³⁸

The tumor is soft, sometimes viscous, with hemorrhagic necrosis caused by the rapid tumor growth outpacing its blood supply. The cortical bone is affected through the haversian canals. The medullary cavity is affected, and infiltration of the bone marrow can progress extensively without radiographic evidence of bone destruction. When the tumor perforates the cortex of the bone shaft and elevates the periosteum, the consequent reactive bone formation causes layered calcification referred to as an "onion-skin" appearance seen radiographically (Fig. 26-14).

Clinical Manifestations

As with other malignant bone tumors, local bone pain is the most common presenting symptom after an injury (e.g., sports-related injury), a factor that sometimes delays diagnosis. Ewing's sarcoma presents most often in the long (tubular) bones (e.g., femur, tibia, fibula, humerus) and the pelvis. Less often, the ribs, scapula, vertebrae, feet, and craniofacial bones are involved.

Swelling occurs in approximately 70% of all cases, and both pain and swelling are usually progressive. The pain



Figure 26-14

Ewing's sarcoma of the humerus. Bone destruction is seen in the proximal metadiaphysis. The cortex is infiltrated and a multilaminar periosteal reaction with an onion-skin appearance is present medially; Codman's triangles are present on the lateral aspect. (From Grainger RG, Allison D: *Grainger and Allison's diagnostic radiology: a textbook of medical imaging*, ed 4, Philadelphia, 2001, Churchill Livingstone.)

may be intermittent, which also delays diagnosis. There may be a palpable or observable mass. Pathologic fractures occur at the site of the tumor in long bones but only in 5% to 10% of cases. In young children, feulike symptoms, including a low-grade fever, may be present, which may lead to the mistaken diagnosis of osteomyelitis.⁴⁵

Ewing's sarcoma frequently metastasizes to other bones, especially late in the course of the disease. When the cervical or lumbar spine is involved, neurologic deficit may lead to a mistaken diagnosis of disc disease.⁴⁵

MEDICAL MANAGEMENT

DIAGNOSIS. Anyone suspected of having Ewing's sarcoma is staged for both local and metastatic disease. Radiographs show an obvious lytic process with a moth-eaten appearance involving a diffuse area of bone (Fig. 26-15). As mentioned, an onion-skin formation may be seen, which is due to layers of reactive bone (see Fig. 26-14). On radiographs the appearance may not differentiate this lesion from osteomyelitis or osteosarcoma.

An elevated ESR may be noted but is not diagnostic. CT, MRI, and bone scans can help diagnose and define the extent of the tumor. MRI is more sensitive than CT

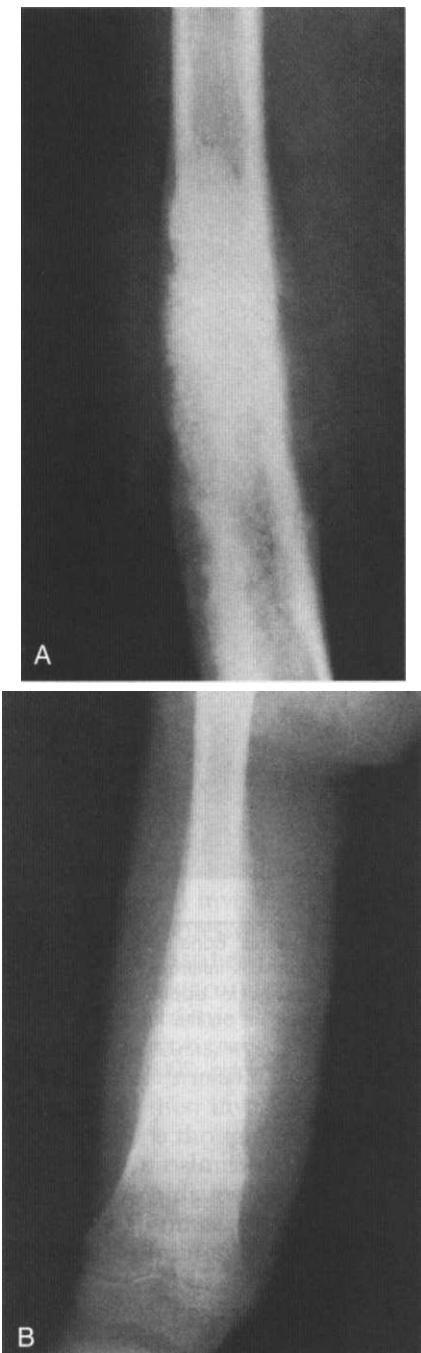


Figure 26-15

Ewing's sarcoma. **A**, A mixed lytic-sclerotic lesion in the femur of a child with periostitis that is amorphous and sunburst that is characteristic of Ewing's sarcoma. **B**, This is a predominantly sclerotic process with large amounts of sunburst periostitis in the diaphysis of a femur that, on biopsy, was found to be Ewing's sarcoma. [From Helms C: *Fundamentals of skeletal radiology: benign cystic lesions*, Philadelphia, 1989, WB Saunders.]

scan in assessing soft tissue involvement and bone marrow spread. The MRI or CT scan is repeated after several cycles of chemotherapy to better assess the response to chemotherapy and help plan further treatment of the local site with radiation or surgery.

Metastatic disease is evaluated at the time of presentation with chest x-ray or chest CT scan looking for pulmo-

nary metastases. Bone scan to detect bone metastases, bone marrow aspirate at a site far from the local tumor site, and tumor biopsy are used to assess the spread of the disease and help with staging and treatment planning. Researchers are investigating the use of real-time polymerase chain reaction (PCR) to provide accurate quantitative estimates of circulating tumor burden in this disease.⁶⁷

TREATMENT. Significant progress has been made in the management of Ewing's sarcoma in the past 25 years. Cure requires intensive therapy to control both local and distant disease. Multimodal treatment can include chemotherapy, radiotherapy, immunotherapy or biotherapy, embolization, and surgery.⁵⁹ Local tumors are very responsive to high-dose radiation. In some cases, radiation is associated with the additional morbidities of second malignancy and a significant adverse impact on both cardiac and pulmonary function.⁸⁹

Effective combination chemotherapy has been developed to eradicate distant metastases. Selective surgery in the treatment of primary Ewing's sarcoma can result in amputation, but the development of limb-sparing techniques has reduced amputations considerably. There is no ideal method of reconstruction in limb salvage surgery. The choice of method is individualized based on many factors, including age; location and extent of the tumor; preferences of the client or, in the case of a child, the family; the availability of surgical facilities and expertise; and cost of the procedure.⁹⁹

Targeted therapies using drugs against the insulin-like growth factor receptor I (IGF-IR or CD99) are under clinical investigation. CD99 is a cell surface transmembrane protein that is highly expressed in Ewing's sarcoma. Neutralizing IGR-IR functions has been shown in animal studies to significantly affect tumor cells by causing massive apoptosis of Ewing's sarcoma cells, thus reducing their malignant potential.⁸⁷ Studies incorporating intensive therapy followed by stem cell infusion show no clear benefit.^{9,32}

PROGNOSIS. Although Ewing's sarcoma is extremely malignant with a high frequency of both metastatic spread and local recurrence, the prognosis for clients with this tumor is improving steadily. Just a few decades ago only about 5% to 10% of clients with Ewing's sarcoma lived longer than 5 years after detection. The 5-year survival rate is now in excess of 70% if metastasis has not occurred at the time of diagnosis and treatment.⁵¹

People with Ewing's sarcoma of distal sites such as the bones of the hands and feet have a much better prognosis than people with lesions in central sites such as the pelvis and sacrum. Tumors larger than 8 to 10 cm have a significantly poorer outcome than smaller tumors.⁹⁷

Long-term survival is determined by the presence or absence of metastasis and the site and extent of the local tumor⁵⁹; only about 25% of individuals with metastatic disease at the time of diagnosis survive 5 years.⁹

Many individuals without metastasis are remaining continuously disease free at 5 and 10 years. As many as 35% of clients will have metastatic disease at the time of diagnosis, usually to the lung. More than four metastatic

nodules is a poor prognostic indicator, whereas good response to chemotherapy (e.g., decrease in the size of the tumor mass, greater than 95% tumor kill) is a favorable prognostic sign.^{78,102}

There is much debate about the role of age at diagnosis. Some studies show older age to be associated with poorer outcome; others show no association between age and survival. It may be that younger children with small, well-defined, distal lesions have the best prognosis.⁸⁸ With the increase in long-term survival rates following improved treatment intervention, the problems of late local recurrence, late functional impairment secondary to complications of radiation therapy, and radiation-induced sarcomas are on the rise.⁹⁷

SPECIAL IMPLICATIONS FOR THE THERAPIST 26-6

Ewing's Sarcoma

PREFERRED PRACTICE PATTERNS

See previous discussion and Special Implications for the Therapist: Primary Tumors earlier in the chapter.

As with osteosarcoma, initial intervention is aggressive, involving extensive surgical resection, limb salvage, and sometimes amputation. Saving the person's life is the first priority. After that, rehabilitation becomes the focus, including recovery of function, social reintegration, and return to work.

Analysis of rehabilitation suggests that clients with cemented modular oncologic endoprostheses recover faster than individuals treated using other techniques. The level of functional performance may be different depending on the treatment plan chosen. For example, sparing the extremity may lead to greater functional impairment compared to some people undergoing amputation who are provided with a modern prosthesis.

Some of the newer amputation surgeries and reconstructive techniques provide greater function but possibly less cosmetically acceptable results for some people. Some clients complete the entire course of rehabilitation but eventually decide that an amputation will provide greater functionality.

Chordoma

Overview and Incidence

Chordomas are usually slow-growing but locally aggressive malignant neoplasms. Chordomas account for 1% to 4% of all malignant bone tumors, primarily affecting older adults.^{11,106}

Chordomas do not have a capsule and tend to infiltrate into neighboring soft tissues. Metastases can occur to the liver, lungs, lymph nodes, peritoneum, skin, heart, brain, and distant regions of the spine but often remain asymptomatic and are discovered only on postmortem examination. Metastases occur most often when there is local recurrence of the primary tumor.⁶⁵

Clinical Manifestations

Most chordomas arise in the midline of the body, involving the clivus (central skull base) in half the cases. One third of all chordomas occur in the sacrum, with the remaining found in the cervical and lumbar spine. The high cervical region, especially C2, is affected most often.¹⁰⁶ Clival chordomas are frequently midline lesions whose posterior growth may breach the dura and invaginate the brainstem.

Clinical manifestations based on the biologic behavior of chordoma appears to differ from person to person. The most common presenting symptom is pain; generally, symptoms depend on the location of the tumor. For example, clival chondromas may cause headaches, visual disturbances, dysphagia, muscle weakness, and even hemiparesis.⁵⁰

Night pain or pain at rest that is not relieved by analgesics is a red flag finding. Other symptoms can include bowel and/or bladder dysfunction, gait disturbances, and motor impairment.

MEDICAL MANAGEMENT

TREATMENT. The mainstay of treatment for chordoma is aggressive surgical resection. Complete resection of the tumor is not always possible, especially when it is located in the high cervical region. Adjuvant therapy (radiation and/or chemotherapy) may be administered before and/or after surgery. Recurrence is seen, often requiring subsequent treatment. Metastases require resection and chemotherapy unless metastases are too extensive for systemic treatment.⁶⁵

PROGNOSIS. Although chordoma is a relatively slow-growing tumor, it has a high incidence of local recurrence and poor long-term prognosis.^{104,106} Cancer recurrence often necessitates repeat surgical procedures with risk for complications.

Metastases are becoming more common as people with chordomas live longer as a result of more aggressive surgical and adjuvant treatments. Researchers hope to identify markers that will help predict which tumors will behave aggressively in order to direct treatment toward early diagnosis and intervention for people with aggressive tumors.⁶⁵

Giant Cell Tumor

Overview and Incidence

Giant cell tumor of bone is a distinct, locally aggressive neoplasm that accounts for approximately 5% of all primary bone tumors. Although classically considered benign, these tumors are now considered a low-grade (malignant) sarcoma because of their high rate of recurrence and potential for malignant transformation.²⁸

The tumor most frequently involves the epiphyseal ends of long tubular bones in skeletally mature adults between the ages of 20 and 55 years of age, with a peak age incidence in the third decade of life. Giant cell tumor occurs more often in Chinese people (up to 20% of the population are affected) compared to Caucasians in Western countries.

Sixty percent occur around the knee; 10% to 12% involve the distal radius. The bones of the hand and wrist are rarely affected.⁵² Although the sacrum can be affected, it is extremely rare in the vertebrae.

Etiology and Pathogenesis

The etiology of giant cell tumor is unknown. The tumor cells have been reported to produce chemoattractants that can attract osteoclasts and osteoclast precursors.⁵⁰

Pathologic examination of the neoplasm reveals a tumor that is soft, friable (easily breaks apart), fleshy, and red-brown with yellow areas. The tumor usually extends to but not into the articular cartilage. Destruction of the bone cortex with expansion into soft tissue can occur (Fig. 26-16). Hemorrhage, cyst formation, and necrosis can be seen on gross pathology. Hemorrhage and necrosis (often accompanied by pathologic fracture) occur often in the weight-bearing bones. The tumors can be locally invasive (into bone and soft tissue) with extensive bone destruction and cortical expansion.

Clinical Manifestations

Pain on weight bearing with pathologic fracture may be the presenting clinical feature when tumors occur in the weight-bearing bones. Sacral tumors may present with localized pain in the low back radiating to one or both of the legs. Abdominal discomfort and bowel and bladder symptoms may be present.⁵⁰

Pulmonary metastases referred to as benign pulmonary implants occur in 1% of cases. The nodules grow slowly and can be excised effectively. They are usually asymptomatic and discovered when a routine chest x-ray is taken. Multiple lung lesions or progressive spread can result in death.

MEDICAL MANAGEMENT

Diagnosis is by x-ray and confirmed by histologic assessment with findings typical of this particular type of tumor observed. Treatment is with surgical excision; bone grafting to fill the cavity and further reconstruction may be needed.⁵⁵

Recurrence is usually confined to the bone and does not extend to the soft tissue. Recurrence after excision occurs in up to one third of clients. Recurrence usually occurs within 3 years of the index removal but can occur many years (even decades) later. Although it is rare, giant cell tumors can transform to a malignant form.⁴²

Radiation is not a mainstay of treatment but may be utilized in cases of surgically inaccessible or incompletely resectable lesions.⁶⁶ The use of adjuvant treatment such as chemotherapy and radiotherapy is debated. Studies using radiofrequency ablation, bone substitutes, and liquid nitrogen and phenol as alternative therapies are underway.⁴¹

MULTIPLE MYELOMA

Multiple myeloma is a hematopoietic neoplasm involving bone marrow. It is a primary bone cancer with plasma cell proliferation and is one of a group of disorders called

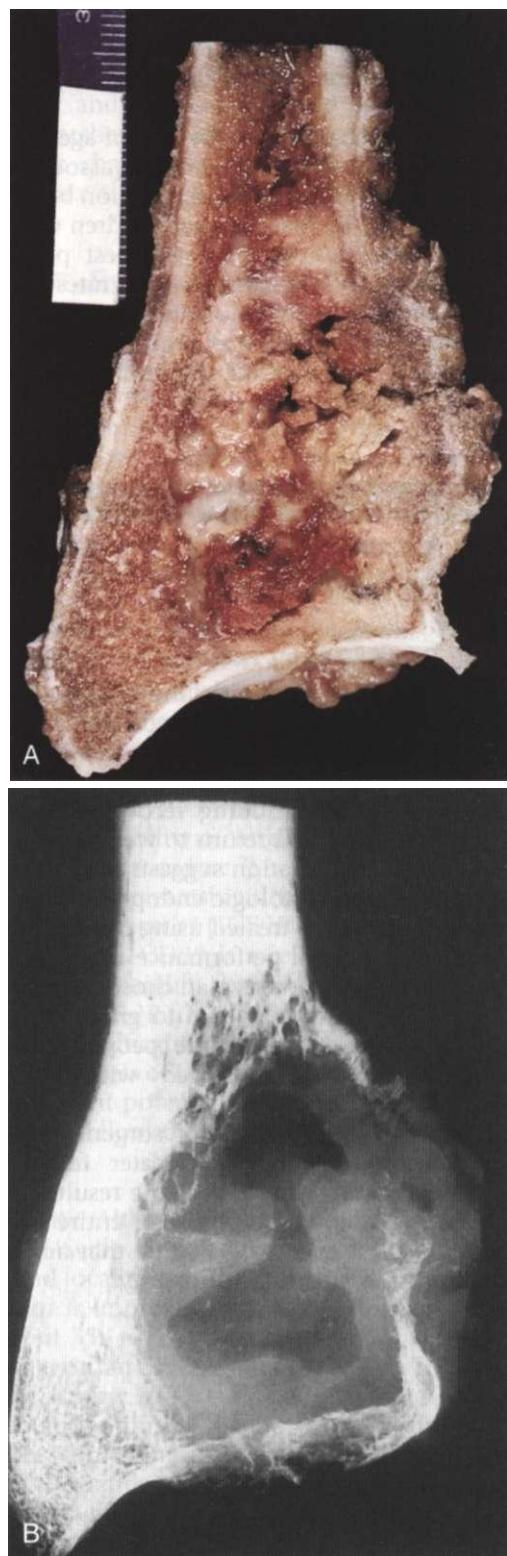


Figure 26-16

Giant cell tumor. Gross morphologic features of giant cell tumor. **A**, Bisected distal end of radius with well-demarcated tumor mass expanding bone contour. Tumor tissue is red-brown with yellow septations. **B**, Radiographic presentation of tumor showing focal destruction of cortex. (From Dorfman HD, Czerniak B: *Bone tumors*, St Louis, 1998, Mosby.)



Figure 26-17

Multiple myeloma. Small lucencies in the distal femur, proximal tibia, and patella. [From Ghelman B: Radiology of bone tumors, *Orthop Clin* 20:307, 1989.]

plasma cell dyscrasias (see Chapter 14 for a detailed description of this condition).

Skeletal involvement is most common in the spine, pelvis, and skull, because bone marrow is found in high concentrations in these structures. Deep bone pain is often present clinically, and radiographs may demonstrate osteopenia and punched-out areas of bone with sclerotic borders (in flat bones) (Fig. 26-17).

The prognosis is generally poor, with most people dying from the disease within 1 to 3 years after the diagnosis is made.

PRIMARY SOFT TISSUE TUMORS

Benign Soft Tissue Tumors

Common benign soft tissue tumors include lipoma, ganglia, popliteal cyst (Baker cyst), nerve sheath tumor (neurofibroma and schwannoma), and desmoid tumors.

Lipoma is the most common soft tissue tumor, generally occurring during middle age and late adulthood and comprised of mature fat cells. These tumors are usually superficially located in the subcutaneous tissue and remain asymptomatic. Occasionally a lipoma of the breast will grow large enough to cause tenderness and block lymphatic drainage, requiring removal. Even without surgical excision, lipomas are unlikely to ever

undergo malignant transformation, but recurrence is possible if the lesion, including microscopic cells, is not completely removed.

Ganglia arise from a joint capsule or tendon sheath, usually on the dorsal aspect of the wrist but sometimes on the volar aspect of the wrist or on the lower extremity. Pain or tenderness may or may not be present; pressure on a nerve can cause focal neurologic symptoms.

Popliteal cyst, more commonly referred to as a *Baker cyst*, is a subtype of ganglion that often communicates with a joint space. A Baker cyst is most often palpated behind the knee in older adults with osteoarthritis. Rupture of the cyst or hemorrhage from the joint into the cyst causes episodes of severe pain. Swelling distal to the lesion (calf and foot) may also occur.

Nerve sheath tumor is a tumor of the nerve sheath arising in a peripheral nerve and growing concentrically from the center of the nerve. Neurofibromas infiltrate the nerve and splay apart the individual nerve fibers. They are usually superficially located, painless, and benign but can sometimes degenerate into cancer.

Neurofibromas can occur as a single lesion or in greater numbers as part of a collection of symptoms in association with von Recklinghausen's disease (neurofibromatosis) and schwannomas. Neurofibromas contain cells and features of Schwann cells but also contain fibroblasts and perineurial cells. Both neurofibromas and schwannomas are benign, grow slowly, and can be cured surgically.^{1,60}

Schwannomas and neurofibromas arise from the coverings of peripheral and cranial nerves. Schwannomas arise from Schwann cells as the name suggests. Schwannoma is a rare tumor of the sheath or lining around the peripheral nerves. It starts in the Schwann cells, which is how it gets its name. Schwann cells help form the cover around the nerves called the myelin sheath. Schwannomas can be benign or malignant. The malignant type is called *neurosarcoma* or *neurogenic sarcoma*.

In the benign form, growth is slow and painless. The tumor stays on the outside of the nerve. The benign form does not spread to other areas and is not likely to cause death. But if it grows large enough to put pressure on the nerve, then pain, numbness, and even paralysis can occur.

Schwannomas can arise from Schwann cells covering the vestibular portion of cranial nerve VIII, causing benign acoustic neurinomas. Although the tumors grow slowly and are considered benign, they can compress the eighth cranial nerve, resulting in hearing loss and tinnitus. Vestibular function is lost but slowly enough that the body compensates; for this reason vertigo is uncommon with acoustic neuromas. Large tumors can compress the cerebellum and brainstem, resulting in ataxia and hydrocephalus. The affected individual may also experience facial paralysis if the trigeminal nerve is compressed.⁶⁰

Schwannomas can also occur as intradural extramedullary tumors, most often in individuals with neurofibromatosis. Multiple schwannomas in this population group are common. The tumors often extend through the intervertebral foramen into the abdomen or thoracic cavity. Compression causes local or radicular pain and may progress to include symptoms of spinal cord compression (e.g., motor weakness, sensory disturbances, autonomic

Table 26-5 Soft Tissue Sarcoma*

Tumor	Age (yr)	Sex Ratio	Common Sites
Malignant fibrous histiocytoma	50-70	3:1 (M/F)	Leg, thigh, retroperitoneum; extremities (lower > upper)
Liposarcoma	40-60	1:1 (M/F)	Any site of adipose tissue; extremity, trunk, retroperitoneum, breast
Rhabdomyosarcoma	Children and adolescents; two peaks: 2-6 and 15-19	1.4:1 (M/F)	Any site; four main areas: head and neck, genitourinary tract (bladder, prostate, testes), extremities, trunk
Leiomyosarcoma	50-70	Women > men	Skin, deep soft tissues of the extremities, retroperitoneum, uterus
Malignant schwannoma	20-50; can occur at any age	Men > women	Peripheral nerves, any site; flexor surface extremities
Synovial sarcoma	Young adult, 15-40	Men > women	Extremity, knee (popliteal area), feet, hands, forearm
Epithelioid sarcoma (extremely rare)	Young adult	Men > woman	Extensor surface of the extremities, tendon sheath, joint capsule (shoulder), hands, feet
Clear cell sarcoma (extremely rare)	Young adult	Women > men	Deep to dermis; tendon, aponeuroses, spinal nerve root (rare)
Fibrosarcoma (extremely rare)	35-55	Men > women	Fibrous connective tissue (thigh, posterior knee); scars, subcutaneous fibrous tissue, deep connective tissue, around tendons or nerve sheaths, ligaments, muscle fascia; can occur as bone tumors (periosteum)

*Listed in approximate descending order of prevalence. Most soft tissue sarcomas are rare; some (as labeled) are extremely rare.

changes). As with all benign schwannomas, surgical resection is curative.

Malignant Soft Tissue Tumors

Overview and Incidence

Soft tissue sarcomas are a heterogeneous group of rare tumors that arise predominantly from the embryonic mesoderm and present most often as an asymptomatic mass. They can occur anywhere in the body, but most originate in the extremities (59%), trunk (19%), retroperitoneum (15%), or head and neck (9%).²³

Sarcomas account for 1% of all newly diagnosed adult cancers. In 2007, there were 9220 cases of soft tissue tumors, including heart tumors.⁵⁴ The incidence is much higher in children, constituting 15% of annual pediatric malignancies.

Types of Soft Tissue Sarcomas. Currently there are more than 50 histologic types of soft tissue sarcoma that have been identified. The most common are malignant fibrous histiocytoma, leiomyosarcoma, liposarcoma, synovial sarcoma, and malignant peripheral nerve sheath tumors. Rhabdomyosarcoma is the most common soft tissue sarcoma of childhood (Table 26-5).²³

Malignant schwannoma, also known as *neurosarcoma* or *neurogenic sarcoma*, is a rare nerve sheath tumor of the peripheral nerves arising from Schwann cells or within existing neurofibromas. They can occur anywhere in the body but are often located on the flexor surface of the extremities. They are usually slow growing and painless, often present for years.⁵⁴ When pressure is placed on the involved nerve, then pain, paresthesia, and paralysis may occur.

Rhabdomyosarcomas constitute more than half of all soft tissue sarcomas in children under 15 years of age. Occurrence in adults is possible but relatively rare.⁷⁴ Eighty percent of the affected individuals are Caucasian. Boys are affected slightly more than girls; approximately 250 children in the United States are diagnosed each year with rhabdomyosarcoma.^{6,73}

Rhabdomyosarcoma is a malignancy of striated muscle but can occur sporadically at any site in the body (e.g., bladder, prostate, head and neck, limbs, testes, muscle) and is of unknown cause. Symptoms are site dependent, but the tumor presents as a painless mass in the soft tissues. About one third of all people with rhabdomyosarcoma have readily resectable tumors, half do not, and in about half of all cases, regional lymphatic spread at diagnosis is evident, with a much less favorable prognosis.⁷² Diagnosis is often delayed as lesions are frequently attributed to sports-related trauma.

Other sites of metastases include the lungs, bone, and bone marrow. Tumors are aggressive and must be excised whenever possible. If tumors are too large to remove surgically, preoperative chemotherapy is used first to shrink the tumor. This allows for the possibility of complete resection and possibly a lower dose of radiation to achieve local control. Reduced exposure to radiation may decrease the late effects of radiation.⁶

Over the last 30 years, the prognosis for children with rhabdomyosarcoma has improved dramatically with the use of multiagent chemotherapy, aggressive surgery for local disease, and more precise delivery of radiation therapy. Prognosis depends on the type of gross residual tumor (histology), location of the tumor, and the presence and number of metastases at the time of diagnosis.

Age and completeness of resection are additional prognostic factors.⁸³

Current 5-year survival in rhabdomyosarcoma reaches 60% to 70% in nonmetastatic cases and remains below 20% in metastatic situations.³² Children with relapsed, recurrent, or metastatic sarcomas represent a complex challenge for the pediatric oncologist.^{24,47}

Other common soft tissue sarcomas include malignant fibrous histiocytoma, liposarcoma, synovial sarcoma, epithelioid sarcoma, and clear cell sarcoma. *Malignant fibrous histiocytoma* is now recognized as the most common (although still occurring rarely) soft tissue sarcoma in adults, primarily affecting men 50 to 70 years old. Malignant fibrous histiocytoma occurs as a deep-seated mass that typically enlarges to 5 cm or more by the time of diagnosis and is usually located on the leg, especially the thigh.

Liposarcoma is a soft tissue malignancy with a peak incidence between ages 40 and 60 years. These are slow-growing lesions that can achieve a large size (10 to 15 cm), usually located in the thigh but occasionally retroperitoneally, causing pain and weight loss. *Synovial sarcoma* occurs most often in a young adult as a slow-growing mass of the extremities, often located near the knee. These lesions are painful and tender to palpation and often present similarly to a Baker cyst or ganglion. Reclassification of this sarcoma will eventually reflect the fact that the synovium is not involved in this type of sarcoma.

Epithelioid sarcoma, a small, firm, slow-growing mass, typically occurs in young adults on the extensor surface of an extremity but can also occur on the shoulder. These can develop deep enough to be undetectable on physical examination. Epithelioid sarcoma can look like a rheumatoid nodule, ganglion, or draining abscess and is often confused with a benign lesion.

Clear cell sarcoma arises deep to the dermis, has a uniform growth pattern, and is often located on tendons or aponeuroses. In rare cases this type of tumor can also originate in the spinal nerve roots with dissemination to the vertebral bodies, resulting in cauda equina. In approximately 20% of individuals the tumor has a dark appearance resulting from production of melanin, and it is often confused with benign soft tissue tumors.⁹⁴

Etiology and Risk Factors

Soft tissue sarcomas do not seem to develop from malignant changes of benign soft tissue tumors. Specific inherited genetic alterations are associated with an increased risk of soft tissue sarcomas. Distinct chromosomal translocations that code for oncoproteins are associated with certain histologic subtypes of soft tissue sarcomas. Oncogenes identified in the development of soft tissue sarcomas include *MDM2*, *N-myc*, *c-erbB2*, and members of the *ras* family.²³ Ras proteins regulate cell proliferation, survival, and differentiation and are activated by mutations in many cancers.

Risk factors for soft tissue sarcomas include radiation therapy for cancer of the breast, cervix, testes, or lymphatic system with a mean latency period of approximately 10 years. Other risk factors include occupational exposure to chemicals, including herbicides and wood preservatives. Chronic lymphedema following axillary

dissection is an additional risk factor for the development of lymphangiosarcoma.²³

Pathogenesis

All sarcomas share a mesodermal cellular origin, but research has not been able to completely identify the pathogenesis involved. Sarcomas probably do not originate from normal tissue but arise from aberrant differentiated and proliferative malignant mesenchymal cell formations. There are some genetic origins that have been specifically identified for individual sarcoma types. Many sarcoma-linked oncogenes appear to be triggered by viruses; sequencing of these viruses may eventually allow for the development of specific antibodies against oncogenic activation.⁹⁶

Clinical Manifestations

Soft tissue sarcomas present most often as painless, asymptomatic masses. They can grow quite large before being observed but do not usually produce pain when compressing surrounding structures. Metastasis occurs primarily hematogenously, with lymph node dissemination in rare cases.

MEDICAL MANAGEMENT

DIAGNOSIS. Diagnostic imaging, fine-needle aspiration, biopsy, and clinical studies are the mainstay of diagnosis. X-rays are used to look for lung metastases; CT scans and contrast-enhanced techniques provide details of high-grade lesions and large tumors, and assess the extent of tumor burden and proximity to vital structures. MRI is the preferred imaging modality for sarcomas of the extremities.⁴⁸

Staging of soft tissue sarcomas follows the AJCC method of staging based on anatomic location (depth), grade, size of the tumor, and presence of distant or nodal metastases (nodal status). Metastases occur to the lungs first, but also to the bone, brain, and liver. Intracompartmental or extracompartmental extension of extremity sarcomas is important for surgical decision making and planning.⁷¹

TREATMENT. Treatment depends on the type of tumor, stage, and location. For example, a multidisciplinary approach is taken for people with soft tissue sarcomas of the extremities. Surgical excision with clear margins combined with radiation yields good local control, but metastasis and death remain significant problems, especially for those individuals who have sarcomas at sites other than the extremities.

Systemic therapy (i.e., cytotoxic chemotherapy) is effective only for certain histologic subtypes; the adverse toxic side effects in individuals who do not respond to chemotherapy negate the routine use of this form of treatment. Many studies with randomized controlled trials have now shown that chemotherapy does not improve disease-free and overall survival in people with soft tissue sarcomas.^{39,79,92}

Likewise, there are few supportive data to show that the use of preoperative chemotherapy can improve survival rates. Studies are underway to combine systemic chemotherapy with radiosensitizers and concurrent

external beam radiation in hopes of treating microscopic disease, thus producing favorable local as well as systemic results.

There has been a gradual change in the local treatment of soft tissue sarcomas from amputation to a more conservative, limb-sparing, function-preserving approach combined with radiation.⁷⁹ Amputation may be required for high-grade extremity sarcomas in about 5% of people whose tumor cannot be removed while still preserving function using limb-sparing techniques.^{12,23} See previous discussion in Primary Tumors in this chapter.

PROGNOSIS. The overall 5-year survival rate for soft tissue sarcomas of all stages remains about 50% to 60%.⁸² Death from recurrence and metastatic complications occurs within 2 to 3 years of the initial diagnosis in 80% of cases. Despite improvements in local control rates, individuals with high-risk soft tissue sarcomas have poor long-term results.

Advanced, metastatic sarcomas are always incurable; management is palliative. Factors associated with a poorer prognosis include age older than 60, tumors larger than 5 cm, and high-grade histology.⁷¹ Individuals with leiomyosarcomas, clear cell sarcomas, and malignant fibrous histiocytomas may have a poorer survival rate compared with those individuals who have fibrosarcomas, liposarcomas, and neurofibrosarcomas.⁶³

Cartilaginous Tumors

Many tumors of cartilaginous origin can occur. Three of the more common tumors of a cartilaginous origin are the enchondroma, osteochondroma, and chondrosarcoma. Cartilage tumors involving some parts of the skeleton (e.g., small bones of the hands and feet) are almost always benign, whereas cartilaginous lesions of the ribs, sternum, and flat bones such as the pelvis and scapula are more likely to be aggressive.³⁰

Determining the aggressiveness of cartilaginous tumors is especially difficult, and even the histologic differentiation is troublesome. Sometimes the presence of pain or the development of pain in a previously diagnosed benign cartilaginous tumor such as an enchondroma is all that raises suspicion of a malignant process or transformation.

Benign Cartilaginous Tumors

Enchondroma

Overview and Incidence. Enchondroma is a common, benign tumor arising from residual islands of cartilage in the metaphysis of bones (Fig. 26-18). The tubular bones of the hands and feet (phalanges, metacarpals, metatarsals) are common sites, although the long tubular bones (femur, humerus) can be affected. They are rarely seen in sites most commonly affected by chondrosarcoma (trunk bones). Enchondromas account for approximately 10% of benign skeletal tumors. They are seen in people between the ages of 20 and 40 but can occur at any age in both men and women.

Pathogenesis and Clinical Manifestations. Cartilaginous tumors are lesions in which cartilage is produced, rather than osteoid as in the osteosarcomas. These lesions



Figure 26-18

Enchondroma of the proximal phalanx of the small finger in a 27-year-old woman. Note radiolucent, expansile lesion that resulted in attenuation and thinning of the cortex. (From Greenspan A: Tumors of cartilage origin, *Orthop Clin* 20:351, 1989.)

are classified as chondromas. Enchondral ossification is the process by which most bones in the skeleton are formed—that is, bone is slowly absorbed from the inner cortex while at the same time, periosteal reactive bone is deposited on the outer surface. A cartilaginous model exists as a precursor to mature bone. A tumor may then develop from cartilage islands displaced from the growth plate during development. This is thought to occur perhaps secondary to trauma or to an abnormality in the growth plate.

Histologically, enchondroma consists of hyaline cartilage appearing as lobules rimmed with a narrow band of reactive bone. These may be difficult to differentiate from a slow-growing chondrosarcoma, and in a small percentage of cases, a single enchondroma (usually in a large, long bone) does undergo malignant change to become a chondrosarcoma.⁸⁴

Enchondromas may be asymptomatic. In some cases, some swelling may occur. When present in the hands, pain may be a symptom of pathologic stress fracture.

MEDICAL MANAGEMENT

DIAGNOSIS. In those cases where no symptoms are present, plain radiographs or bone scans performed for other reasons reveal the tumor as an incidental finding. Once detected, differentiating the lesion from a chondrosarcoma is crucial. The radiograph and clinical history, not the histologic makeup, are the most informative. Radiographs of enchondromas do not show cortical destruction. Pain without evidence of a fracture is also suspicious of malignancy rather than enchondroma.

TREATMENT AND PROGNOSIS. Curettage is a common form of treatment, with or without bone grafting, depending on the size and location of the lesion. Clients with enchondromas in the hand may develop stress fractures, which often respond to splinting. Recurrence of enchondromas after curettage is less than 5%, and malignant transformation occurs in 2% of all cases (usually adults).⁸⁴

Osteochondroma

Overview and Incidence. Osteochondroma is the most common primary benign neoplasm of bone, accounting for 90% of all benign bone tumors.⁴⁰ A continuous osseous outgrowth of bone with a cartilaginous cap is characteristic (Fig. 26-19). The outgrowth arises from the metaphysis of long bones and extends away from the nearest epiphysis. The metaphyses of long bones, especially the distal femur, proximal humerus, and proximal tibia, are common sites. The flat bones of the ilium and scapula can also be involved.⁴⁰

The incidence of osteochondroma is unknown. Some reports indicate that men are affected more often, but this may be due to the fact that it is often an incidental finding, and men may be more likely to have a radiograph taken during the second decade of life when the lesion is usually seen.

Pathogenesis. Osteochondromas appear to result from aberrant epiphyseal development. They are an extension of normal bone capped by cartilage that forms a prominent "tumor" (lump, swelling), sometimes referred to as *osteocartilaginous exostosis*. The younger the individual, the larger is the cartilage cap, because during the growing years, an osteochondroma has its own epiphyseal plate from which it grows.⁸⁴

The lesion will usually cease growing when the individual reaches skeletal maturity. The central portion of the lesion is normal medullary bone. The lesion may begin as a displaced fragment of epiphyseal cartilage that penetrates a cortical defect and continues to grow.

Clinical Manifestations. In some people, a hard mass will be detected, sometimes present for many years. When the tumor is palpable it may, owing to the cartilaginous cap, feel much larger than is apparent on radiographs.

Osteochondromas are not painful lesions in themselves, but they may interfere with the function of surrounding soft tissues such as tendons, nerves, or bursae. Blood vessels can also be compromised by the tumors (Fig. 26-20), and if tumors are sufficiently large, they may even limit joint motion.

Synovial osteochondromatosis can occur secondary to benign proliferation of the synovium and presents as multiple loose bodies within a joint.

MEDICAL MANAGEMENT

DIAGNOSIS. Plain radiographs may show a slender stalk of bone directed away from the nearest growth plate. This is referred to as a *pedunculated osteochondroma*. A sessile osteochondroma has a broad base of attachment (Fig. 26-21). In both types the most important feature to note is the continuity of the cortex between the host bone and the tumor.

CT and MRI are not commonly used in the diagnostic workup of benign lesions, but if atypical clinical mani-



Figure 26-19

Osteochondroma. Two radiographs (A and B) showing mature osteochondroma: stalked lesion pointing toward the diaphysis and away from the growth plate. [From Bogumill G, Schwamm H: *Orthopaedic pathology*, Philadelphia, 1984, WB Saunders.]

festations or recent changes in the appearance of the lesion on plain radiographs are evident, MRI may be indicated. For example, MRI can demonstrate the continuity of the marrow between the tumor and the host bone, thereby ruling out a periosteal osteosarcoma.

TREATMENT AND PROGNOSIS. Since osteochondromas usually cease their growth at skeletal maturity, no intervention is needed unless they are symptomatic or interfering with normal limb function. Removal of the lesion is sometimes required when symptoms such as vascular compromise, chronic bursitis, or pain develop secondarily. Rarely, an osteochondroma can transform into a

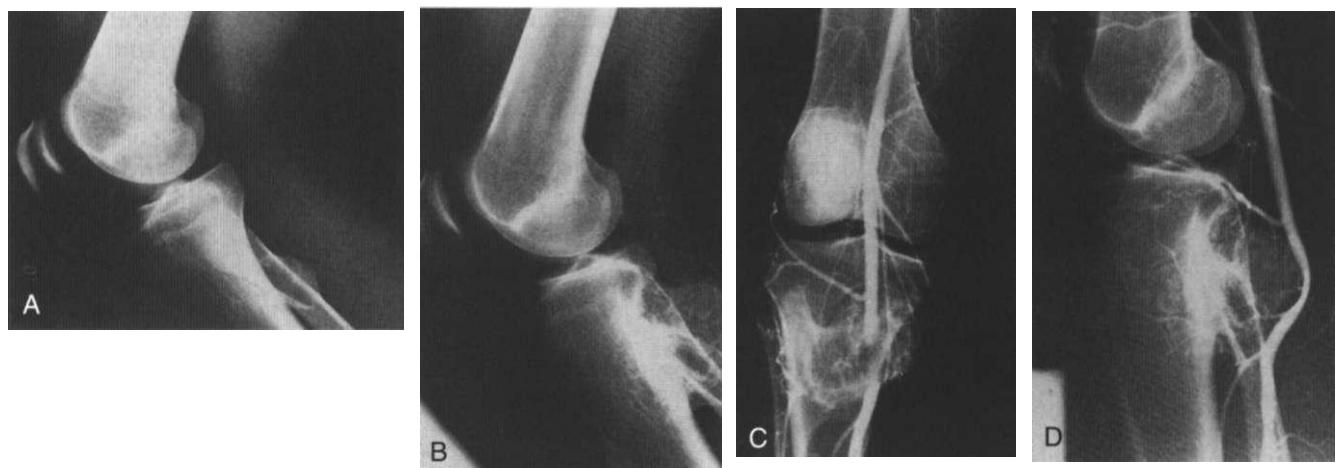


Figure 26-20

Osteochondroma of the proximal fibula in a young man. **A**, Lateral radiograph of the right knee obtained when the patient was 17 years old demonstrates an exophytic lesion arising from the proximal fibula. **B**, Lateral radiograph obtained 8 years later shows considerable interim growth of the osteochondroma, although a smooth outline is maintained. **C**, Anteroposterior and **D**, lateral angiograms demonstrate displacement and marked narrowing of the distal popliteal artery by the tumor. (From Guidici M, Moser R, Kransdorf M: Cartilaginous bone tumors, *Radial Clin North Am* 31:247, 1993.)

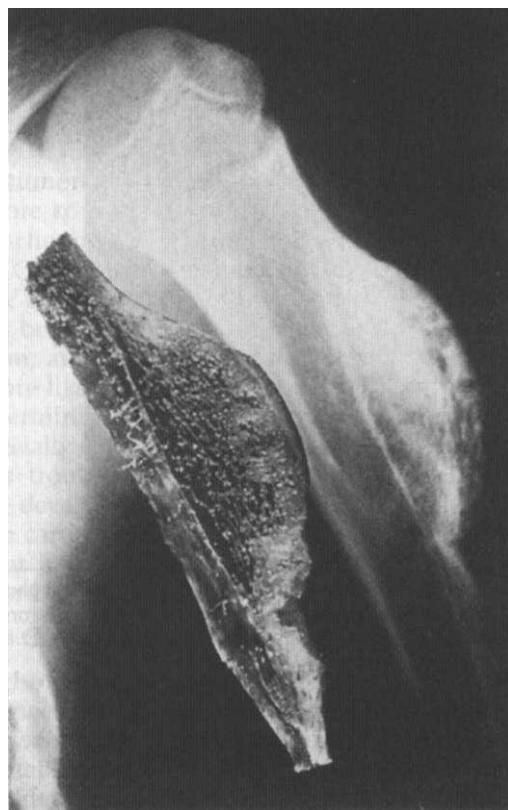


Figure 26-21

Osteochondroma. Radiograph and gross specimen of the sessile osteochondroma. Note the cartilaginous component causing the radiographic defect in the distal portion. Note also incorporation of hematopoietic tissue into the base of the osteochondroma. (From Bogumill G, Schwamm H: *Orthopaedic pathology*, Philadelphia, 1984, WB Saunders.)

chondrosarcoma. Those symptomatic lesions that are removed have a very low recurrence rate.

Malignant Cartilaginous Tumors

Chondrosarcoma. *Chondrosarcoma* is defined as a malignant tumor of cartilage in which the matrix formed is uniformly or entirely chondroid in nature. These tumors are classified as malignant bone tumors and therefore are discussed in the section on Primary Malignant Bone Tumors in this chapter.

SPECIAL IMPLICATIONS FOR THE THERAPIST 26-7

Cartilaginous Tumors

With *enchondromas*, as with benign neoplasms of bone, limitations on early function may be needed, depending on the size and location of the tumor. Since *osteochondroma* is a benign tumor and will likely require only symptomatic, if any, intervention, the role of the therapist is to educate clients and alleviate any anxiety that may be present. The special implications of *chondrosarcoma* for the therapist are similar to those of other malignant neoplasms such as *osteosarcoma*.

Fibrous Lesions

Overview

Fibrous (fibroosseous) lesions (also referred to as fibrous dysplasia) within bone are a common osseous anomaly of mesenchymal tissue. They are usually solitary lesions found in the femur, skull, humerus, and tibia. Adolescents and young adults are affected. These lesions vary from small, fibrous cortical defects to larger fibrous dysplasias. Although most are benign, fibrosarcoma has

many of the features of osteosarcoma. Many children have defects in the metaphysis, but most resolve spontaneously. Those that persist are seen in young adult men. The distal femur and tibia are common sites.

Pathogenesis and Clinical Manifestations

The hallmark of this disease is the inability of bone-forming tissue to produce mature bone. The process is arrested at the level of woven bone; even if a large amount of osteoid tissue is produced, it cannot or does not mature to lamellar bone. The pathogenesis is unknown, but it appears the underlying molecular mechanism involves the fundamental cell differentiation process.³⁰

Although the defect occurs in the metaphysis, during normal bone growth the defect may be displaced into the diaphysis. Microscopic examination reveals disorganized, haphazard deposits characteristic of woven bone, sometimes accompanied by local hemorrhage and serous fluid accumulation. Growth of lesions is often stabilized during puberty.

Most fibrous defects are asymptomatic. Some individuals experience mild to moderate pain with swelling or deformity of the affected site. The more extensive the disease, the earlier the onset of symptoms. Pathologic fractures may be the initial symptom and occur where large lesions exist. Depending on the specific form of dysplasia, affected bones include ribs; craniofacial bones; long, tubular bones; and pelvis.

There may be associated extraskeletal symptoms such as hyperpigmentation of the skin (cafe au lait spots corresponding to the site of musculoskeletal involvement) or endocrine dysfunction (e.g., early menarche in females, acromegaly, hyperthyroidism, hyperparathyroidism, Cushing's syndrome).

MEDICAL MANAGEMENT

Plain radiographs are usually diagnostic. Fibrous defects are usually observed as an incidental finding on radiographs. The lesion has an irregular shape with a thin sclerotic border (Fig. 26-22). Even though this is a benign lesion, treatment sometimes requires surgery. When the dysplasia thins the cortex of a weight-bearing bone or occupies more than one half of the diameter of the bone, the risk of pathologic fracture increases. Benign fibrous defects generally have a good prognosis.

Implications for the therapist are similar to those with other benign bone tumors.

METASTATIC TUMORS

Overview

Cancer commonly metastasizes to bone; skeletal involvement represents the third most common site of metastatic spread (after lung and liver).³¹ Secondary or *metastatic neoplasms* refer to those lesions that originate in other organs of the body.

All malignant tumors have the capability to spread to bone; the skeleton is the third most common site of metastatic carcinoma, exceeded only by lung and liver. Malignant tumors that have metastasized to the bone are the most common neoplasm of the bone.



Figure 26-22

Fibrous dysplasia. A predominantly lytic lesion with some sclerosis and expansion is seen in the distal half of the radius in a child. A long lesion in a long bone typifies fibrous dysplasia. Although parts of this lesion indeed have a ground-glass appearance, most of it does not. Expansion and bone deformity like this are commonly seen in fibrous dysplasia. (From Helms C: *Fundamentals of skeletal radiology: benign cystic lesions*, Philadelphia, 1989, WB Saunders.)

Although all of the factors that affect the timing and location of metastasis are not known, some patterns do exist. Cancer metastases (both carcinomas and sarcomas) to bone are a common clinical problem, because the cancers that cause them are prevalent and often metastasize.³² Primary cancers responsible for 75% of all bone metastases include prostate, breast, lung, kidney, and thyroid.

Common sites for *breast cancer* to metastasize include the pelvis, ribs, vertebrae, and proximal femur. *Lung cancer* can metastasize to the bone early in the disease, remaining asymptomatic until widespread dissemination has taken place; therefore, treatment is often not successful. Neoplasms in the *kidney* metastasize to the vertebrae, pelvis, and proximal femur in about 40% of the cases. The *prostate* is the most common source of skeletal metastases in men.

Early detection is important for successful intervention. Therapists should be aware of this possible cause of lumbar spine and hip pain, especially in men over age 50. Cancer of the thyroid is uncommon but does metastasize to bone. Women are affected by bone metastases from the thyroid three times more often than men. Thera-

pists should remember that the development of metastasis may be delayed and may even occur after removal of a cancerous thyroid. For discussions of specific primary cancers, see the relevant chapters.

Incidence and Etiology

Metastatic bone neoplasms are much more common than primary bone lesions; about half of all individuals with cancer (except skin cancer) will develop bone metastases at some point. Incidence increases to 80% of individuals with advanced cancer. The incidence of bone metastasis is expected to increase with the prolonged survival associated with improved antineoplastic therapies now available. The spine is the site most commonly affected, with more than 50% of the metastases involving the spine⁹³—usually the thoracic or lumbar spine, much less often the cervical spine, and rarely the atlantoaxial region.²

In the spine, the size of the vertebral body may influence the distribution of metastases. The larger lumbar vertebral bodies are more commonly affected than the smaller thoracic or cervical vertebrae. Neurologic compromise is more likely to occur when metastatic lesions affect the thoracic spine because of the smaller ratio between the diameter of the spinal canal and the spinal cord within the thoracic spine.⁹⁹

Risk Factors

Risk factors are those related to the primary cancer. For some cancers the risk factors are well documented, and efforts to educate individuals on health risks should be stressed. Adequate exercise, proper diet and nutrition, and avoidance of tobacco use are the primary preventive measures. It is likely that the increase in incidence of spinal (and other) metastases can be attributed to the improving survival of clients with cancer.⁹⁹

Pathogenesis

The pathophysiology of metastasis is not completely understood, but new information on the biology of tumor metastases derived from advanced techniques in molecular pathology is contributing new insight daily (see the section on Invasion and Metastases in Chapter 9). The development of metastatic disease, regardless of the eventual target organ, usually follows a common pathway.

Cancer can spread through the bloodstream, lymphatic system, or by direct extension into adjacent tissue. Hematogenous spread of the cancer is most common, and therefore skeletal metastases are found in areas of bones with a good blood supply. These include the vertebrae, ribs, skull, and proximal femur and humerus.

The skeletal vasculature represents a significant proportion of the body's total vasculature. At the same time, the vertebral plexus of veins has no valves, so that the retrograde venous pressure is often increased in the abdominal and chest regions. This enables the retrograde blood flow to bypass the caval system, reaching the bones of the vertebral column instead via the extradural Batson venous plexus.^{8,30} Batson's plexus may be the route by which breast cancer cells metastasize directly to the thoracic spine.⁹⁹

The unique vasculature of the spine contributes to the high rate of spinal involvement in metastatic disease. The vertebral venous system is a valveless channel that extends from the sacrum to the skull. Venous connections to this system exist from the breasts, lungs, thyroid gland, kidneys, and prostate gland. Cells from the primary tumor mass enter the circulation by traversing either the walls of small blood vessels in normal tissue or those of vessels induced by the tumor itself.⁶⁹ Once having gained access to the vertebral vein system, tumor cells can travel to distant organ sites. There are also direct connections to the vertebrae, ribs, pelvis, skull, and the shoulder and pelvic girdles.³⁴

From a biologic point of view, it is very unlikely that the abundance of the vascular network within the bone is the only factor that predisposes to metastasis, because metastases rarely develop in other tissues that have an equally rich vascular supply. It is proposed that the biologic conditions of bone tissue must be important factors in promoting the growth of tumor cells that reach the marrow through the venous and arterial blood network.³⁰

The development of skeletal metastasis involves a series of events that begins when a tumor cell separates from the primary site, enters the blood system, and then extravasates from the blood vessel to the secondary site.⁹⁹ Adhesion molecules control separation and clustering of cancerous cells. The presence or absence of certain molecules controls the ability of cells to metastasize. Various types of adhesion molecules have been implicated. Cadherins, integrins, and selectins each have distinct properties that can regulate the propensity for a primary lesion to metastasize to a specific organ.

Metastasis to bone often results in osteolysis, because cancer cells secrete a number of paracrine factors that stimulate osteoclast function. The cancer tries to destroy the bone (lytic process), and in response, the bone attempts to grow new bone (blastic process) to surround the cancer. If the cancer overwhelms the bone, it becomes weak and fractures easily. Bone metastases may be lytic (most common), blastic, or mixed. Lesions originating from the breast, lung, kidney, and thyroid are usually lytic. Blastic metastases are commonly associated with advanced carcinomas of the prostate and sometimes the breast.⁷⁰

Clinical Manifestations

Although as many as 50% of people with breast or prostate metastasis have no bone pain, pain remains the most common presenting symptom, often characterized as sharp, severe, worse at night, transient or intermittent in the early course but eventually constant in more advanced cancer, and mechanical (see the section on Cancer Pain in Chapter 9).

Bone pain of a mechanical nature associated with skeletal metastases occurs as a result of significant bone destruction, joint instability, mechanical insufficiency, and fracture. It is often incapacitating and persistent despite local and systemic therapies. Long bone or vertebral fractures with or without spinal cord compression may be the first indication of advanced disease. Spinal cord compression, the most serious complication of bone

metastasis, occurs secondary to increased pressure on the spinal cord or as a result of vertebral collapse. Classic signs and symptoms of cord compression include pain, numbness, and/or paralysis.³⁴

Pain may also arise from a biologic origin for a number of reasons. It may occur as a result of rapid growth of the tumor stretching the periosteum. Increased blood flow or angiogenesis (sometimes giving a throbbing or pulsatile sensation) and the release of cytokines at the site of the metastases gives rise to bone pain. And neuropeptides elaborated by or acting on bone-associated nerves in the endosteum can result in bone pain.^{31,68} Because the skeleton provides both form and support, growing tumors that deform the cortical bone contribute to activity-associated pain. This type of pain is often intermittent and related to weight bearing and movement.⁶⁸

Bone often functions as a metastatic conduit for peripheral nerves, as bone metastases travel hematogenously from distal body parts to the central nervous system. Therefore, bone tumor growth and invasion into surrounding tissues can result in neuritic pain syndromes, plexopathies, and spinal cord compression.

These pain syndromes contribute to increasing loss of mobility and bed rest, the effects of which are increasing generalized weakness, risk of thromboembolism, hypercalcemia, atelectasis, and pneumonia. The latter occur particularly in anyone with painful rib metastases. Mechanical failure or pathologic bone fracture may occur as a result of prolonged immobilization (osteoporosis). As with primary tumors, pathologic fractures can occur directly from the tumor itself or from the secondary effects of intervention.⁶⁸

Metabolic changes can also occur as a result of the disease or the treatment, increasing the risk of fracture. In people with multiple metastases, the resultant hypercalcemia may cause anorexia, nausea, vomiting, general weakness, and depression. Unexplained weight loss is typically a late sign of metastatic disease.

Left untreated, hypercalcemia may lead to diffuse osteoporosis, renal insufficiency, and dehydration (see Chapter 5). These symptoms may be relieved (and possibly prevented)⁷⁵ by the use of bisphosphonates (e.g., intravenous pamidronate [Aredia] and clodronate; oral ibandronate and clodronate), small molecules that inhibit osteoclast-induced bone resorption. The reactive bone formation stimulated by these lesions accounts for the elevation of serum alkaline phosphatase.⁸⁴

MEDICAL MANAGEMENT

DIAGNOSIS. A history of malignancy raises the suspicion of recurrent disease or a metastatic lesion. The evaluation of an individual with a previous history of cancer or a current malignancy and bone pain begins with a physical examination and basic radiographic studies. Spinal metastasis may be evident by the loss of the pedicle as seen in the anteroposterior view of a standard spinal radiograph.

Another early manifestation is the pathologic fracture of the lesser trochanter. Since much of the bone matrix must be destroyed before the lytic process is noted on radiographs, plain films are not sensitive and are not

useful in early detection but are more important in staging and treatment planning.

Whole-body bone scans are much more sensitive for early detection of skeletal metastasis but are not useful in predicting fractures. Approximately one third of those with skeletal metastatic disease have positive bone scan findings yet negative radiographic results. Scans are also used to determine the extent of dissemination.

CT and MRI also have roles in delineating various types of metastasis and assessing the size and extent of the lesion. More advanced technology using single-photon emission tomography (SPET) allows for better determination of anatomical location of the areas of radioisotope uptake.^{85,99} Biopsy is sometimes necessary to confirm a diagnosis when the primary source is not known. CT-guided biopsy is used to assess spinal lesions; diagnostic accuracy is greater for lytic lesions (93%) compared to sclerotic lesions (76%).⁶²

Other diagnostic tests may include serum chemistries, urinalysis, serum protein electrophoresis, and prostate-specific antigen determination (for men). Biochemical markers of bone turnover such as N-telopeptide and pyridinium cross-links (pyridinoline and deoxypyridinoline) may provide information on bone dynamics that reflect diseases activity in bone.

Several studies have shown bone markers to be elevated in people with documented evidence of metastatic bone disease. Increased levels are also observed in some people without clinical evidence of bone metastases, when compared with normal subjects. Rises in such markers may be the first indication of bone involvement and possibly a useful early diagnostic sign of progression.

Preliminary data suggest that bone marker level correlates with the extent of metastatic disease and the number of skeletal sites involved. Markers of bone turnover may be helpful in identifying those individuals likely to respond to bisphosphonate treatment and as a means of monitoring the effectiveness of bisphosphonate therapy in the management of bone metastases.⁶¹

TREATMENT. Therapeutic interventions may depend, in part, on the extent of involvement. The person with localized disease may be offered potentially curative therapy, whereas the individual with extensive skeletal and visceral involvement may only benefit from palliative treatment.⁵³

Treatment of bone metastasis is problematic, costly, and primarily palliative. Prolonging survival is not always possible, so improving function with pain relief, local control of disease, and bone stability is often the primary goal. This is becoming more important as treatment for primary cancers improves. Individuals may die from the primary tumor or from the metastasis (e.g., breast cancer). When survival rates and longevity increase, the likelihood of skeletal metastasis increases.

Intervention for skeletal neoplasms requires a multidisciplinary approach to optimize therapy options and coordinate their sequencing. Intervention modalities may include endocrine therapy (for breast and prostate cancer), chemotherapy, biotherapy (immunotherapy), use of bone-seeking radioisotopes (a therapy that has

analgesic and antitumor effects), and bisphosphonates to suppress bone resorption. These are often combined with other localized interventions such as surgery and site-directed radiation therapy.

Surgery is rarely curative but can be an effective therapy to decompress neural tissue for resolution of symptoms and/or restoration of function, reduce anxiety, improve mobility and function, facilitate nursing care, preempt fracture (i.e., repair bony lesions before they fracture), and control local tumor when nonsurgical therapies fail.^{70,103}

Pathologic fractures that occur in the femur and humerus often require surgical stabilization. Intramedullary fixation with interlocking devices to limit motion at the fracture site is indicated in many instances. The desire to restore normal anatomy must be weighed against the reality that the individual may have a terminal disease. An estimated life expectancy of at least 6 months is desirable before extensive joint reconstructive procedures are carried out.⁴⁹

Where the risk of fracture is great, as when more than 50% of the cortex is destroyed, prophylactic nailing of the femur may be indicated (Fig. 26-23). See the discussion of fractures and fracture treatment, including newly developing fracture treatment procedures, in Chapter 27.

Spinal metastases can cause severe pain, instability, and spinal cord compression with neurologic compromise. Pathologic fractures of the spine can be immobilized in an appropriate spinal brace, but a progressive neurologic deficit is an indication for surgical intervention. Surgery can take the form of decompression, posterior stabilization, excision, and reconstruction or prosthetic replacement. Vertebroplasty or kyphoplasty may be considered for the person with a vertebral compression fracture and minimal bone deformity.³⁷

PROGNOSIS. Although management of the skeletal metastasis may be successful in terms of restoring stability to a pathologic fracture, the prognosis for the primary cancer is still guarded. Only rarely is the skeletal metastasis actually the cause of death. Skeletal morbidity includes bone pain, hypercalcemia, pathologic fracture, spinal cord or nerve root compression, and immobility, all of which can impact mortality rates.²²

The median survival for people with tumors that have metastasized to the bone is determined by the type of tumor (e.g., prostate: 29 months; breast: 23 months; kidney: 12 months; lung: less than 4 months). The overall median survival after detection of bone metastases is approximately 19 months; this significant amount of time allows for interventions that can dramatically improve a person's quality of life and functional independence.³¹

Favorable prognostic factors include indolent nature of the primary lesion (e.g., prostate cancer); well-differentiated tumor on histologic examination; a long recurrence-free survival (greater than 3 years); sclerotic lesion on radiograph as opposed to a lytic lesion, especially after treatment; a single bone lesion; a single system involved with metastatic disease; low tumor markers; no vital

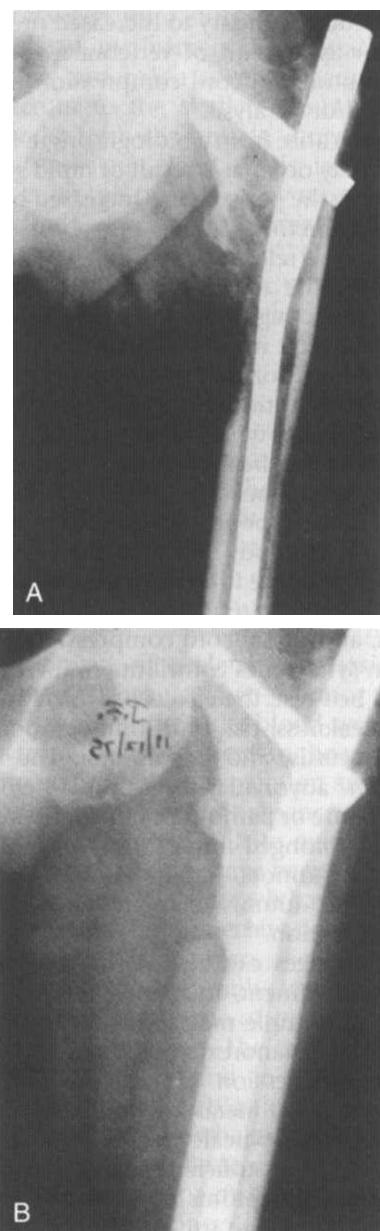


Figure 26-23

A, Prophylactic fixation in a 63-year-old woman with an impending fracture secondary to breast metastasis treated by Zickel nailing. **B**, Complete healing of this subtrochanteric lesion 5 months after radiation and chemotherapy. (From Habermann E, Lopez R: Metastatic disease of bone and treatment of pathologic fracture, *Orthop Clin* 20:475, 1989.)

organ involvement; and general good condition of the individual.

Unfavorable prognostic factors include the following³¹:

- Aggressive nature of the primary lesion (e.g., lung cancer)
- Poorly differentiated tumor on histology
- Short recurrence-free survival (less than 1 year)
- Lytic lesion
- No sclerosis on radiograph following treatment

- Multiple bone lesions
- Multiple system metastases
- High tumor markers
- Vital organ involvement
- General poor condition of the individual

The risk of pathologic fracture is greater in osteolytic lesions of the long bones. A direct relationship exists between the degree of cortical destruction and the risk of pathologic fracture. When cortical destruction is less than 25% to 35%, the risk for fracture is low. Destruction greater than 50% correlates with a much higher risk for pathologic fracture. The presence of pain with weight-bearing activities indicates compromised structural integrity and therefore also places the individual at greater risk of fracture.^{34,38}

SPECIAL IMPLICATIONS FOR THE THERAPIST 26-8

Metastatic Tumors

PREFERRED PRACTICE PATTERNS

See *Preferred Practice Patterns in Special Implications for the Therapist: Primary Tumors* earlier in the chapter.

Early Detection

Metastases to the skeleton are important to the therapist because the presence of musculoskeletal pain may be the initial symptom of an undetected primary carcinoma elsewhere. Early detection is essential for effective intervention. A thorough history and a high index of suspicion can lead to the timely communication with a physician. In people with a history of cancer, the clinician should be vigilant regarding the likelihood and common sites of metastasis. Autopsy-based analyses of the distributions of bone metastases demonstrate that the most favored sites are the vertebrae, pelvis, femur, and bones of the upper extremity. Metastases distal to the elbow or knee are rare; when they do occur, the kidney is most likely the site of the primary tumor.⁷⁰

Preoperative Intervention

Exercise is recommended for individuals with bone metastases before and after surgery, focusing on increasing muscle strength and endurance while maintaining bone protection. Exercise programs directed at strengthening and stretching are often needed; high-impact and high-torsion activities should be avoided.³¹

An understanding of common postoperative impairments helps in treatment planning, preventing or minimizing length of hospitalization, and fostering an early return to independence. Chemotherapy for some cancers includes the use of steroids that can lead to muscle atrophy, especially of the type II fibers (see Chapter 5). Isometric exercises may prevent marked atrophy. Radiation therapy can lead to contracture of soft tissues, and clients should be taught to stretch and self-mobilize the soft tissues of susceptible areas before treatment.

Instruction in fall prevention strategies, including optimal body mechanics and exercises to maintain strength and balance, is essential before and after surgery.³¹ This is especially true for anyone taking pain medication that causes drowsiness and decreased coordination.³⁴

Rehabilitation

People who have had a pathologic fracture stabilized are often referred for rehabilitation. Hypercalcemia is common in the acute or subacute phase¹⁶ and occurs when bone resorption is greater than new bone formation. The osteolysis that occurs with bone metastasis is one cause of hypercalcemia.

Treatment of the primary cancer with chemotherapy and/or radiation therapy often provides additional challenges, such as fatigue and increased risk of infection. For a client with lung cancer, baseline pulmonary status should be established and proper breathing techniques taught. Management of clients with metastatic disease is challenging, because in addition to these complications, clients often need extensive rehabilitation after the medical treatment.

Management of skeletal metastasis, including fracture, is aimed at improving or restoring function, especially maintaining ambulatory function to preserve quality of life and prevent the negative sequelae of immobility (see Table 6-7). If the bone has been compromised or fractures have occurred, surgical intervention will attempt to stabilize the defect.

After the surgery, early mobilization, including gait training, bed mobility, and transfers, is essential. Maximizing functional independence is the driving force behind all rehabilitation efforts. Safety and bone protection are important during mobility and strengthening activities. Evaluation of upper extremity function and coexisting upper extremity metastases before allowing weight bearing through the arms is important.³¹

There is a reluctance to ambulate clients who are at risk of pathologic fracture because a measure of risk has not been developed, but in fact an active rehabilitation program may not place a client at increased risk of fracture.¹⁷ The risk of producing pathologic fractures in clients with cancer by increasing mobility and function is low.¹⁸ Many individuals with skeletal metastases and pathologic fracture have been shown to be good candidates for intensive rehabilitation programs if they do not have hypercalcemia caused by lytic metastases or pain severe enough to require parenteral narcotics.¹⁴

Since many of the people with metastatic disease are at risk for pathologic fractures, the risk of falling must be considered when planning for ambulation training, especially among older adults. Assessments of mental status, balance, strength, ROM, endurance, vision, ambulation history, and symptoms of dizziness are all important and will help plan ambulation training. Even with the most critical analysis of the risks and benefits, therapists who work with individ-

Continued.

als who have serious medical conditions such as metastatic lesions and pathologic fractures must be prepared for setbacks and unexpected events to occur when attempting to preserve or maximize function.

Rehabilitative decision making in this area requires collaboration between the therapist and the medical staff (e.g., oncologist, surgeon) and takes into primary consideration the degree of cortical involvement. It is very helpful if the therapist has access to imaging studies with accurate information about the extent of involvement, specific levels affected, and knowledge of stability (or instability) of spinal segments to assist in treatment planning. The following guidelines are just that: a guide to be used as a template to begin with but modified by individual differences and interests, postoperative protocols, physician input, and so on.

For clients with less than 25% of the cortex invaded, submaximal isometrics and gentle aerobics (e.g., bicycling at low resistance, aquatics if approved by the physician for those with wounds or fractures that are healing) are generally permitted, and the involved

limb most typically is cleared for weight bearing as tolerated.

When cortical involvement increases to 25% to 50%, restrictions tighten and allow for gentle ROM without pressure into the end ROM and limb offloading to partial weight bearing. Finally, with greater than 50% cortical involvement, exercise may need to be deferred and the limb maintained non-weight bearing.^{21,34} See Chapter 9 for other exercise guidelines for the individual with cancer and Special Implications for the Therapist: Primary Tumors earlier in this chapter.

References

To enhance this text and add value for the reader, all references are included on the companion Evolve site that accompanies this textbook. The reader can view the reference source and access it on-line whenever possible. There are a total of 106 cited references and other general references for this chapter.

CHAPTER 27

Soft Tissue, Joint, and Bone Disorders

CATHERINE C. GOODMAN

People presenting with muscle, joint, and bone disorders make up a significant percentage of the therapist's practice. These conditions are primarily manifested by pain, deformity, and loss of mobility and function. Many of the people seen by therapists have these conditions secondary to trauma or repetitive overuse; these conditions are generally self-contained or local in terms of involved tissues.

Therapists may treat dysfunction in other body regions to reduce the mechanical stresses on the involved joint, but the disorder itself (i.e., degenerative joint disease, bursitis, tendinitis) does not spread to other body regions. This is in contrast to rheumatic disease, a systemic disorder, which can be manifested not only by local joint or muscle pain and dysfunction but also by additional complaints associated with other body systems.

Although this book is primarily a compilation of diseases and conditions of all systems, this chapter contains both orthopedic and systemic conditions that affect the bones, joint, or muscles that may not fall into any other category. Because the focus of this text is not orthopedics, many orthopedic conditions have not been included. For the most part, those conditions with a more generalized effect or accompanied by a systemic component are included here. The concepts presented in Chapter 22 are especially important to the discussion of this chapter and should be reviewed or read along with this chapter.

This chapter is divided into three distinct anatomic areas (soft tissue, joint, bone) with conditions and diseases placed in the area most notably affected. Frequently there is overlap, and one condition affecting more than one area is found in a single section. As always, the reader is encouraged to keep a broad perspective whenever studying an isolated condition or anatomic area.

SOFT TISSUE

Soft Tissue Injuries

Soft tissue injuries, such as strains and sprains, lacerations, tendon ruptures, muscle injuries, myofascial compartment syndromes, dislocations, and subluxations, are described briefly in this section. For a more detailed description of these conditions, the reader is referred to the *Guidelines for Exercise Testing and Prescription* by the American College of Sports Medicine (ACSM).¹⁵

Strains refer to stretching or tearing of the musculotendinous unit; they may be partial or full tears. The musculotendinous junction is a region of highly folded basement membranes between the end of the muscle fiber and the tendon. These involutions maximize surface area for force transmission but contain a transition zone where the compliant muscle fibers become relatively noncompliant tendon, placing this junction at increased risk for injury.⁵⁷ A helpful mnemonic device to recall strain versus sprain is that the *t* in strain can be matched to the *t* in musculotendinous. A *sprain* is an injury of the ligamentous structures around a joint caused by abnormal or excessive joint motion.

Strains and sprains can be classified as mild, moderate, or severe (complete) tears or as injuries of first, second, or third degree depending on the severity of tissue damage. Stretching or minor tearing of a few fibers without loss of integrity is classified as *first degree* (mild), with only minor swelling and discomfort accompanied by no or only minimal loss of strength and restriction of movement.²²⁷

Second-degree (moderate) strain refers to partial tearing of tissue with clear loss in function (ability to contract). Pain, moderate disability, point tenderness, swelling, localized hemorrhaging, and slightly to moderately abnormal motion are typical.

A *third-degree* (severe) strain or sprain refers to complete loss of structural or biomechanical integrity extending across the entire cross section of the muscle and usually requires surgical repair. An alternate classification scheme uses three grades of injury (I, II, III). Common sites for this type of injury include the ankle, knee, and fingers.

The tendon is most vulnerable to injury (*tendinitis*, *tendon rupture*) when it is tense or the attached muscle is maximally contracted or stressed and tension is applied quickly or obliquely. Tendinitis and spontaneous tendon ruptures have been reported to occur as a potential side effect of antibiotic treatment, especially with the use of fluoroquinolone antibiotics (e.g., drugs ending in "floxacin," such as ofloxacin, norfloxacin, levofloxacin).

Reports suggest that fluoroquinolone-associated tendon disorders are more common in people over 60 years of age, especially those who are also taking oral corticosteroids.⁵¹⁸ Tendon injuries occur at a higher rate in kidney transplant recipients, possibly caused by

medications. In such cases, care should be taken to avoid overloading tendons, since dramatic ruptures following even small trauma have been reported.⁴⁶⁵

Injured muscle is also at increased risk for complete rupture if the muscle is subjected to high tensile force. The clinical manifestations of soft tissue injuries are local pain, edema, increased local tissue temperature, ecchymosis, hypermobility or instability, and loss of function. Muscle contusion (bruising with intact skin) is common in contact sports and incites an inflammatory response, sometimes involving hematoma formation.

Inflammatory reaction from injured soft tissue may lead to structural adaptation of tissue, scarring, weakness, and inflexibilities that can cause structural deficits or functional adaptations. If, after an injury, the therapist notes quick onset of joint effusion and the joint feels hot to the touch and movement is extremely painful and limited, the joint needs to be examined by a physician to rule out hemarthrosis.

Myofascial compartment syndromes develop when increased interstitial pressure within a closed myofascial compartment compromises the functions of the nerves, muscles, and vessels within the compartment. Compartment syndromes may be acute or chronic and are most likely to occur within the "envelopes" of the lower leg, forearm, thigh, and foot where the fascia cannot give or expand.

Many clinical conditions predispose to the development of compartment syndromes, including fractures, severe contusions, crush injuries, excessive skeletal traction, and reperfusion injuries and trauma. Other risk factors may include burns, circumferential wraps or restrictive dressings, or a cast or other unyielding immobilizer. Ischemia and irreversible muscle loss can occur, resulting in functional disability (and even potential loss of limb) if the condition is left untreated.

The earliest clinical symptom of impending compartment ischemia is pain out of proportion to that expected from the injury. The pain is described as deep, throbbing pressure. There may be sensory deficit or paresthesia within the region distal to the area of involvement. In severe compartment syndromes, objective signs are visible, such as a swollen extremity with smooth, shiny, or red skin. The extremity is tense on palpation, and passive stretch increases the pain.³²⁹ Prompt surgical decompression is the standard intervention.

Injury to the *growth cartilage* can occur in skeletally immature children and adolescents. The three areas of growing cartilage in a skeletally immature individual include the physis (growth plate), articular cartilage of joint surfaces, and major bone-tendon attachments (apophyses). These sites account for a large number of sports injuries in young athletes, including osteochondritis dissecans (articular surface) and Osgood-Schlatter disease (apophysis); both conditions are discussed later in this chapter.

The terms *subluxation* and *dislocation* relate to joint integrity. Subluxation is partial disruption of the anatomic relationship within a joint. Mobile joints are at risk of subluxation. These include the glenohumeral, acromioclavicular, sacroiliac, and atlantoaxial joints. Once the joint condition has stabilized, rehabilitation should

address local muscle imbalances and adjacent joint hypomobility, which could increase mechanical stresses at the joint.

Dislocation implies complete loss of joint integrity with loss of anatomic relationships. Often significant ligamentous damage occurs with this type of injury. Dislocations most often occur at the glenohumeral joint. Congenital dislocations are most frequently seen at the hip joints (see the section on Developmental Dysplasia in Chapter 23).

Joint dislocation can also be a late manifestation of chronic disease, such as rheumatoid arthritis (RA), paraparesis, and neuromuscular disease. In the presence of a joint dislocation, the integrity of nerve and vascular tissue must be assessed. If compromise is suspected, timely reduction is essential to prevent serious complications.

SPECIAL IMPLICATIONS FOR THE THERAPIST 27-1

Soft Tissue Injuries

PREFERRED PRACTICE PATTERNS

4C: Impaired Muscle Performance

4D: Impaired Joint Mobility, Motor Function, Muscle Performance, and Range of Motion Associated with Connective Tissue Dysfunction

4E: Impaired Joint Mobility, Motor Function, Muscle Performance, and Range of Motion Associated with Localized Inflammation

4I: Impaired Joint Mobility, Motor Function, Muscle Performance, and Range of Motion Associated with Bony or Soft Tissue Surgery

Immediate immobilization is required with soft tissue lesions to avoid excessive scar formation and prevent rerupture at the injury site. Further retraction of the ruptured muscle stumps and hematoma size can be minimized by placing the injured extremity to rest.²²⁶ Immobilization appears to provide the new granulation tissue with the needed tensile strength to withstand the forces created by muscle contractions. Immobilization should not extend beyond the first few days following the injury.²²⁷

Early mobilization for the treatment of acute soft tissue injuries has proven effective, especially in treating injured athletes. Early mobilization has been shown to induce rapid and intensive capillary ingrowth into the injured area with better repair of muscle fibers and more parallel orientation of the regenerating myofibers in comparison to immobilization. Early mobilization has the added benefit in muscle of improved biomechanical strength, which returns to the level of uninjured muscle more rapidly using active mobilization.²²⁷

The therapist can guide the injured individual in following a recovery protocol to enhance healing. Crutches may be advised with severe lower extremity muscle injuries, especially injuries where adequate early immobilization is difficult to achieve (e.g., groin area).²⁶⁴ Movement during the first 3 to 7 days should be with care to avoid stretching the injured muscle.

The therapist can be very helpful in treating soft tissue injuries by preventing the detrimental effects of immobilization (see Table 6-7), by promoting tissue flexibility and strength, by minimizing inflammation, and by enhancing tissue healing.

Between 7 and 10 days, the therapist can gradually progress the individual in using the injured muscle more actively, using pain and tolerance as a guide to setting limits. All rehabilitation activities should begin with a warmup of the injured muscle, as it has been shown to reduce muscle viscosity and relax muscles neurally.¹⁷⁴ Stimulated, warm muscles absorb more energy than unstimulated muscles and can better withstand loading. Combining a warmup with stretching can improve the elasticity of injured muscle.⁴²⁹

Isometric training should be started first and progressed to isotonic training; isotonic strengthening begins without a resisting load/counterload, then one is progressively added. All exercises should be done within the limits of the client's pain. When the individual can complete isometric and isotonic exercises without pain, then isokinetic training with minimal load can begin.²²⁷

The effects of loading on the musculotendinous unit during rehabilitative exercise are increased tendon size, tensile strength, and enhanced collagen fiber organization of newly formed collagen. Restoring kinesthetic and proprioceptive awareness at the site of injury and restoring mobility and strength are also important elements of the rehabilitation program.

Fluoroquinolone-induced Tendon Rupture

A growing number of people are experiencing tendinopathy as a result of quinolone antibiotics. The presentation of joint tenderness and swelling of apparently unknown cause can occur up to 6 months or more after the administration of the drug. The therapist should be alert to this kind of presentation in anyone with a history of fluoroquinolone use with any of the following risk factors: age over 60, previous history of tendinopathy, magnesium deficiency, hyperparathyroidism, diuretic use, peripheral vascular disease, RA, diabetes mellitus, or participation in strenuous sports activities.^{151,447}

Creatine Supplementation in Athletes

The therapist working with athletes at all levels (high school, collegiate, recreational, amateur, professional) and of all ages should be aware that performance-enhancing supplements can cause muscle damage despite their intended use to build muscle mass in order to increase strength or power.

One example of this type of supplement is creatine (Cr) used to increase lean body mass in conjunction with a resistance training program. Potential side effects of creatine supplementation include muscle cramping, diarrhea and other gastrointestinal symptoms, and dehydration.⁴¹²

Injury Prevention

Overuse injuries from repetitive stresses and microtrauma are common among children and adults, espe-

cially young athletes participating in organized sports. The therapist working with athletes from any sport can emphasize injury prevention by educating both the athletes and their parents and encouraging coaches to emphasize injury prevention.

Prevention begins with conditioning, especially at the beginning of the season for one-sport athletes who do not play year round. Training errors, variable skeletal and muscle growth rates, anatomic malalignment, and faulty equipment are just a few of the key factors that contribute to injury. For those individuals involved in multiple sports, volume and intensity of athletic involvement combined with inadequate time for recovery after injuries of any kind are key issues.⁴⁰²

Learning and practicing the basic skills (e.g., sliding into bases correctly, making a tackle in football, learning how to head-butt the ball in soccer) and understanding the fundamentals for each sport activity is essential. Many more injuries occur during practice than during actual competitive play, since this is where more time is spent. Early participation in organized sports at younger ages often results in overuse injuries, likely due to strength and flexibility imbalances.⁴⁰²

The therapist can help identify and correct such risk factors before they translate into injury. Early detection of risk factors and injuries can help minimize the severity of injury and reduce long-term consequences of soft tissue damage. Everyone should be encouraged to think about injury prevention during practices as well as during competitions.

Heterotopic Ossification

Overview and Definition

Heterotopic ossification (HO) is defined as bone formation in nonosseous tissues (usually muscles and other soft tissue areas). It is considered a benign condition of abnormal bone formation in soft tissue that occurs most commonly after trauma such as fractures, surgical procedures (especially total hip replacements), spinal cord and traumatic brain injuries, burns, and amputations. HO is the most common complication of total hip arthroplasty.⁷⁵ Classification of HO is based on the anatomic location and effect on functional motion (Box 27-1).

There is an increased incidence of HO among military personnel with blast injuries. The extreme force destroys bone, muscles, and tendons, resulting in amputation. Bone growth associated with HO in the residual limb does not follow a predictable pattern, and bone may grow into long spikes or develop more like cobwebs.

In addition to acquired forms of HO, there are forms due to hereditary causes such as fibrodysplasia ossificans progressiva, progressive osseous heteroplasia, and Albright's hereditary osteodystrophy. These conditions are extremely rare but do provide helpful information on the pathophysiology of the condition.⁵¹⁵

Heterotopic ossification and *myositis ossificans* (MO) are terms often used interchangeably. Both conditions represent the deposition of mature lamellar bone and share

Box 27-1**CLASSIFICATION OF HETEROtopic OSSIFICATION**

Class I	Presence of heterotopic ossification but without functional range-of-motion limitations
Class II	Heterotopic ossification with limitations in all planes of motion
Class III	Heterotopic ossification with ankylosis preventing motion

Data from Hastings H: Classification and treatment of heterotopic ossification about the elbow and forearm, *Hand Clin* 10:417-437, 1994.

radiographic and histologic characteristics, but the locations in which they occur are different. HO develops in nonosseous tissues, while MO forms in bruised, damaged, or inflamed muscle.⁷¹

HO in people with spinal cord injuries is often referred to as *neurogenic heterotopic ossification* (NHO). NHO appears to be related more to the degree of completeness of spinal cord injury than the level involved; individuals with complete transverse spinal cord injuries are more likely to develop HO compared to those with incomplete spinal cord injuries.⁷¹

Risk Factors

Risk factors for HO include a serious traumatic injury, previous history of HO, hypertrophic osteoarthritis, ankylosing spondylitis (AS), and diffuse idiopathic skeletal hyperostosis (DISH). Men seem to be at higher risk for HO than women. Other risk factors may include Paget's disease, RA, posttraumatic arthritis, neural axis and thermal injuries, and osteonecrosis.^{71,75}

Surgery-related factors may contribute to the formation of HO. Individuals who have undergone multiple surgical interventions over a short period of time are at increased risk of HO. This may be attributed to the extensive damage to soft tissues, presence of disseminated bone dust, or formation of hematoma. Length of time in surgery has also been implicated.⁷¹

HO occurs in 1% to 3% of the burn population. It appears to be related more to the degree of thermal injury than to the location of the burn. Individuals with third-degree burns affecting more than 20% of the total body surface are at greatest risk for the development of HO. Systemic physiologic factors in conjunction with local factors are the likely underlying etiology.^{113,211}

Etiology and Pathogenesis

The cause of HO remains unknown. Direct trauma is the most common cause of heterotopic bone formation in the elbow. It appears that there is a link between the severity of injury and the amount of ectopic bone formation that develops. Someone who sustains a massive traumatic injury is very likely to develop HO; HO is five times more likely if there is both fracture and dislocation of the elbow.⁷¹

It is most likely that pluripotent mesenchymal (stem) cells that could differentiate into cartilage, bone, or tendon/ligament become osteoblasts instead. Differentiation begins early after surgery and peaks at 32 hours, possibly induced by a bone-inducing substances such as bone morphogenetic protein (BMP). The stimulus and mechanism that causes this to happen in soft tissues after trauma has not been determined. There may be local factors such as mechanical stress (e.g., articular disruption, muscle damage) and/or systemic factors.²⁹⁷

Individuals with traumatic brain injury are predisposed to HO, most likely due to osteoinductive factors released at the site of the brain injury, although little is known about this process.¹⁴⁰ In the case of bone fracture or reaming of the bone during joint replacements, bone marrow, which is capable of forming bone, may spread into well-vascularized muscle tissue. Bone marrow combined with growth factors from traumatized tissues may set off a series of steps leading to bone development and HO.^{29,75}

Histologically, in the acute phase, the inflammatory process results in edema and degeneration of muscle tissue. After a few weeks, the inflamed tissue is replaced with cartilage and bone, and the bone undergoes intensive turnover. Histologically, this process cannot be distinguished from the formation of bone callus in fractures.⁴⁸⁰

There are histologic differences between normal bone and the ectopic (displaced) bone formed in HO. In normal bone, the periosteal layer covering the external surface of the bone has an inner vascular cambium layer surrounded by an outer fibrosus layer. In HO, the ectopic bone is not enveloped by periosteum. Instead there are three zones: the center is made up of dense cells and is surrounded by a layer of osteoid. The outermost layer consists of highly organized bone, although ectopic bone has twice the number of osteoclasts compared with normal bone and a higher number of osteoblasts as well.⁵⁴³

Clinical Manifestations

HO may be asymptomatic and without pain, but pain and loss of motion are the most common presenting symptoms, often within 2 weeks of the precipitating trauma, surgery, burn, or neurologic insult. Swelling, warmth, erythema, and tenderness mimic a low-grade infection or, in the case of surgery, the normal postoperative inflammation that is often present. The hallmark sign of HO is a progressive loss of joint motion at a time when posttraumatic inflammation should be resolving.

As the ectopic ossification advances, the acute symptoms described may subside, but motion continues to decrease, even with intervention such as dynamic and/or static progressive splinting. Over the next 3 to 6 months, the HO matures and the individual develops a rigid or abrupt end feel with pain at the end range of motion. Delayed nerve palsy is common when the elbow is affected.⁷¹

Areas of calcification and bone spurs may progress to ankylosis. Sites affected most often include the hip, elbow, knee, shoulder, and temporomandibular joints. The elbow is the most common site of HO in burn patients; of the 1% to 3% of burn patients affected, the elbow is involved more than 90% of the time.²¹¹ Typically, a bridge of ectopic bone forms across the

posterior aspect of the elbow, possibly filling in the olecranon fossa.

Pressure from the bone formation can result in pressure ulcers and interfere with skin grafts. Loss of motion can have serious consequences for daily function, especially for those individuals who are already neurologically compromised.

Different classification schemes are used depending on the site affected. Most grade the condition based on a scale from 0 to 3 or 0 to 4. Grade 0 is no islands of bone visible on x-ray. The final grade is bony ankylosis, with progressive involvement between the lowest and highest grade (e.g., bone spurs, periarticular bone formation).

MEDICAL MANAGEMENT

PREVENTION. Measures can be taken to prevent HO, such as radiation treatment and pharmaceuticals (e.g., nonsteroidal antiinflammatory drugs [NSAIDs], diphosphonates). Diphosphonates inhibit osteoid cells from calcifying, thus preventing HO. The effect lasts only as long as the drug is taken. Gastrointestinal disturbance and osteomalacia are adverse side effects of this treatment, making it less than optimal.

NSAIDs (indomethacin) are effective in reducing the frequency and magnitude of ectopic bone formation in some areas (e.g., hip). Used during the first 3 weeks postoperatively, indomethacin inhibits precursor (undifferentiated) cells from developing into osteoblasts.

Low-dose external beam radiation is another effective preventive measure. Fractionated radiation of the pluripotent mesenchymal cells has been shown to be effective in preventing HO from developing when delivered within 72 hours after surgery.²⁸⁸

It can be used alone or in combination with NSAIDs. Prevention is recommended for individuals at high risk of ectopic ossification, including those with neurologic injury, burns, past history of HO, and/or a previous history of other conditions previously mentioned.

The best prevention for HO is to avoid soft tissue trauma, especially among high-risk individuals undergoing surgery of any kind. Complete wound lavage and the removal of all bone debris and reamings may help prevent HO.⁷⁵

DIAGNOSIS. Radiographic evidence with mineralization may be observed 4 to 6 weeks after the trauma (sometimes as early as 2 weeks after the incident event). X-rays show both the location, extent, and maturity of pathologic bone. HO must be differentiated from metastatic calcification, most often associated with hypercalcemia, and from dystrophic calcifications in tumors. History and radiographic examination usually provide the tools needed to diagnose this condition. Ultrasound may prove useful in diagnosing HO around the hip or elbow.

A computed tomographic (CT) scan may be best to show the exact location and involvement of the articular surfaces. Laboratory tests to measure the level of serum alkaline phosphatase are used by some, but they are not consistently accurate.

TREATMENT AND PROGNOSIS. Radiation applied to the damaged limb site within a few days after the injury may

respond but there is always the risk of impaired healing for those with bone fractures. Surgical resection is delayed until the bone matures and develops a distinct fibrous capsule in order to minimize trauma to the tissues and reduce the risk of recurrence and may only be done in cases where activities of daily living (ADLs) are compromised by loss of motion.²¹¹

Indication for surgery may not be just the presence of HO but rather the severity of functional restriction when loss of motion prevents the individual from using the affected extremity. A comprehensive rehabilitation program is needed to maximize motion, restore function, and reduce the risk of developing ankylosis. Once surgical removal is done, radiation and NSAIDs are continued to prevent recurrence.

SPECIAL IMPLICATIONS FOR THE THERAPIST

27-2

Heterotopic Ossification

PREFERRED PRACTICE PATTERNS

4D: Impaired Joint Mobility, Motor Function, Muscle Performance, and Range of Motion Associated with Connective Tissue Dysfunction

4I: Impaired Joint Mobility, Motor Function, Muscle Performance, and Range of Motion Associated with Bony or Soft Tissue Surgery

The therapist's management of HO has evolved in the recent past based on knowledge of the condition. Traditional thinking that passive range of motion is contraindicated with HO has been abandoned. There was concern that passive range of motion could lead to further bone growth, but this has not proven accurate. Forceful joint manipulation can lead to muscle tears and ossification within the muscle and is contraindicated but should not be confused with passive range-of-motion exercises, which can be effective in preventing loss of motion and ankylosis.⁷¹

A specific program of physical therapy intervention can be planned based on the timing of the referral. During the acute and edematous phase (first 1 to 2 weeks postoperatively), proper measures are taken to reduce swelling, minimize scar formation, and provide pain management to allow for maximum participation in the program. Range-of-motion exercises (passive and active) can begin but must take into account the type and extent of injury present (e.g., fracture, joint instability).

Phase 2 occurs during the inflammatory stage approximately 2 to 6 weeks after the injury or incident event. Unorganized scar tissue forms during this phase but remains soft and deformable so that range-of-motion gains can be made. The soft tissues still respond to various modalities, and self-passive stretching with weighted stretches and/or dynamic or static progressive splinting is most likely to recapture lost motion. Specific recommendations for HO affecting the elbow are available.⁷¹

The therapist should continue to encourage functional use of affected areas, including strengthening

Continued.

when appropriate, and emphasize motion throughout all motions, even if x-rays show HO developing around week 4 to 6 in this phase. By week 6, bone fractures are typically healed, allowing for more aggressive splinting. Scar tissue is fully formed but still malleable during this third (fibrotic) phase from 6 to 12 weeks. Splinting and resistive exercises can continue to maximize gains in motion.

Finally, during the last phase, 3 to 6 months after injury or surgery, scar tissue is organized and fibrotic. The individual may continue to make small gains, but often motion has reached a plateau and splints are discontinued gradually. Clients should be encouraged to continue a home strengthening program for at least another 6 months.⁷¹

Connective Tissue Disease

Overview and Incidence

Sometimes people have features of more than one rheumatic disease. This has been called the overlap syndrome or mixed connective tissue disease (MCTD). This category includes people who have overlapping features of systemic lupus erythematosus (SLE), scleroderma, or polymyositis. The incidence of this disease is unknown, but adults, particularly women, are predominantly affected.

Initially MCTD was considered a distinct entity defined by a specific autoantibody to ribonuclear protein (RNP). In the late 1980s this concept of MCTD was considered flawed, since with time, in many of the affected people, the manifestations evolve to one predominant disease, and since many people with autoantibodies to RNP have clearcut SLE. Therefore the designation *overlap connective tissue disease (OCTD)* became the preferred name for the disorder in people having features of different rheumatic diseases.

There is also a condition called undifferentiated connective tissue syndrome in which the systemic rheumatic diseases present have several properties shared to a variable extent by RA, SLE, polymyositis, dermatomyositis, and Sjogren's syndrome, which makes a specific diagnosis for a recognizable connective tissue disease difficult.⁵

More advanced technology has brought about immunogenetic and serologic studies that demonstrate once again that MCTD is quite distinctive from other disorders, especially SLE and systemic sclerosis. There is now good evidence that the clinical and serologic features of MCTD are not just a haphazard association but represent a distinctive subset of connective tissue disease in which specific autoimmune response is relevant to clinical expression and to understanding the underlying pathogenesis.²⁹⁹

Etiologic and Risk Factors and Pathogenesis

The cause of connective tissue disease is unknown, but hypotheses implicating modified self-antigens or infectious agents in the pathogenesis of MCTD have been advanced.¹⁹⁹ Persons with this condition often have

hypergammaglobulinemia and test positive for rheumatoid factor, suggesting an immune injury.

There is also a high titer of antibody to RNP (anti-RNP), but as previously mentioned this feature is also present in SLE. The cause for the formation and maintenance of the high titer of anti-RNP antibody is unclear. There is no direct evidence that these antibodies induce the characteristic involvement of the various organ systems.

There has been considerable controversy over the possible connection between silicone breast implants (and other silicone-containing devices, such as shunts and catheters) and the risk of connective tissue diseases. To date, there has been no convincing evidence of an association between breast implants in general, or silicone gel-filled breast implants specifically, and any of the individual connective tissue diseases or other autoimmune or rheumatic conditions.

From a health perspective, breast implants appear to have a minimal effect on the number of women in whom connective tissue diseases develop; the elimination of implants would not be likely to reduce the incidence of connective tissue diseases.^{225,268} See also the section on Infections with Prostheses and Implants in Chapter 25.

Likewise, efforts to prove an association between organic solvents and connective tissue disease have not been consistently replicated; which solvents convey risk remains unknown.¹³⁷

Clinical Manifestations

OCTD/MCTD combines features of SLE (rash, Raynaud's phenomenon, arthritis, arthralgias), scleroderma (swollen hands, esophageal hypomotility, pulmonary interstitial disease), polymyositis (inflammatory myositis), and, in most people, polyarthralgias. Seventy-five percent have RA. Proximal muscle weakness with or without tenderness is common.

Pulmonary, cardiac, and renal involvement, as well as such findings as Sjogren's syndrome, Hashimoto's thyroiditis, fever, lymphadenopathy, splenomegaly, hepatomegaly, intestinal involvement, and persistent hoarseness, may occur. Neurologic abnormalities, including organic mental syndrome, aseptic meningitis, seizures, multiple peripheral neuropathies, and cerebral infarction or hemorrhage, occur in about 10% of people affected by this disorder. A trigeminal sensory neuropathy appears to be seen much more frequently in MCTD/OCTD than in other rheumatic diseases.

MEDICAL MANAGEMENT

DIAGNOSIS, TREATMENT, AND PROGNOSIS. The diagnosis is considered when additional overlapping features are present in persons appearing to have SLE, scleroderma, polymyositis, RA, juvenile idiopathic arthritis, Sjogren's syndrome, vasculitis, idiopathic thrombocytopenic purpura, or lymphoma. High titers of serum antibodies to U1-RNP are a characteristic serologic finding seen much more often with OCTD/MCTD than with any other rheumatic disease.

General medical management and drug therapy are similar to the approach used in SLE. Most persons are

responsive to immunosuppression with corticosteroids, especially if administered early in the course of the disease. Mild disease often is controlled by salicylates, other NSAIDs, antimalarials, or very low doses of corticosteroids. High doses of steroids may be used in combination with cytotoxic drugs when the disease is progressive and widespread.

The overall mortality has been reported as 13%, with the mean disease duration varying from 6 to 12 years. Individuals who respond well to steroid therapy have a good prognosis. Pulmonary and cardiac complications (e.g., pulmonary hypertension) are the most common cause of death in MCTD.¹⁷⁸ Sustained remissions for several years in some people receiving little or no maintenance corticosteroid therapy have been observed.

SPECIAL IMPLICATIONS FOR THE THERAPIST 27-3

Connective Tissue Disorders

Preferred practice patterns and special implications are as for specific diseases discussed later and in other chapters (e.g., SLE, systemic sclerosis, RA, Raynaud's phenomenon, Sjogren's syndrome, polymyositis).

Polymyalgia Rheumatica

Overview

Polymyalgia rheumatica (PMR, literally "pain in many muscles") is a disorder marked by diffuse pain and stiffness that primarily affects the shoulder and pelvic girdle musculature. This condition is significant in that diagnosis is difficult and often delayed; severe disability can occur unless proper intervention is initiated. PMR may be the first manifestation of a condition called giant cell arteritis, an endocrine disorder, malignancy, or an infection.⁴⁶⁸

The initial symptoms associated with PMR are often subtle and of gradual onset, resulting in a delay in the person's seeking care. The complaints also may be localized to one shoulder, leading to an initial diagnosis of bursitis. As the disease progresses, carrying out ADLs becomes increasingly difficult. Bed mobility and sit-to-stand transfers are among the functional activities affected.

Finally, a significant number (15% to 20%) of those with PMR also develop giant cell arteritis, a condition characterized by inflammation in the arteries of the head and neck (see further discussion in Chapter 12). The risk related to the arteritis is blindness secondary to obstruction of the ciliary and ophthalmic arteries from inflammation-associated swelling.

Incidence and Risk Factors

Female gender, age, and race are the three primary risk factors associated with PMR. Women are affected twice as often as men, and the disease is rare before the age of 50 years; most cases occur after age 70 years. White

women are more commonly affected than are women of other ethnicity. PMR is a relatively common condition, with incidence estimated at 1 in 200 (one half as common as RA).⁴³³

Etiologic Factors and Pathogenesis

The cause of PMR is unknown, but experts suspect that genetic factors, infection, or an autoimmune malfunction may play a role. There is a genetic predisposition for PMR; human leukocyte antigen (HLA) DR4 (see Table 40-20) has been identified. Besides associations with HLA, tumor necrosis factor (TNF) appears to influence susceptibility to both PMR and giant cell arteritis. Additional studies are under way to clarify the genetic influence on susceptibility to these conditions.¹⁵³

Despite complaints of pain and stiffness in the muscles, PMR is not associated with any histologic abnormalities. Serum creatinine kinase levels, electromyograms, and muscle biopsy results are negative in this population. Rather, the aching and stiffness typical of this condition are caused by joint inflammation.

More specifically, magnetic resonance imaging (MRI) studies have shown that subacromial and subdeltoid bursitis of the shoulders, ilipectineal bursitis, and hip synovitis are the predominant and most frequently observed lesions in active PMR. The inflammation of the bursae associated with glenohumeral synovitis, bicipital tenosynovitis, and hip synovitis may explain the diffuse discomfort and morning stiffness.³⁹³

Clinical Manifestations

PMR may begin gradually, taking days or weeks for symptoms to become fully evident, but more often it develops suddenly, and the person wakes up one morning feeling stiff and sore for no apparent reason. Getting out of bed in the morning can be the biggest challenge for individuals with PMR before initiating drug therapy.

Even though the initial muscle pain and stiffness may occur unilaterally, the symptoms are often bilateral and symmetric, affecting the neck, sternoclavicular joints, shoulders, hips, low back, and buttocks. Painful stiffness lasts more than 1 hour in the morning upon arising and is a hallmark feature of this disorder. Flu-like symptoms such as fever, malaise, and weight loss are not uncommon.

Peripheral manifestations (e.g., wrists or metacarpophalangeal joints) are present in about one half of all cases of PMR and include joint synovitis, diffuse swelling of the distal extremities with or without pitting edema, tenosynovitis, and carpal tunnel syndrome.⁴³² Many people are misdiagnosed with fibromyalgia, myositis, tendonitis, thyroid problems, or depression and spend months searching for answers and help before the correct diagnosis is made.

Despite the complaints of difficulties with bed mobility, sit-to-stand maneuvers, and accomplishing ADLs such as combing the hair or brushing the teeth, muscle weakness is not the problem. Pain and stiffness are the primary issues. Local tenderness of the involved muscles is noted with palpation. In addition, fever, malaise, unexplained weight loss, and depression may occur.

For those individuals with concomitant giant cell arteritis, additional symptoms of headache, jaw pain, scalp tenderness, fever, fatigue, weight loss, anemia, or blurred or double vision can occur.

MEDICAL MANAGEMENT

DIAGNOSIS. Since there are no definitive tests to identify PMR, the diagnosis is often based on the presence of a constellation of findings and the person's rapid response to a trial of prednisone. Besides the complaints noted under Clinical Manifestations, the person may be anemic and present with an elevated erythrocyte sedimentation rate (ESR; measure of viscosity); lowered hemoglobin and elevated platelet count (indicators of inflammation); and elevated C-reactive protein (indicator of current disease activity).

The current diagnostic criteria include as a requirement an ESR higher than 30 or 40 mm/hr. However, several reports have indicated that a large number of people with PMR (7% to 22%) have a normal or slightly increased ESR at the time of diagnosis, supporting the notion that an increased ESR should not be an absolute requirement for the diagnosis of PMR. This subset is characterized by younger age, less marked predominance of females, lower frequency of constitutional symptoms (e.g., weight loss, fever), and a longer diagnostic delay.⁵¹¹

The lack of rheumatoid factor, the presence of ANAs, and the lack of histologic changes in the muscles contribute to the diagnosis by excluding other conditions. MRI or ultrasonography of the joint or joints may facilitate diagnosis in anyone with typical proximal symptoms of PMR who also has normal ESR values.⁶⁷

TREATMENT AND PROGNOSIS. Untreated, PMR can result in significant disability. It is imperative that the individual be checked for giant cell arteritis, a frequently concurrent condition that can cause irreversible blindness.⁵¹²

Treatment is with corticosteroids (e.g., prednisone); the response is dramatic. In fact, if dramatic improvement is not noted within 1 week of starting the prednisone, the diagnosis of PMR is questioned and the person must be reevaluated.

Most people require a maintenance dosage of prednisone for 6 months to 2 years that is gradually tapered to the lowest effective dose required to control symptoms. Treatment may take up to 5 years or longer before complete clinical remission occurs.⁵¹² Methotrexate may be used for individuals who develop a dependency on corticosteroids.⁴⁶⁸

PMR is not life-threatening but it can limit daily activities, decrease restful sleep with nighttime awakenings and difficulty turning in bed, and decrease a sense of well-being and quality of life. With proper treatment, the prognosis is good, as the disease is self-limiting in many people with resolution within a period of 1½ to 2 years; however, recurrence can be as high as 30% in people who received treatment for 1 to 2 years. Those individuals with temporal arteritis are at increased risk for stroke or blindness.

Polymyalgia Rheumatica

PREFERRED PRACTICE PATTERNS

4A: Primary Prevention/Risk Reduction for Skeletal Demineralization (medication related)

4B: Impaired Posture

4E: Impaired Joint Mobility, Motor Function, Muscle Performance, and Range of Motion Associated with Localized Inflammation

When treating someone with a history of PMR, the therapist must be aware of the potential risk of giant cell or temporal arteritis. An older adult (more than 65 years) with sudden onset of temporal headaches, exquisite tenderness over the temporal artery, scalp sensitivity, or visual complaints should be seen by his or her physician immediately as this vasculitis is associated with stroke and blindness.

Increased complaints of muscle pain and stiffness should direct the therapist to ask if the client is still taking the prednisone as directed. Because of the dramatic relief obtained with prednisone, clients may quit taking it prematurely. Careful monitoring of the dosage level is necessary for proper tapering of the medication. Communication with the primary physician is warranted in the presence of this scenario.

Potential side effects of prednisone include weight gain, mood swings, cataracts, glaucoma, diabetes, easy bruising, rounding of the face, difficulty sleeping, and hypertension (see further discussion in Chapter 5).

Side effects are less likely to occur at low doses; any of these side effects must be evaluated by the physician. Accelerated bone loss and compression fractures are important concerns. The therapist can be very instrumental in client education about preserving bone strength through the use of calcium, vitamin D, and exercise (see the section on Osteopenia and Osteoporosis in Chapter 24).

Since PMR has been shown to be an inflammatory response involving bursitis and tenosynovitis, therapy intervention can begin with this pathogenesis in mind. For example, the use of ultrasound as a deep heating agent in the presence of inflammation should be reconsidered when approaching this type of problem.

Rhabdomyolysis

Overview and Definition

Rhabdomyolysis is the rapid breakdown of skeletal muscle tissue due to mechanical, physical, or chemical traumatic injury (Box 27-2). The principal result is a large release of the creatine phosphokinase (CPK) enzymes and other cell by-products into the blood system. Accumulation of muscle breakdown products can lead to acute renal failure.

Box 27-2**CAUSES OF RHABDOMYOLYSIS****Physical**

- Prolonged high fever; hyperthermia
- Electric current (electrical and lightning injuries)
- Excessive physical exertion (push-ups, cycling, marathon running)

Mechanical

- Crush injury
- Burns (including electrical injuries)
- Compression (e.g., tourniquet left on too long)
- Compartment syndrome

Chemical

- Medications (e.g., antibiotics, statins, first-generation H₁-receptor antagonists)
- Herbal supplements containing ephedra (rare)
- Excessive alcohol use
- Electrolyte abnormalities
- Infections
- Endocrine disorders
- Heritable muscle enzyme deficiencies
- Mushroom poisoning (rare)

Etiology and Risk Factors

Of particular note is the potential for muscle pain from statins (cholesterol-lowering medications) and rhabdomyolysis from high-dose statins.⁴⁶ Less than 5% of the adult population who take statins develop this problem. However, with more than 15 million Americans taking these drugs, the prevalence is on the rise.⁴⁴⁵

Underlying neuromuscular diseases may become clinically apparent during statin therapy and may predispose to myotoxicity.^{28,79} Rhabdomyolysis also has been reported in performance athletes taking herbal supplements containing ephedra; there are similar reports of rhabdomyolysis in individuals using weight-loss herbal supplements.

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Strenuous exercise, including marathon running, biking, and exercises such as push-ups, sit-ups, or pull-ups can result in damage to skeletal muscle cells, a process known as exertional rhabdomyolysis.⁴⁵

Pathogenesis and Clinical Manifestations

The individual may report muscle pain (myalgia) and weakness ranging from mild to severe.

The exact mechanism for statin-induced myopathy remains unknown. There may be a drug influence on deoxyribonucleic acid (DNA), an enzyme deficiency, or autoimmune reaction triggered by the drug.⁷⁹ The effect of the process is well known; specifically, when muscle proteins are released into the blood, one of these proteins (myoglobin) can precipitate in the kidneys and spill into the urine. The client may report a change in color of the urine, most often tea colored or the color of cola soft drinks.

The therapist is most likely to see this with military recruits or marathon runners who have been exercising

in hot and humid weather, or who have taken analgesics, had a viral or bacterial infection, and/or have a preexisting condition.⁴⁵ Acute excessive consumption of alcohol exacerbated by a hot environment and dehydration can also predispose individuals competing in athletic events to exercise-induced rhabdomyolysis.

Massive skeletal muscle necrosis can also occur, further complicating the situation with reduced plasma volumes leading to shock and reduced blood flow to the kidneys resulting in acute renal failure. As the injured muscle leaks potassium, hyperkalemia may cause fatal disruptions in heart rhythm.

MEDICAL MANAGEMENT

DIAGNOSIS, TREATMENT, AND PROGNOSIS. The diagnosis is typically made by history and clinical presentation and confirmed by laboratory studies when an abnormal renal function and elevated CPK are observed. To distinguish the causes, a careful medication history is considered useful. Often the diagnosis is suspected when a urine dipstick test is positive for blood, but no cells are seen on microscopic analysis. This suggests myoglobinuria, and usually prompts a measurement of the serum CPK, which confirms the diagnosis.

Treatment is directed toward rehydration and correction of electrolyte imbalances by administering intravenous fluids, and in the case of renal failure, dialysis may be necessary. In most cases of rhabdomyolysis, especially in the case of exertional rhabdomyolysis, damage to skeletal muscle cells resolves without consequence. Clinically significant rhabdomyolysis is uncommon but, when present, can be life-threatening.⁴⁴⁵

Myopathy**Definition and Overview**

Myopathy is a term used to describe nonspecific muscle weakness secondary to an identifiable disease or condition. The term *myositis* is also used to describe idiopathic inflammatory myopathies.

Many metabolic and hormonal diseases and autoimmune diseases can cause muscle weakness. Myopathies are usually classified as either hereditary or acquired (Box 27-3; see also Table 39-3). Myopathy associated with polymyositis or dermatomyositis is discussed in Chapter 10. Myopathy (myositis) associated with infectious causes is mentioned briefly in Chapter 25. Information about other sources of muscle pain not discussed in this chapter and their neurophysiologic bases is also available.³³¹

Etiologic Factors and Pathogenesis

The idiopathic inflammatory myopathies are thought to be immune-mediated processes that are triggered by environmental factors in genetically susceptible individuals. The pathogenesis of acquired myopathies and their course are highly variable and depend on the underlying cause. For example, in thyrotoxicosis, the high metabolic rate reduces the muscle stores of nutrients, whereas in hypothyroidism, the entire metabolism, including the energy-generating metabolism of muscles, is slowed down. Myopathy associated with RA is caused by the rheumatic joint disease.

Box 27-3**CLASSIFICATION OF MYOPATHIES*****Hereditary**

- Muscular dystrophy
- Congenital myopathy
- Myotonia
- Metabolic myopathy
- Mitochondrial myopathy (e.g., zidovudine [AZT] myopathy [rare])
- Neurologic (e.g., Charcot-Marie-Tooth disease)

Acquired

- Inflammatory myopathy
 - Idiopathic
 - Dermatomyositis, polymyositis
 - Rheumatoid arthritis
 - Autoimmune diseases
 - Human immunodeficiency virus (HIV)-associated myopathy
- Endocrine myopathy
 - Diabetes mellitus
 - Thyroid disease
- Myopathy associated with systemic illness
 - Renal impairment
 - Cancer
 - Acute lung injury (ALI)
 - Acute respiratory distress syndrome (ARDS)
 - Septic inflammatory response syndrome
- Drug-induced or toxic myopathy
 - Corticosteroids
 - Alcohol

Data from Barohn RJ: General approach to muscle diseases. In Goldman L, Bennett C, eds: *Cecil textbook of medicine*, ed 21, Philadelphia, 2000, Saunders, p 2201.

*See Table 39-3.

Expression of proinflammatory cytokines such as interleukin-1 (IL-1) on endothelial cells and expression of major histocompatibility complex (MHC) class I antigens on muscle fibers have been associated with muscle weakness in individuals with active and chronic disease.⁷

Diabetes is associated with myopathy of three origins: vascular, neurogenic, and metabolic. Diabetes affects the small blood vessels and is associated with chronic hypoperfusion of muscles with blood. Diabetes also affects the peripheral nerves and causes neurogenic muscle atrophy and weakness. The disturbances of carbohydrate and lipid metabolism caused by insulin deficiency or insulin resistance adversely affect muscle function.

Acquired myopathy can also occur as part of a paraneoplastic syndrome (see discussion in Chapter 9). Tumors may produce muscle weakness with or without inflammation. Human immunodeficiency virus (HIV)-associated myopathies are less common now with improved medical intervention but may still be encountered by the therapist.

A new disorder called *critical illness myopathy (CIM)* has also been introduced. Disorders associated with prolonged stays in intensive care units (ICUs; e.g., acute respiratory illness, septic inflammatory response syndrome, acute respiratory distress syndrome) often result in excessive and prolonged weakness. CIM is a nonnec-

rotizing myopathy accompanied by fiber atrophy, fatty degeneration of muscle fibers, and fibrosis. As improvements in medical technology and medical management of individuals with severe illness continue to improve, the incidence of CIM is expected to rise.⁴²⁴

Use of systemic corticosteroids combined with prolonged exposure to neuromuscular blocking (paralytic) agents during the treatment of various critical illnesses in the ICU may be the key risk factor for this type of acute myopathy. Septic inflammatory response syndrome may be another risk factor.⁴²⁴

Clinical Manifestations

Myopathy is characterized by progressive proximal muscle weakness with varying degrees of pain and tenderness. Distal involvement is possible but is more common in myositis. During the early stages of disease, the muscles may be acutely inflamed and painful to move and touch. Muscle weakness and easy fatigability eventually compromise aerobic capacity and affect the person's ability to work, socialize, and complete ADLs.¹⁹² Other symptoms of systemic illness may be present, including fever, fatigue, morning stiffness, and anorexia.

MEDICAL MANAGEMENT

DIAGNOSIS. The management of myopathy is determined by the underlying cause. Muscle biopsy, electromyography (EMG), and laboratory findings (measurement of muscle enzymes) are essential to ensure diagnostic accuracy, especially in the case of idiopathic myopathy. EMG can allow differentiation between myopathy and neuropathy and can localize the site of the neuropathic condition. The typical laboratory profile reveals mild to marked elevations in muscle enzymes, including creatine kinase and aldolase.

Some imaging techniques such as MRI and magnetic resonance spectroscopy of muscles can assess changes in local inflammatory activity. Changes in protein and gene expression patterns in repeated biopsy specimens provide molecular information that may lead to a more precise disease classification scheme and improved treatment, but these are research tools at this time.²⁹⁶

TREATMENT AND PROGNOSIS. Inflammatory myopathies may respond to pharmacologic treatment, especially corticosteroids but also immunosuppressives and antimalarial agents. Oral creatine supplements combined with exercise have proven effective for improving muscle function without adverse effects in adults with inflammatory myopathies.⁸¹

Effective therapy for noninflammatory myopathies remains lacking; antiinflammatory agents do not appear to be helpful in these cases. Presently there is no known pharmacologic treatment or prevention for CIM. Medical management to minimize the risks is suggested.⁴²⁴

Prognosis is variable, with some people responding well to medical therapy and rehabilitation and others continuing to decline. Long-standing disability is not uncommon despite aggressive immunosuppressive treatment; the reasons for the persisting disability remain unknown.⁷ Additionally, corticosteroid-related complications can have a significant impact.

Factors associated with poor survival include onset after age 45 years, delayed diagnosis and intervention, severe weakness and pharyngeal dysphagia, malignancy, myocardial involvement, and interstitial lung disease. CIM is reversible, but there is often considerable morbidity (e.g., persistent pain and weakness, HO with frozen joints).²⁶⁷ ICU-acquired myopathy prolongs hospitalization because of the need for extensive rehabilitation. Even with rehabilitation, many affected individuals remain heavily dependent upon others for personal care and ADLs.³⁰⁹

SPECIAL IMPLICATIONS FOR THE THERAPIST 27-5

Myopathy

PREFERRED PRACTICE PATTERNS

4A: Primary Prevention/Risk Reduction for Skeletal Demoralization (medication related)

4C: Impaired Muscle Performance

4D: Impaired Joint Mobility, Motor Function, Muscle Performance, and Range of Motion Associated with Connective Tissue Dysfunction (myalgia, myositis)

See also the Special Implications for the Therapist boxes in the section on Dermatomyositis and Polymyositis in Chapter 10 and the section on Corticosteroids and Immunosuppressives in Chapter 5.

Reduced muscle strength, endurance, and coordination accompanied by fatigue are commonly reported with myopathies. Myalgia occurs at rest and with exercise in half or more of all affected individuals in all stages of the disease. Left untreated, most cases of muscle weakness associated with inflammatory myopathies progress slowly over months and result in further decline of muscle strength and endurance.⁷

Baseline measurement of muscle function using manual muscle testing assesses strength but not endurance, an important feature with this condition. A functional index to specifically test muscle impairment is under investigation but has not been finalized. For now, outcome measures are limited to activity limitation and participation restriction.⁷

Acute Care

Physical therapists in the acute care setting frequently see the effects of bed rest, even without associated injury and after only as little as 1 week as disuse atrophy causes decrease in muscle mass. Often this occurs in the older adult population who have already experienced significant decline in muscle mass.

The effects of ICU-acquired myopathy are even more pronounced in the person who is both on bed rest and critically ill. CIM is also often accompanied by critical illness polyneuropathy (CIP), a disorder of the peripheral nerves triggered by the same events as CIM.⁴²⁴

Patients with the combination of these two conditions have difficulty weaning from the ventilator. Once the individual is alert and less sedated, weakness and atrophy of the limbs becomes more readily apparent.

Severe flaccid tetraparesis may even be observed. Muscles innervated by the cranial nerves appear to be spared. Whereas CIP can affect all limbs and muscle groups, distal weakness and sensory changes are more common. CIM typically affects larger, more proximal muscle groups; sensation is not impaired.⁴²⁴

The therapist can use a handheld dynamometer to establish a baseline and measure progress and improvement over the course of the treatment plan. There is no specific physical therapy plan of care proven effective beyond a general rehabilitation program. Some experts suggest that a neuromuscular rehabilitation program should be started as soon as possible, including strength training and bracing as needed. Shorter sessions conducted more often may be needed during the initial phase of recovery.²⁰⁹

Recovery can be delayed by weeks to months. Regaining ambulatory status at 4 months postillness is achieved by approximately 50% of affected individuals.²⁶⁶ The therapist is a key member of the rehabilitation team, recognizing the need for psychologic and emotional support to the patient and the family. Understanding that the patient is not just deconditioned and has a complex pathologic condition can help facilitate appropriate referrals to other disciplines (e.g., occupational therapy, psychology, social work, psychiatry, speech pathology).⁴²⁴

Exercise and Myopathy

Early rehabilitation is important in the course of myopathy, with careful application of rest and exercise (rest during the active inflammatory phase; rebuilding of muscle strength during remission). During periods of severe inflammation, bed rest and passive range of motion are recommended; active range of motion exercises are contraindicated.

It is important to design a rehabilitation program according to the type, stage, and severity of myopathy. Muscle assessment and functional evaluation are prerequisites to determining an appropriate intervention program. In extremely acute cases, a tilt table may be necessary to reacclimate the cardiovascular system and assist with balance training for the individual who has been on bed rest.

The exercise program begins in the acute phase with stretching and passive range of motion and progresses throughout the recovery process according to the person's tolerance to include isometric, isotonic, and low-intensity aerobic activities. Moist heat applied before stretching inflamed or sore muscles may be helpful. Performing exercises in a gravity-eliminated environment (aquatic program) or gravity-eliminated position may be necessary in the beginning.¹⁹² Attention to the muscles of respiration and breathing assessment are also important, and anyone with cardiac involvement must be evaluated before initiating an aerobic program.

Concern about stressing the already inflamed muscles with a resultant increase in CPK level has traditionally prevented the use of strengthening exercises for anyone with inflammatory myopathies. But

Continued.

exercise itself can cause elevated serum creatine kinase levels in healthy individuals,³⁰³ and studies have shown that people with stable active disease can perform isometric exercise without causing a sustained rise in CPK level.

Continued studies evaluating the effect of exercise training on inflammatory myopathies are under way; preliminary exercise guidelines are available.^{193,195} Studies have shown improvement in adults with stable myopathies after a 12-week 20-minute home exercise program combined with a 15-minute walking program 5 days/wk. Improvement was measured as reduced impairment and reduced activity limitation/participation restriction.⁶

Similar results have been reported for individuals with active myopathies performing an intensive resistive exercise program.^{6,9} People in a variety of exercise programs, including stair climbing, stationary cycling, strength training, group exercise in a pool or at a gym, and outdoor walking using a wide range of frequency, intensity, and duration, have all shown improvement in fatigue and aerobic fitness while serum creatine kinase levels remain unchanged.⁷

Most of these studies have had small sample sizes, but all of them support the idea that exercise can be used to reduce impairment and activity limitation without evidence of increased inflammation. Until more definitive data are available, experts advise a general recommendation of daily physical activity for 30 minutes 5 to 7 days each week. Supervised continuous aquatic exercise adapted to the individual's disease level and disability is also recommended.⁷

A home program including heat modalities, prescriptive exercise, and assistive devices assists the individual to manage with functional disability. Upper extremity splinting and lower extremity bracing may be necessary to prevent contractures, prolong mobility, and enhance functional skills. A weak quadriceps mechanism combined with footdrop or a shuffling gait can contribute to increased falls, necessitating a muscle strength, balance, and fall assessment with necessary intervention.

Client education about this condition is important and should include energy conservation (see Box 9-8) and joint protection education. Serious side effects can accompany high-dose corticosteroid therapy, compounding the functional difficulties already present with the myopathy (see further discussion in Chapter 5).

Myofascial Pain Syndrome

Overview

Myofascial pain syndrome (MPS) is an overuse or muscle stress syndrome marked by the presence of myofascial trigger points (TrP) within a taut band of muscle. These hyperirritable foci located in skeletal muscle or its fascial components were first described in 1952.⁵⁰⁸ On palpation of these points, a characteristic pattern of local and

referred pain is provoked. Referred pain may be provoked at quite a distance from the points of local tenderness.

TrPs may be either *active* (those that cause pain at rest or with activity of the involved muscle) or *latent* (not painful but causing movement restriction and weakness of the involved muscle with increased muscle tension and muscle shortening present). A latent TrP may become active in the presence of an acute, sudden overload of the muscle or a more chronic strain. A *satellite* TrP may develop in the same or other muscles within the referred pain pattern of the primary TrP or in synergistic muscles.

TrPs are separate and distinct from the tender points associated with fibromyalgia (see description of fibromyalgia tender points in Chapter 7). The terms should not be used interchangeably, and the term *fibromyalgia TrPs* is a misnomer.

TrPs appear to be a peripheral muscle phenomenon, whereas the widespread pain of fibromyalgia syndrome is a combination of both peripheral and central nervous system factors (e.g., abnormal pain processing). Although it is possible to have both TrPs and tender points in the same person, usually the individual presents with a distinct clinical presentation of predominantly either MPS or fibromyalgia syndrome. The widespread tender points of fibromyalgia have a very different underlying physiology compared with the TrPs of MPS.

Etiologic and Risk Factors

The cause of myofascial pain dysfunction is thought to be related to a sudden overload or overstretching of a muscle, direct impact trauma, postural faults, psychologic stress, or chronic repetitive or sustained muscle activity.⁴⁶² TrPs can be the source of pain in other conditions such as tension headache.

People involved in occupations or recreation marked by repetitive or sustained activities or postures are at increased risk of developing this condition. Structural abnormalities or postural or mechanical stress could also place a chronic strain on certain muscle groups. Structural abnormalities that can predispose an individual to TrPs include significant leg length discrepancy, small hemipelvis, short upper arms in relation to torso height, and a foot with a relatively long second metatarsal compared to the first metatarsal.⁴⁶²

Other predisposing factors that can trigger activation of TrPs include overwork fatigue, chronic infection, impaired sleep, psychologic stress, and nerve entrapment (i.e., radiculopathy).^{462,508} TrPs can be activated indirectly by other existing TrPs, visceral disease (e.g., myocardial infarction, peptic ulcer, renal colic, gallbladder disease), arthritic joints, joint dysfunctions, and emotional stress.⁴⁶²

Pathogenesis

Previously, the TrP concept was viewed as a syndrome of unknown etiopathogenesis, but this has been replaced by the notion that TrPs are the result of an established neuromuscular disease characterized by muscle tension and its sequelae.⁴⁰⁶

According to one highly respected researcher in the area of TrP research, myofascial TrPs are most likely triggered by the performance of unaccustomed eccentric

muscle activity. Eccentric movement of a muscle requires it to contract while being lengthened at the same time (e.g., action of the quadriceps muscle walking downhill). A buildup of acetylcholine causes the muscle to remain tense and even activate nearby muscles in the referral zone to activate latent triggers, making them satellite myofascial TrPs.¹⁴⁶

Electrophysiologic and histopathologic evidence now makes it clear that dysfunctional motor endplates of skeletal muscle fibers are at the heart of the pathophysiology that characterizes myofascial TrPs. Spontaneous EMG activity in the TrP is greater than EMG activity in a non-involved area of the same muscle, with a specific electrical discharge characteristic of a TrP identified. It appears that the electrical signal originates from the motor endplate rather than from the muscle spindle.²⁰⁰

The myofascial TrP mechanism is also closely related to spinal cord integration. The pathogenesis of TrPs is probably related to an integrative mechanism in the spinal cord in response to sensitized sensory nerve fibers (nociceptors) associated with dysfunctional endplates. When the input from nociceptors in an original receptive field persists (pain from an active TrP), central sensitization in the spinal cord may develop and the receptive field corresponding to the original dorsal horn neuron may be expanded (referred pain). Through this mechanism, a new (satellite) TrP may develop in the referred zone of the original TrP.²⁰⁰

Muscles protecting themselves against perceived trauma from overuse or repetitive contraction do not go into a protective spasm as was once thought but rather shorten and "shut off" as a means of guarding and self-protection. Energy requirements are reduced through this mechanism, and the body compensates by finding other muscles to do the task. It is hypothesized that the nervous system forgets to "turn the muscle back on" as identified by surface EMG studies.¹⁸³

It has been hypothesized that there are two different types of TrPs: central and attachment. Pathophysiologic differences between central TrPs located in the muscle belly or endplate region and those located in a region of the muscle attachment where the taut band attaches to the tendon or where the tendon attaches to the bone (attachment TrPs) have yet to be adequately explored. When the pathologic mechanisms for TrPs have been fully determined, more specific intervention can be developed as well.⁴⁶²

The pathophysiology of the taut band (a localized contracture within the muscle) is now much clearer as well, although much of this remains a hypothesis that requires further validation. Intracellular calcium in certain muscle fibers may be excessively released in response to trauma or abnormal stress. The abnormally increased calcium may cause uncontrolled shortening activity and increased metabolism.

The muscle fiber shortening also impairs local circulation, which causes a loss of oxygen and nutrient supply to the region. This completes a vicious cycle; thus an energy crisis occurs, and taut bands form. It appears that these taut bands are necessary precursors for the development of TrPs based on the fact that taut bands frequently exist in pain-free individuals.²⁰⁰

Clinical Manifestations

A taut, palpable myofascial band that is exquisitely tender on palpation with a characteristic and reproducible referred pain pattern (with sustained palpable pressure) is the hallmark of myofascial pain dysfunction. This clinical manifestation has also been described as a ropelike, nodular, or crepitant (crackling or grating) area within a muscle; there may be fibrotic tissue resembling a small pea present that exhibits a highly localized, exquisitely tender spot. Once present, the TrPs are self-sustained and self-perpetuating hyperirritable foci.

Mechanical stimulation of the TrP, either by dry needling or by manual palpation, frequently results in a local twitch response (a brief contraction of the palpable mass in response to a brisk rolling or snapping palpation of the band, a visible indication of an active TrP). The same stimulus also produces a jump sign characterized by vocalization or withdrawal (person jumps away from the examiner in response to pressure exerted on the TrP). These two signs are usually present, observable, and reproducible before effective intervention eliminates the TrP and the signs. Additionally, the examiner may palpate a distinct nodule in the center of the taut band that is tender, sometimes exquisitely tender.

Pain referral patterns associated with TrPs are documented by several authors.^{258,462,509} Besides the pain, myofascial pain dysfunction is manifested by a reduced range of motion of joints under the control of the involved muscle and muscle weakness. The affected individual may be aware of numbness or paresthesia rather than pain, but there are no neurologic abnormalities, and the hypesthesia does not follow a radicular distribution.³⁹⁴

Systemic signs and symptoms are absent (unlike in fibromyalgia syndrome with its multiple presentation of various systemic manifestations), although a mild autonomic nervous system response to pain may result in nausea, diaphoresis, or change in blood pressure when TrPs are palpated. Related proprioceptive disturbances caused by TrPs may also include imbalance, dizziness, tinnitus, and distorted weight perception of lifted objects.⁴⁶²

Disturbances of motor function caused by TrPs include spasm of other muscles, weakness of the involved muscle function, loss of coordination by the involved muscle, and decreased work tolerance of the involved muscle. The weakness and loss of work tolerance are often misinterpreted as an indication for strengthening exercise, but if this is attempted without inactivating the responsible TrPs, the exercise is likely to encourage and further ingrain muscle substitution and further deconditioning of the involved muscle.⁴⁶²

MEDICAL MANAGEMENT

DIAGNOSIS. Because myofascial pain dysfunction is more of a clinical entity, the diagnosis is first made by clinical examination. Several diagnostic tests can help substantiate objectively the presence of characteristic TrP phenomena, including surface EMG, needle EMG, and ultrasound.

There is limited consensus on the diagnostic criteria for TrPs associated with MPS. A literature review of

Box 27-4**MYOFASCIAL TRIGGER POINT DIAGNOSIS AND TREATMENT****Steps to Diagnosis of Myofascial Trigger Points**

- Complete a past medical history
 - Assess for sudden onset from acute injury, trauma, overload stress, overstretching, or overshortening
 - Assess for gradual onset with chronic overload, microinjury, microtrauma, repetitive trauma
- Determine the biomechanics of the injury
- Determine the referred pain patterns
- Assess for limitations in joint and muscle range of motion
- Assess for muscle weakness of involved muscle or muscles
- Palpate for local tenderness with possible referred pain; palpate for taut band and nodularity of the affected muscle
- Assess for latent or satellite trigger points
- Complete examination (other orthopedic, neurologic, special, differential diagnostic tests including fibromyalgia tender point assessment)
- Complete evaluation
- Determine diagnosis, prognosis
- Perform intervention and reexamine

Guidelines in Myofascial Intervention

- Modalities to the affected muscle (e.g., moist heat, electrical stimulation, laser, ultrasound); begin teaching client how to recognize and avoid perpetuating factors
- Trigger point therapy, ischemic compression; instruct client in breathing and relaxation techniques; physician may perform dry needling or procaine injection; qualified physical therapists, depending on state laws, may perform dry needling
- Myofascial stretching; observe for positive stretch sign indicating need to decrease stretch while remaining within the muscle's therapeutic range; observe for pain from stretching the involved muscle, indicating need for vapocoolant or ice combined with stretching
- Persistent increased trigger point activity after treatment may require repeating above steps for a few sessions until referred pain pattern is significantly decreased and range of motion is 70% of normal before initiating muscle strengthening sequence
- When steps above are completed, add muscle-strengthening sequence; when joint and muscle ranges of motion are within functional levels and the client is pain free, proceed to the next step
- Proprioceptive training
- Home exercise program is ischemic pressure, massaging of the affected area, and sustained self-stretching with good breathing techniques emphasized
- Reexamination to modify or redirect intervention based on new clinical findings, client progress, or lack of client progress; assess for need for consultation with or referral to another provider

Data from Kostopoulos D, Rizopoulos K: *Hands-on seminars: an intensive training on trigger point, myofascial and proprioceptive training*, Astoria, NY, 2001; Kostopoulos D, Rizopoulos K, Kurman RJ, et al: *The manual of trigger point and myofascial therapy*, Thorofare, NJ, 2001, Slack. Used with permission.

criteria used to diagnose TrPs found no less than 19 different diagnostic criteria. The four most commonly applied criteria were a tender spot in a taut band of skeletal muscle, patient pain recognition, predicted pain referral pattern, and local twitch response.⁵⁰⁷

Simons et al⁴⁸² state that the criteria have changed in response to clinical observation and evidence from diagnostic reliability studies. According to this source, criteria no longer considered essential for diagnosis are local twitch response (least reliable diagnostic test) and predicted pain pattern, which is considered nonspecific. Simons et al have made further changes to the diagnostic criteria by adding *nodule in a taut band* and *painful limitation to motion*.⁴⁶² However, these modifications were made on the basis of clinical experience and have not been tested experimentally for reliability, sensitivity, and specificity.⁵⁰⁷

Clearly in the absence of diagnostic laboratory tests or molecular markers, there is a need to define and standardize the way in which diagnosis of TrPs and MPS is made. At the present time, there is not a single set of criteria that is universally accepted.⁵⁰⁷

TREATMENT. Many techniques aimed at desensitizing TrPs have been employed, such as injections using dry needling, saline, or local anesthetics (performed by a physician or in some states by a qualified physical ther-

apist); application of ice in the direction of prescribed patterns; laser; ultrasound; and sustained (ischemic) manual pressure to the TrP. High-power, pain-threshold, static ultrasound technique has been shown to resolve acute TrPs more rapidly than conventional methods of using ultrasound for this condition.^{301,473} All of these techniques should be accompanied by sustained stretch of the involved muscle to desensitize the band.^{462,509}

Ischemic compression is described as one that applies a steady pressure using the thumbs or four fingers on one or both hands inward toward the center and then is slowly released. Pressure application varies and may start from a few pounds and increase up to 10 lb, lasting from 30 to 45 seconds. On release, the skin blanches and then shows reactive hyperemia. The person should breathe deeply and slowly as pressure is progressively increased.

Non-ozone depleting vapocoolant spray (a topical skin refrigerant) may be used with the stretching procedures to facilitate pain relief and return of function. It is hypothesized that elongation of the muscle to its full normal length is the underlying mechanism that relieves pain caused by myofascial TrPs. Muscle lengthening utilizing postisometric relaxation may also be a successful technique.²⁸³

Additional rehabilitation to restore muscle strength and proprioception is required (Box 27-4). The physical therapist may employ a variety of additional modalities

Box 27-5**PERPETUATING FACTORS IN MYOFASCIAL TRIGGER POINTS****Mechanical Stress**

- Leg length discrepancy
- Postural imbalance (e.g., shoulder protraction, forward head position)
- Movement impairment
- Pelvic upslip
- Muscle imbalance
- Overuse, repetitive muscle contraction, unaccustomed eccentric muscle activity¹⁴⁶

Nutrition

- Vitamin deficiency of B1, B6, B12, folic acid, vitamin D
- Mineral deficiency or imbalance (iron, calcium, potassium, magnesium)

Metabolic Conditions

- Hypothyroidism
- Hypoglycemia
- Allergies
- Visceral disease (e.g., peptic ulcer, renal colic, colitis, myocardial infarction)

Psychologic Factors

- Anxiety
- Depression
- Emotional stress and tension

Other

- Chronic viral infections
- Sleep disturbance
- Indirectly triggered by other existing trigger points

in the treatment of TrPs, such as low-voltage electrical stimulation, ultrasound, moist heat, or laser. Some experts recommend nutritional counseling with supplementation of vitamins B1, B6, and B12; folic acid; and vitamin C.

PROGNOSIS. Whereas fibromyalgia syndrome is a chronic, long-term neuroendocrine condition requiring years of management, MPS is a local and/or regional condition of the soft tissue structures that responds well to local intervention as described.

Active TrPs can revert spontaneously to a latent state under the right conditions (i.e., adequate rest, absence of perpetuating factors) (Box 27-5).¹⁴² Chronic myalgia may not improve until the underlying precipitating or perpetuating factors are removed or properly managed.¹⁴³ And even with proper clearing of the TrPs, the muscle activation process might not return to normal until specific training is done to facilitate that process. Recovery of proper motor control strategies is not automatic but depends on restoring normal motor plans.¹⁴⁴ Biofeedback may help with this process; more research is needed to identify specific ways to accomplish this.

SPECIAL IMPLICATIONS FOR THE THERAPIST**27-6****Myofascial Pain Syndrome****PREFERRED PRACTICE PATTERNS**

4B: Impaired Posture

4C: Impaired Muscle Performance

4D: Impaired Joint Mobility, Motor Function, Muscle Performance, and Range of Motion Associated with Connective Tissue Dysfunction

Myofascial pain dysfunction is marked by pain patterns often attributed to other conditions, such as herniated nucleus pulposus, radiculopathy, nerve entrapment syndromes, temporomandibular joint dysfunction, migraine or tension headaches, or facet joint disease.

Assessment of muscle as the source of pain is an important component of the examination process. Early studies demonstrated that muscle irritation could result in referral of pain.²⁴³ The therapist must assess carefully for the difference between TrPs and tender points before initiating intervention (see Box 27-4). The presence of tender points accompanied by other systemic complaints (see Table 7-6) may be more consistent with a diagnosis of fibromyalgia.

There is also always the possibility of a visceral-somatic cause of TrPs, such as occurs with myocardial infarction or enteric (abdominal) disease. Because of the referred nature of visceral pain, application of vapocoolant spray into the somatic reference zone can temporarily relieve the visceral pain with no real effect on the underlying visceral pathologic condition. Screening for medical disease is always necessary when evaluating muscle pain and myofascial TrPs.⁴⁶²

The therapist's knowledge of biomechanics, kinesiology, and mechanisms of injury is an important tool in assessing and eliminating the cause that activated the TrPs and in recognizing current perpetuating factors. Perpetuating factors (see Box 27-5) are often different from what caused activation of the TrPs and may include body positions, postural positions, skeletal asymmetries, and activities that increase mechanical stresses, causing reactivation of TrPs. After the TrP is inactivated (specific techniques are available for the therapist)^{258,462,509} the muscle or muscles must be retrained, and full stretch range of motion must be restored in order to return to normal motor function (see Box 27-4).⁴⁶²

When ultrasound is used for treating TrPs, the continuous mode appears to be more effective than the intermittent mode. To avoid aggravating a highly irritable TrP, the ultrasound intensity should be gradually increased from 0.5 watts/cm² until the client reports feeling warmth under the sound head. More specific details of ultrasound application for myofascial pain versus fibromyalgia are available.²⁹⁴

A home program of pressure followed by sustained stretch for the treatment of myofascial TrPs has been shown effective in reducing TrP sensitivity and pain intensity. It is important to instruct the person in how

Continued.

to apply a sustained stretch without initiating a protective spasm or guarding contraction.¹⁷⁴

This can be done by combining superficial heat or cold, ischemic pressure, breathing techniques, and slow stretching. Compliance regarding the stretching of the involved muscle is paramount to lasting success of treatment. The client can also apply sustained deep pressure over a TrP using a tennis ball or some other firm object. Stretching without applying pressure to minimize the nodules (TrPs) can have a rebound effect, making matters worse. The TrP must be released first before applying stretching alone.

This type of treatment is less successful for clients who have both MPS and fibromyalgia. Deep tissue therapy and sustained stretching are usually too painful for the individual with fibromyalgia syndrome. It may be necessary to rely on medications to increase the pain threshold (e.g., antidepressants) or muscle relaxants to help loosen muscles first. Gentle stretching can be initiated, possibly in addition to or combined with surface electrode biofeedback.¹⁸³

Helping the individual with active TrPs to achieve restful sleep is essential. Proper positioning, bed, and pillow (or other props) should be evaluated and discussed. Sleep disturbances caused by painful symptoms occur when body weight is compressing a TrP. This, in turn, increases pain sensitivity the next day. Active myofascial TrPs become more painful when the muscle is held in the shortened position for long periods of time or compressed.

Various studies have implicated IL-1, which has chondrolytic action by stimulating the release of inflammatory mediators, enhancing the breakdown of cartilage proteoglycans. Clearly, some disruption of the cartilage extracellular matrix occurs leading to chondrolysis, but the key to the process has not been discovered.

Clinical Manifestations

Regardless of the underlying cause of this condition, the affected individual presents with progressive joint stiffness with progressive loss of motion and pain. Chondrolysis of the hip causes anterior hip and/or groin pain accompanied by an antalgic gait. Soft tissue contracture can result in an apparent leg length discrepancy and pelvic obliquity with muscle atrophy. Painful ankylosis may develop in some individuals, while others experience an improvement in pain and range of motion.⁵⁴⁷

MEDICAL MANAGEMENT

DIAGNOSIS, TREATMENT, AND PROGNOSIS. Imaging studies are used to make the diagnosis. Plain radiographs are the first choice, but in difficult cases, the definitive diagnosis may be made on the basis of scintigraphy and/or MRI.

Treatment is with nonsteroidal antiinflammatory medications to control synovial inflammation. Protected weight bearing and maintaining joint motion are important components of the treatment plan. Surgery may be indicated (e.g., capsulectomy, tendon release of the adductor and iliopsoas), but the best course of operative treatment is unknown.⁵⁴⁷

Osteoarthritis

Overview

Osteoarthritis (OA), or degenerative joint disease, is a slowly evolving articular disease that appears to originate in the cartilage and affects the underlying bone, soft tissues, and synovial fluid.

OA is divided into two classifications: primary and secondary. Primary OA is a disorder of unknown cause, and the cascade of joint degeneration events associated with it is thought to be related to a defect in the articular cartilage. Secondary OA has a known cause, which may be trauma, infection, hemarthrosis, osteonecrosis, or some other condition.

OA is present worldwide as a heterogeneous group of conditions that lead to slow, progressive degeneration of joint structures with defective integrity of articular cartilage in addition to related changes in the underlying bone at the joint margins. OA can lead to loss of mobility, chronic pain, deformity, and loss of function.

Incidence

OA is the single most common joint disease, with an estimated prevalence of 60% in men and 70% in women later in life after the age of 65 years, affecting an estimated 40 million people in the United States.

In fact, it is the most common musculoskeletal disorder worldwide affecting the hands and large weight-bearing joints such as the hip and knee and causing disability.³⁰⁸ And the overall prevalence is expected to

JOINT

Chondrolysis

Overview

Chondrolysis is a process of progressive cartilage degeneration resulting in narrowing of the joint space and loss of motion. It is seen most often as a complication of slipped capital femoral epiphysis (SCFE) but can occur in association with infection, trauma, and prolonged immobilization for any reason. Trauma can also include orthopedic procedures such as arthroscopic meniscectomy, shoulder arthroscopy, anterior cruciate ligament reconstruction, and thermal capsulorrhaphy.^{76,173,278,400}

The hip is the most likely location for chondrolysis to occur, but cases have been reported affecting the knee, shoulder, and ankle. Spontaneous chondrolysis without known risk factors occurs occasionally, most commonly in adolescent girls. In fact chondrolysis occurs five times more often in females than in males; adolescence is the most common period of onset.⁵⁴⁷

Etiology and Pathogenesis

The etiology is unknown; many theories have been proposed, including nutritional abnormalities, mechanical injury, ischemia, abnormal chondrocyte metabolism, ischemia, and abnormal intracapsular pressure. There may be some evidence to support an autoimmune mechanism responsible for the cartilage destruction.