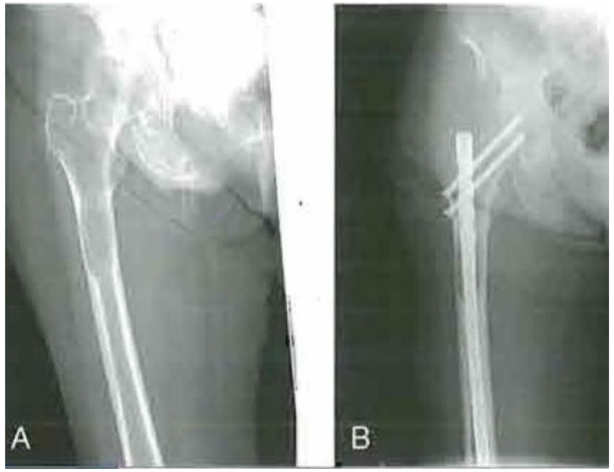
PLEASE CLICK ON THE FOLLOWING LINK TO WATCH THE LECTURE ONLINE:-

PART 1 https://www.youtube.com/watch?v=Oatk9YsFZJs&list=PLuBRb5B7fa_eyzMA0u7jajzWugcmiRi5s&index=4

PART 2 https://www.youtube.com/watch?v=tFhUoMxjsho&list=PLuBRb5B7fa_eyzMA0u7jajzWugcmiRi5s&index=5

METASTATIC BONE DISEASE

Diya' Ajarmeh



Introduction

- Tumor metastasis involves growth and arrest in **different** microenvironments

- The process of tumor metastasis involves **multiple stages** during which malignant tumor cells spread from a primary site to other parts of the body

- The behavior of a tumor may be benign or malignant;   malignant tumors have the capacity to metastasize

- A malignant tumor tends to be poorly encapsulated, invasive, and rapid growing; the cell of origin may be difficult to postulate

- Certain malignancies are believed to be **osteotropic**; the most common of these in clinical practice are **prostate** carcinoma and **breast** carcinoma

- Carcinomas of the **lung**, **thyroid**, and **kidney** also account for a significant percentage of bone metastases

- **Gastrointestinal** carcinomas are responsible for less than 10% of bone metastases; of these, **colon** carcinomas contribute a significant proportion

- **Hematologic** malignancies also are well known to involve bone

Biology of Metastasis

- **Osteoclasts** are derived from the same precursor as **monocytes**
- Macrophage colony-stimulating factor (**M-CSF**) and receptor activator of nuclear factor KB ligand (**RANKL**) are essential to the **production** of osteoclasts
- **M-CSF** is produced by stromal cells within the bone marrow and is important in the **beginning** of osteoclast formation, whereas **RANKL** is involved in the maturation, differentiation, and **activation** of the osteoclast
- Matrix metalloproteinases (**MMPs**) control the bioavailability and function of **RANKL**, and this function may make them **key** players in the process of bone **metastasis**

Biology of Metastasis

- Because bone continuously remodels, **bone-stored growth factors** are continuously released by resorption of bone by osteoclasts

- The release of growth factors provides a **fertile soil** for metastatic tumor cells to reproduce within the bone

Physiology of Metastasis

- For malignant cells to enter the bone marrow, they must be able to penetrate the basement membrane and traverse the extracellular matrix
- This movement can occur only if the normal balance between **proteases** and their **inhibitors** is disturbed
- The family of **MMPs** is central to the process of invasion
- MMPs play a critical role in the process of bone remodeling, which is necessary for bone metastasis to occur

Physiology of Metastasis

- It is not surprising, then, that **MMPs** are **upregulated** in sites in which bone metastasis has occurred

- MMPs can be derived from **several types of cells** within the bone microenvironment,
- in addition to osteoclasts, osteoblasts, and tumor cells

- Once cancer cells are in bone, they are required to undergo **genetic changes** that allow them to establish residence

- During this process, called **osteomimicry**, metastatic tumor cells acquire genetic changes that allow them to produce bone matrix proteins

- **Osteolytic bone resorption** is key to the establishment of residence in bone
- **Active osteoclasts** are associated with bone metastasis deposits and often are adjacent to these deposits

- The ability of the **cancer cells** to **promote the formation of active osteoclasts** is a special property of tumors that produce bone metastases and is required for initiating and sustaining tumor expansion

- Several cancers also directly produce **RANKL**, an important molecule in osteoclastogenesis

hypothesis of the **vicious cycle of bone metastasis**

- In the **first step** of the cycle,
  - bone-lining osteoblasts proliferate and/or differentiate through **metastasis-derived signals**
  - PTHrP is a mediator of this process

- In the **second step**, the metastatic cancer cells produce factors that stimulate osteoblasts
- The osteoblasts express factors that result in the activation of osteoclasts such as RANKL

- In the **third step**, RANKL promotes maturation of the osteoclast precursors into active multinucleated osteoclasts
- Mature osteoclasts subsequently form a seal on the mineralized bone matrix surface, and, through acidification and the secretion of acidophilic **proteases**, mediate the process of bone resorption

- Osteoclasts are major mediators of **angiogenesis** in the bone microenvironment via the regulation of the bioavailability of vascular endothelial growth factor-A (**VEGF-A**). In addition, bone destruction results in the release of TGF-b, which causes further production of PTHrP, completing the vicious cycle

- **Prostate Cancer**

- Prostate cancer is the second most common cause of deaths from cancer among men in the United States

- **Androgen-refractory prostate cancer** can lead to bone metastasis

- More than 80% of all men who die of prostate cancer have some evidence of bone metastasis at autopsy

- **Breast Cancer**

- Breast cancer is the second most common cause of deaths from cancer among women in the United States

- Approximately 70% of patients with advanced breast cancer have bone metastasis

- The **proximal** long bones, pelvis, spine, and ribs are most commonly involved

- **Lung Cancer**

- Lung cancer is categorized on a histologic basis as
  - **small cell** neuroendocrine carcinomas and
  - **non-small cell** lung carcinomas (NSCLCs), which include
    - adenocarcinoma, squamous cell carcinoma, and large cell neuroendocrine carcinoma

- **Bone** metastases are more common in **NS**CLCs, occurring in 30% to 40% of patients

- The incidence of osseous metastasis is **lower** in patients with **lung** cancer than in those with breast or prostate cancer

- **Multiple Myeloma**

- The clinical hallmark is **multiple osteolytic lesions**, which are unique to this disease

- Histologically, the lesion is characterized by a proliferation of monoclonal **plasma cells** in various stages of maturity

- For many years, plasma cells have been known to produce an elusive **osteoclast activating factor**

- monoclonal plasma cells have been shown to express **RANKL**, thereby having the ability to directly induce osteoclastogenesis

- **IL-6** is important in disease progression because it inhibits the apoptosis of monoclonal plasma cells and induces their proliferation

- Although levels of IL-6 are **not correlated with the extent** of bone disease in patients with multiple myeloma, a higher IL-6 level is correIa ted with a **poorer prognosis**

- **Kidney Cancer**

- **Renal cell carcinoma** is the most common renal cancer, representing 80% to 90% of the incidence

- The **highest cure** rates are achieved with **early nephrectomy**, but 20% to 50% of patients are first seen with advanced disease

- The **lungs** are the most common site of renal cell carcinoma metastasis

- However, 20% to 35% of patients will have a **skeleton-related event** caused by the disease, the most common of which is skeletal metastasis

- Fewer than 10% of patients survive 5 years after the onset of metastatic renal cell carcinoma

- More recent research found that **TGF-β** is an important molecule in renal cell carcinoma **metastasis** to **bone**

- TGF-β is a cytokine with effects on both tumor and normal cells

- Bone is a prime site for metastasis in renal cell carcinoma because TGF-β is expressed in renal cell carcinoma bone metastasis tissue

- **RANKL** is an important molecule that causes the osteoclast-mediated bone destruction necessary to release **TGF-β** , is expressed in 60% to 85% of renal cell carcinomas

- Some patients, particularly patients with **clear** cell renal cell carcinoma, have very **high** levels of RANKL, but other patients have low levels

- In at least one study, this distinction was specified as a **prognostic factor**: the patients with a **low RANKL** level had a **longer interval to metastasis** than those with a high RANKL level

- The survival of patients with a **low RANKL** level also was **better** than that of the patients with a high RANKL level

- The **VICIOUS cycle** concept can now be applied to renal cell carcinoma
- Increased **RANKL** leads to **osteoclastogenesis**, and the increase in osteoclasts leads to **bone destruction**, which releases **TGF-β**, allowing for homing of renal cell carcinoma cells to the bone microenvironment

- **Thyroid Cancer**

- Most thyroid carcinomas are well differentiated

- In the absence of metastasis, the rate of survival associated with these carcinomas is as high as 80%

- Most patient deaths are secondary to metastatic disease

- **Follicular carcinoma** is the most common of the differentiated thyroid carcinomas to **metastasize** by hematogenous means

- The **lung** and **bone** are the most common sites of disease spread

- **Integrins**, may have a role in the binding of follicular carcinoma cells to bone

- EGFR and VEGF also have been shown to exist in increased levels in the cells of follicular thyroid carcinomas and therefore have increased metastatic potential

- **Lymphoma**

- Lymphoma is most often identified as **bone disease** if it is part of a systemic disease or is a primary localized disease of bone

- Primary lymphoma of bone accounts for only 1 % to 2 % of all bone tumors and fewer than 1 % of all non-Hodgkin lymphomas

- Secondary involvement of bone by lymphoma occurs in as many as **15%** of patients with systemic lymphoma

- **Adults** are most commonly affected, but primary lymphomas of bone have been documented in children

- The most common histologic subtypes in **adults** are **diffuse large B-cell lymphoma** and its variants

- Primary bone lymphomas are more variable in the pediatric population and include lymphoblastic lymphoma, Burkitt lymphoma, and diffuse large B-cell lymphoma

- Lymphomas, particularly B-cell lymphomas of bone, were shown to produce **RANKL**

- Lymphomas of bone, like many other malignant neoplasms that involve bone, produces osteolysis

- Many malignant B cells also were shown to produce VEGF, which has important roles in both angiogenesis and osteoclastogenesis

- Thus, the vicious cycle of bone destruction and tumor expansion was shown to occur in lymphoma of bone

- **Pathologic fractures in metastatic bone disease**

- Because of the severity of skeletal malignancies, it is important to properly assess which patients are suitable candidates for surgical intervention for **impending pathologic fractures**

- The goals of treatment are to
  - relieve pain
  - prevent fractures
  - Preserve function
  - allow for early weight bearing
  - Provide an intervention that will last the patient's entire lifespan

- Metastatic bone disease varies greatly among patients, and thus each patient’s disease much be addressed individually

- The **prognoses** of these lesions differ according to
  - primary disease
  - location of metastasis
  - metabolic complications
  - functional assessment

- The ability to properly estimate the expected survival has great significance in the process of deciding the suitable method of fixation

- **Primary Disease**

- **Breast** and **prostate** carcinomas are the most common causes of metastatic bone disease, followed by **lung**, **kidney**, and **thyroid** carcinomas

- Patients who have **longer survival times** are **better candidates** for surgical interventions that may require longer postoperative healing times, whereas patients who are terminally ill may not benefit from surgery

- Although survival rates may vary slightly depending on the location of osseous metastases, survival rates, in general, are **longest** for patients with primary carcinomas of the **breast**, **prostate**, and **thyroid**

- The goal is to provide a construct that will survive the patient's life expectancy

- **Metastatic Load**

- Studies have shown that patients with
  - **bone metastases** combined with
  - **visceral metastases**
- have **shorter** mean lengths of survival than individuals with just osseous involvement

- **Metabolic Assessment**

- Patients with metastatic bone disease commonly have **abnormal metabolic feature**

- The most common complication in adults with osseous metastases is **hypercalcemia** of malignancy due to bone destruction from osteolytic Metastases

- Although there are no clear criteria to determine which patients are suited for surgical treatment of an **impending fracture** with **hypercalcemia**, medical management and control of the hypercalcemia, in conjunction with treatments such as **bisphosphonates**, make the patient a more stable surgical candidate

Roles of Pharmaceutical Therapies in the Prevention of Pathologic Fractures

- **Bisphosphonates**
- **Denosumab**

- **Bisphosphonates**

- Bisphosphonates have been one of the key pharmaceutical treatments that assist in the **prevention of pathologic fractures** in patients with bone metastases

- Within the class of bisphosphonates, **zoledronic acid** has been shown to effectively decrease the rate of Skeletal-Related-Events , including pathologic fractures.

- In a study of 773 patients, patients who were given a **4-mg infusion of zoledronic acid over 15 minutes every 3 weeks** for 9 months had an overall pathologic fracture rate of 16%, compared with the placebo group, which had a pathologic fracture rate of 21 %.

- **Denosumab**

- Denosumab is a human monoclonal antibody that **binds** to (**RANKL**)

- By binding to RANKL, denosumab **inhibits** the interaction between (RANK) and RANKL, which in turn
  - **decreases osteoclast activity**
  - decreases bone resorption
  - increases bone mass

- **Denosumab** showed slightly **superior** effectiveness than **zoledronic acid** in decreasing the rate of Skeletal-Related-Events, including pathologic fractures

- With continued research, physicians may find more widespread use of **denosumab**, with or without **bisphosphonates**, in the prevention of pathologic fracture in patients with metastatic bone disease

•Other Alternatives to Open Surgery

- **Radiation Therapy**
- **Radiofrequency Ablation and Cryoablation**

- **Radiation Therapy**

- External beam irradiation is the most common treatment used for **palliation** of bone metastases

- Studies have shown that external beam irradiation provides **relief** in patients with metastatic bone pain

- Irradiation dosage varies among different metastatic diseases with target dosage limited by the bone and surrounding tissue

- **Radiofrequency Ablation and Cryoablation**

- Another nonsurgical means of pain relief for patients with metastatic bone pain is **focal ablative therapy**, which includes radiofrequency ablation (**RFA**) and **cryoablation**

- Focal ablative therapy for the purpose of pain improvement was used in patients who had
  - **moderate** to **severe** pain
  - focal pain limited to one or two sites
  - small lesions that were either osteolytic or mixed osteolytic\osteoblastic.

- **Predicting Impending Pathologic Fractures**

- **Mirels Evaluation System**

- The Mirels scoring system was developed in 1989 as a screening tool for impending fractures in metastatic lesions of long bone and continues to be used

- An overall score of **7 or less** is classified as **low risk** of fracture (5%) and would warrant **medical management** as the recommended treatment

- whereas an overall score of **9 or greater** poses a **high risk** of fracture (33 %), and **surgical intervention** would be recommended

- A score of **8** poses a 15% risk of fracture, with recommendation of **surgery** depending largely on the **physician's clinical judgment**

Table 2

Mirels Scoring System for Risk of Pathologic Fracture

Score (Points)	Site	Radiographic Appearance	Bone Width Involved	Pain
1	Upper extremity	Blastic	<1/3	Mild
2	Lower extremity non-peritrhchanteric)	Mixed (blastic-lytic)	1/3 - 2/3	Moderate
3	Peritrochanteric	(Lytic)	>2/3	Functional[a]

[a]Aggravated by function.
(Reproduced with permission from Bickels J, Dadia S, Lidar Z: Surgical management of metastic bone disease. *J Bone Joint Surg Am* 2009;91(6):1502-1516.)

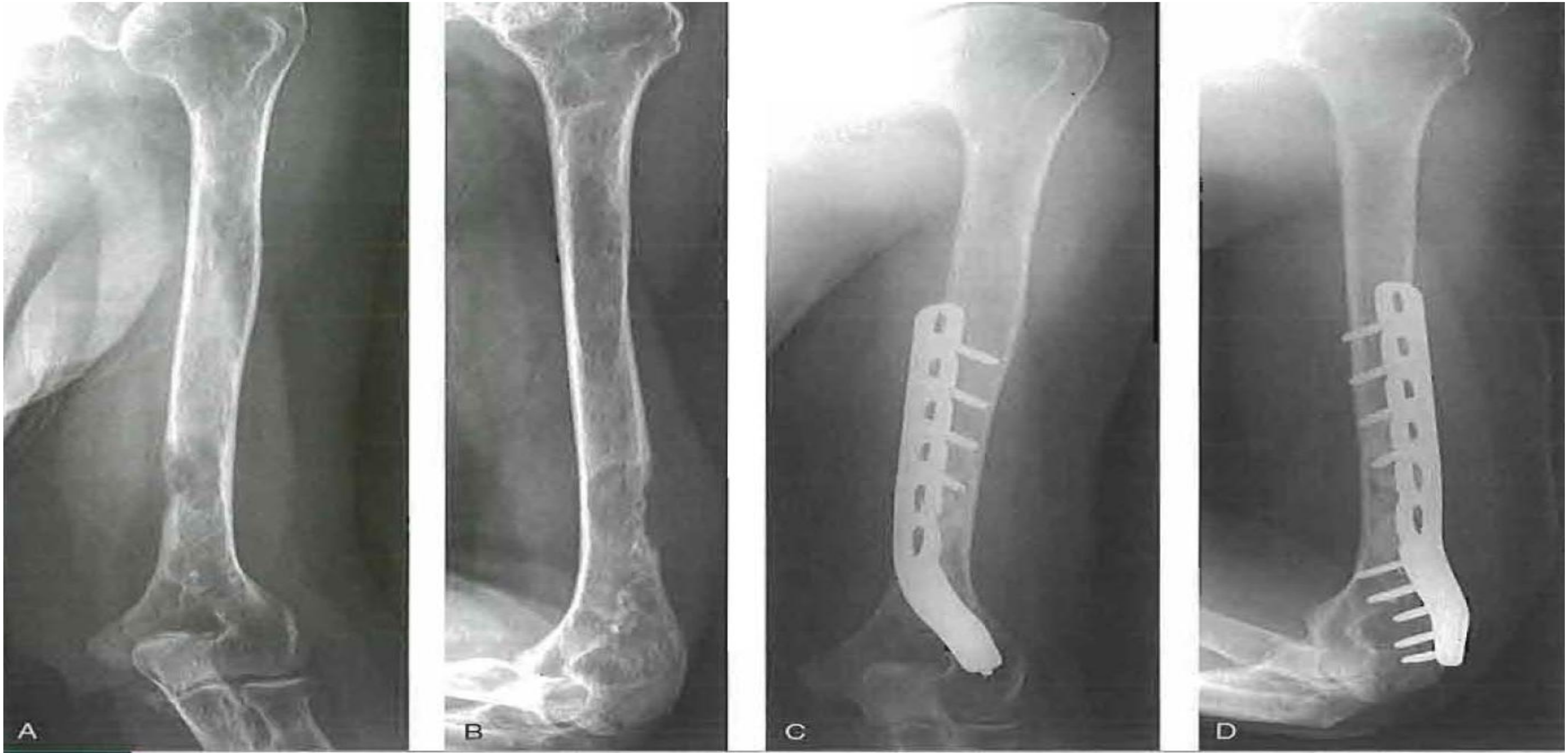


Figure 1 **A,** AP radiograph of the humerus of a 67-year-old woman with metastatic lung cancer. **B,** Lateral radiograph of the humerus of the same patient reveals significant cortical destruction. The lesion is lytic and thought to involve half of the cortex. The upper extremity location along with the patients functional pain yields a score of 9 on the Mirel's scoring system, indicating a graeter than 33% chance of fracture. **C** and **D,** Postoperative radiographs of the extremity after curetage, cementation, and plate fixation.

Principles of Treatment of Impending Pathologic Fractures

- **Perioperative Evaluation**

- A basic **history** and **physical examination** should be performed in all patients being evaluated preoperatively

- Special emphases should be placed on the patient’s previous and current treatments and medications, including **chemotherapy** and **radiation** therapy

- A thorough **social history** should also be taken to evaluate the patient's and family's ability to care for the patient postoperatively

- **Counseling** should be provided for the family and/or caretaker to equip them with realistic expectations regarding the postoperative needs of the patient

- Additionally, all organ systems must be reviewed with foci on the **cardiovascular** and **pulmonary** systems

- Special attention must be given to **educating** the patient and **family** regarding the **palliative** nature of surgical intervention for impending fracture, and the acceptance of surgical risk in exchange for the possibility of preservation of function and pain relief

- **Hypercalcemia** can be seen in up to 20% of patients with malignancy and can be fatal if left untreated

- Serum calcium values **greater than 14 mg/dL** should be considered life threatening and should be treated **immediately** with
  - **rapid hydration and**
  - **loop diuretics**

- **Immediate Stability of Construct**

- A construct should provide **immediate stability** and allow **full weight bearing**

- In most patients, physicians should **avoid fixation methods** that require **bone healing**, porous ingrowths, and bone grafting because of the limitations in activity that these constructs initially require for appropriate healing to occur.

- Whenever possible, priority should be given to providing **immediate optimum functionality** for patients with shortened life expectancies

- In addition, maximizing pain control should be the primary goal

- **Poly methyl Methacrylate**

- Because of the importance of **immediate stability following surgery**, polymethyl methacrylate (PMMA) has become an important adjuvant in the treatment of impending fractures

- PMMA has various properties that allow it to be used in conjunction with constructs, including
  - its ability to conform to atypical cavities
  - Immediate rigidity
  - an exothermic reaction that has shown to cause local tumor necrosis

- **General Guidelines for Treatment**

- Before treatment of any lesion, an individualized treatment plan should be made considering **diagnosis** and **surgical planning**

- Diagnoses of lesions are often made through **biopsy** and histologic confirmation

- The surgical plan may vary according to **primary disease**, **size** of the metastatic lesion, and **responsiveness** to adjuvant therapy

- For example, **solitary metastatic** lesions caused by **renal cell carcinoma** are typically **resistant to irradiation** and may require large resections and reconstructions to prevent local disease progression and complications, although some studies have shown that wide surgical excision does not improve survival
- Other tumors that are less responsive to adjuvant therapy may require de bulking, PMMA, and plate fixation

- Finally, when appropriate, surgeons should pursue more aggressive treatment options to avoid inadequate bone fixation and unwanted additional surgery
- When in doubt, surgeons should maximize immediate mechanical stability and prevention of subsequent complications requiring revision surgery

- **Postoperative Radiation Therapy Following Stabilization**

- Once an impending fracture has been stabilized, postoperative radiation therapy is usually used to **improve function** and **decrease the failure rate**

- A study demonstrated that patients who underwent postoperative irradiation had **higher rates of achieving normal function** status with or without pain than those who did not receive irradiation following fixation of an impending Fracture

- **Location-Specific Treatment Method**
  - Long Bone
  - Spine

- **Long Bone**

- Although different fixation methods exist for treating impending fractures in long bones, all methods should adhere to the following objectives:
  - protect the long bone
  - provide immediate stabilization
  - prevent future fractures

- Fixation methods, either alone or in combination, can include **PMMA**, **endoprostheses**, various **nailing** systems, **plates**, and screws.

- In the **femur**, treatment methods for impending fractures vary depending on the **location** of the lesion

- Lesions in the **femoral head or neck** should be treated with **replacement** arthroplasty because of
  - the high mechanical stress and
  - limited healing found along the proximal femur

- Reconstructive **intramedullary nailing** usually can be performed on impending **subtrochanteric** and **diaphyseal** fractures, stabilizing the lesion while guarding against fracture of potential subsequent, more proximal lesions

- Larger lesions may require an open technique with debulking, PMMA, and fixation

- Similar to methods used in the femur, fixation methods in the **humerus** differ according to the **location** of the lesion

- In the **proximal** humerus, humeral **endoprostheses** are sometimes used because of the difficulties that result with the use of intramedullary nails or plate fixation

- Impending fractures of the **metadiaphysis** or **diaphysis** can be treated with either **intramedullary nailing** or **plate** fixation

- When plate fixation is used, at least three cortical screws are recommended in normal cortical bone

Bone	Location	Pathological Fracture Treatment	Impending Fracture Treatment
Humerus	Proximal	Proximal humerus replacement or proximal humerus plate with cement	Proximal humerus plate or long proximal humerus nail
	Diaphyseal	IM nail with cement	IM nail
	Distal	Total elbow arthropalsty or distal humerus replacement with cement	Distal humerus plate
Radius	Proximal	Small fragment T plate with cement or proximal radial replacement	Small fragment T plate or radial head arthroplasty
	Diaphyseal	Small fragment plate or flexible nail, with cement	Small fragment plate or flexible nail
	Distal	Distal radius plate with cement, or wrist fusion to ulna	Distal radius plate
Ulna	Proximal	Olecranon plate with cement or total elbow arthropalsty	Olecranon plate
	Diaphyseal	Small fragment plate or flexible nail, with cement	Small fragment plate or flexible nail
	Distal	Small fragment plate with cement or resection	Small fragment plate
Femur	Proximal	Head or neck: Proximal femoral repalcement, or calcar-replacing THA Peritrochanteric: Long cephalomedullary nail with cement, or proximal femur replacement	Long cephalomedullary nail or cemented hemiarthroplasty
	Diaphyseal	Long cephalomedullary nail with cement	Long cephalomedullary nail
	Distal	Distal femoral replacement, or distal femoral plate with cement	Distal femoral plate or long retrograde supracondylar nail
Tibia	Proximal	Proximal tibia plate with cement, or proximal tibia replacement	Proximal tibia plate
	Diaphyseal	IM nail with cement	IM nail
	Distal	Distal tibia plate, or amputation	Distal tibia plate
Fibula	Proximal	Nonsurgical	Nonsurgical
	Diaphyseal	Nonsurgical	Nonsurgical
	Distal	Distal fibula plate or ankle fusion	Distal fibula plate

- **Spine**

- The spine is one of the most common sites of skeletal metastases, with approximately 70% of patients dying of malignancy having evidence of spinal metastases

- However, prophylactic surgical treatment of spinal metastases is not done
- Because of the risk involved in operating on spinal metastases, surgical intervention should be performed only when indicated

Surgical Management of Upper Extremity Bone Metastases: A Treatment Algorithm

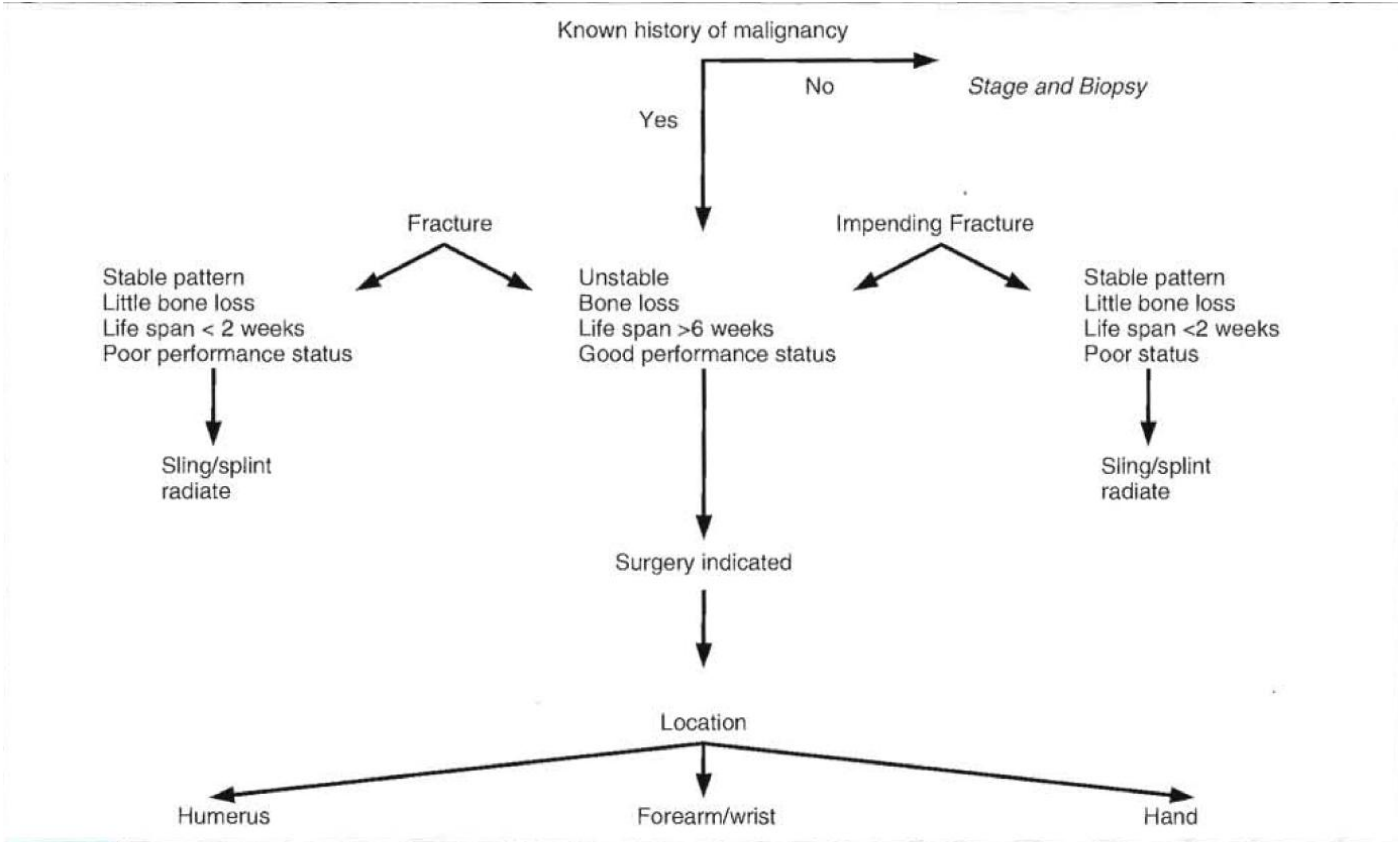


Figure 1 Algorithm for managing upper extremity metastases.

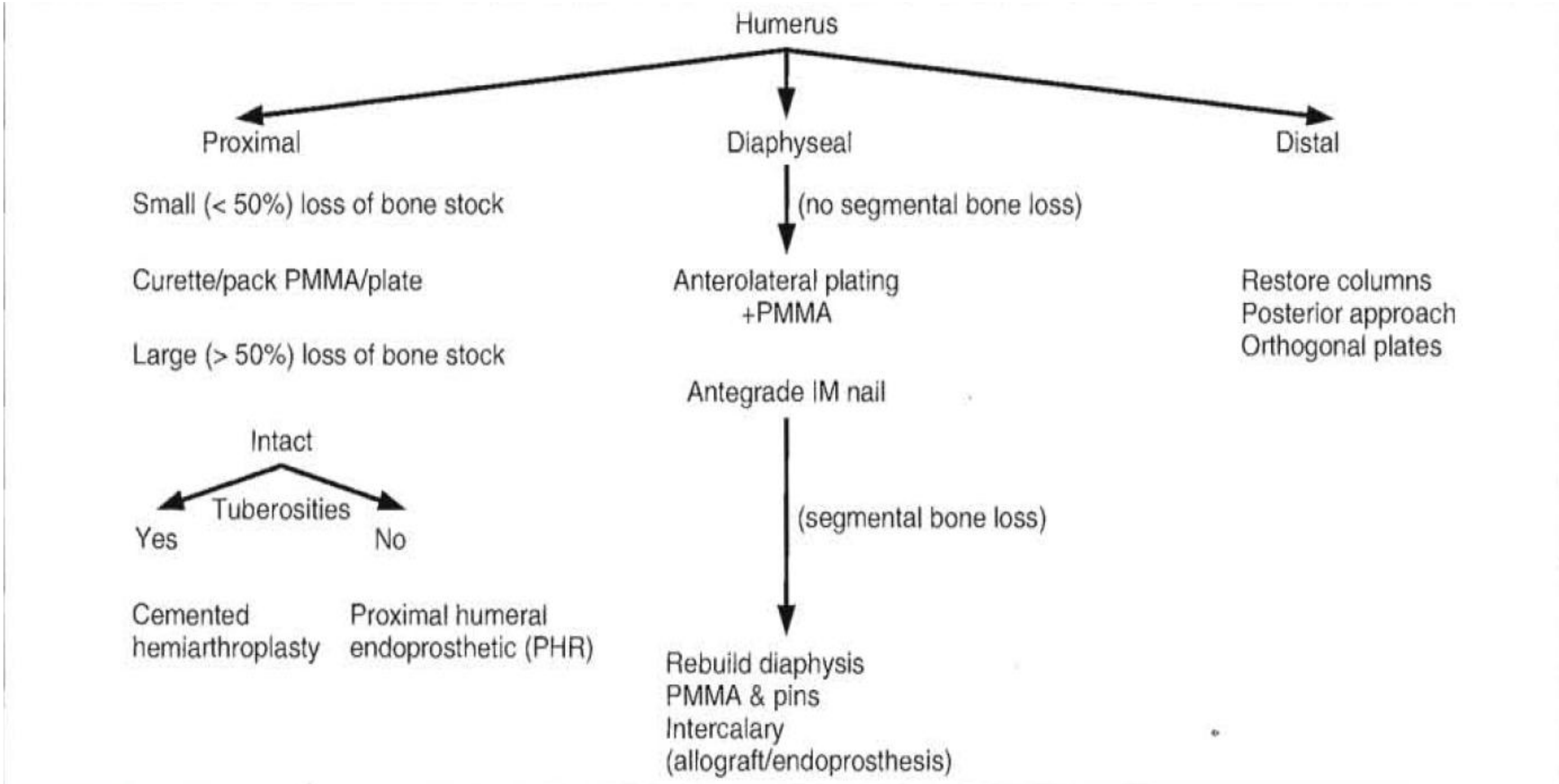


Figure 2 Algorithm for surgical management of metasatic disease in the humerus. IM = intramedullary; PMMA = polymethyl methacrylate; PHR = proximal humeral replacement.

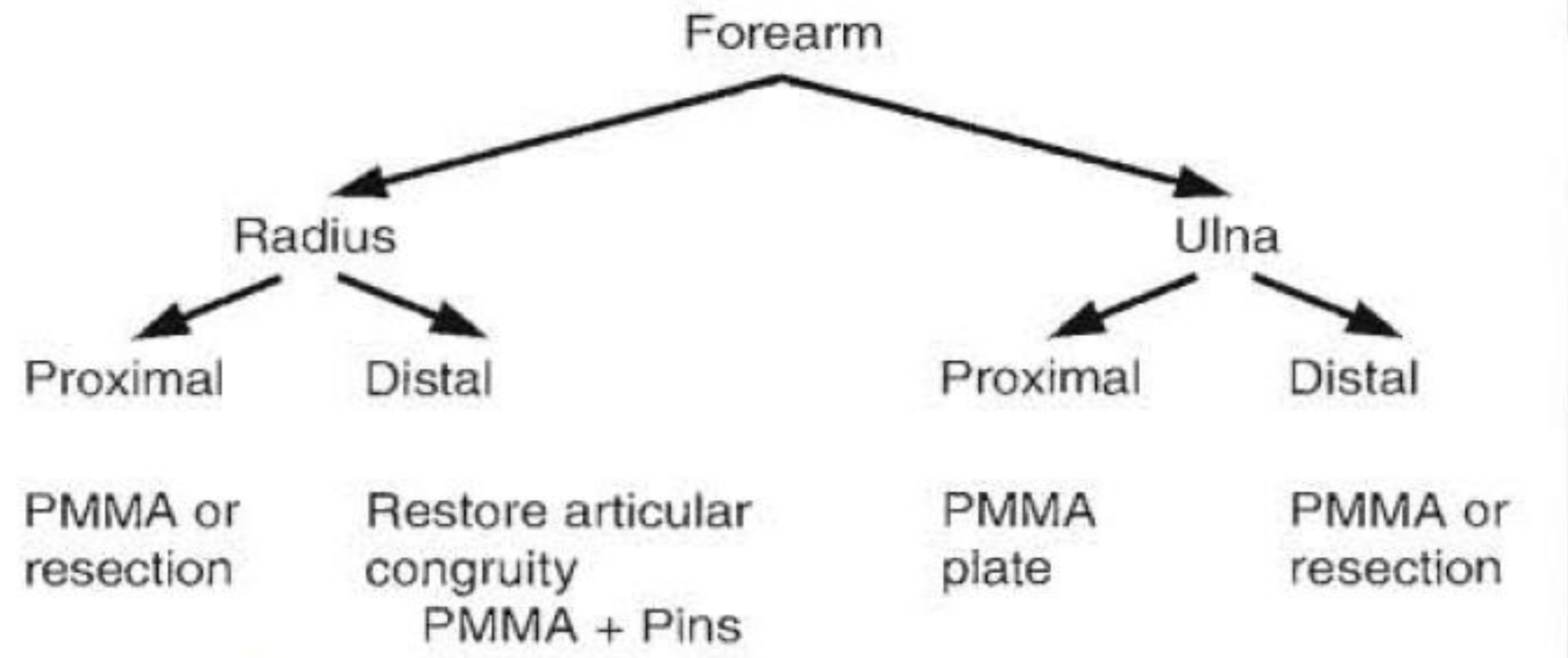


Figure 8 Algorithm for decision making in managing bone metastases to the forearm. PMMA = polymethyl methacrylate.

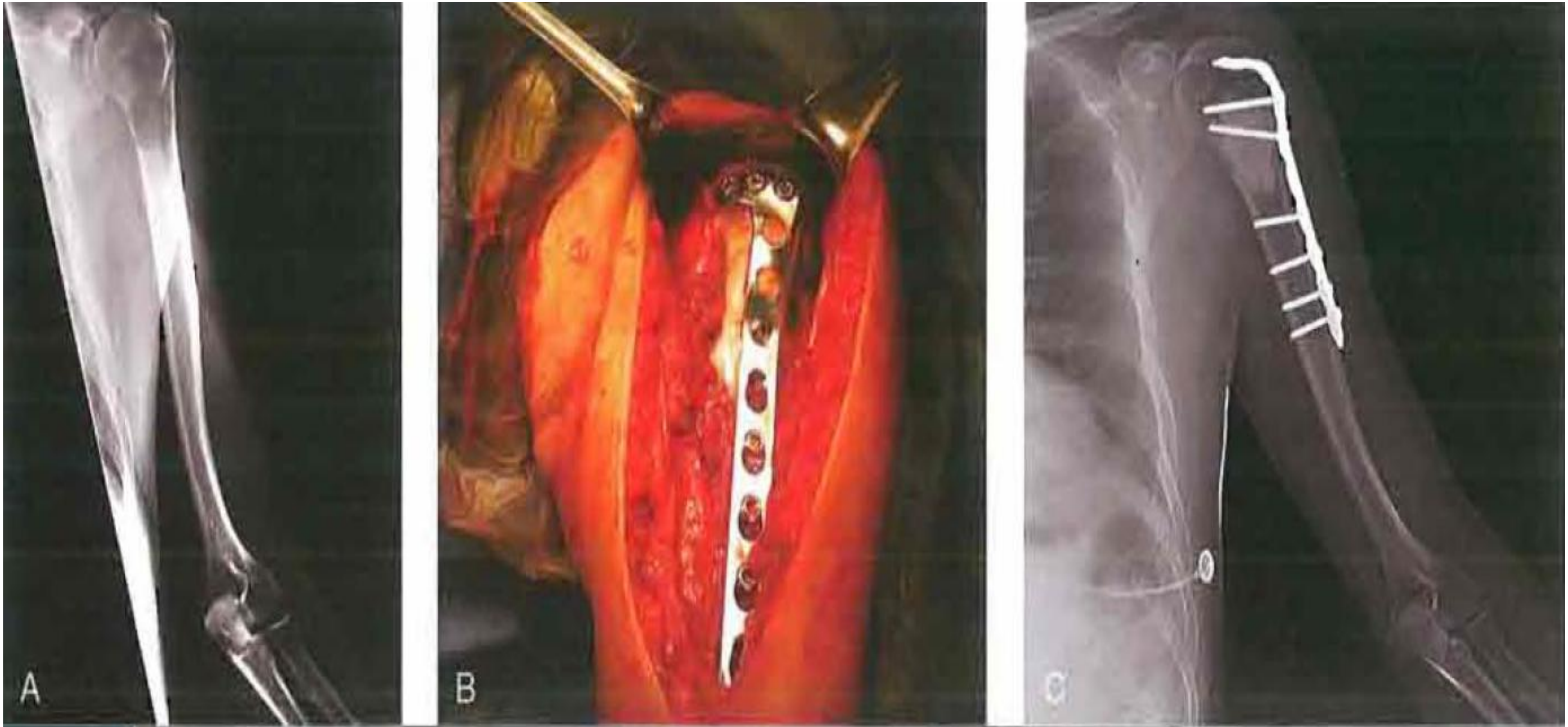


Figure 3 **A,** Radiograph of a metaphyseal lesion in the humerus involving approximately 50% of the bone stock. **B,** Intraoperative photograph showing the relationship of polymethyl methacrylate and internal fixation. **C,** Postoperative radiograph.

Figure 4 **A,** AP radiograph of a thyroid metastasis destroying both the proximal humerus and the greater and lesser tuberosities. **B,** Postoperative radiograph of a proximal humerus replacement.

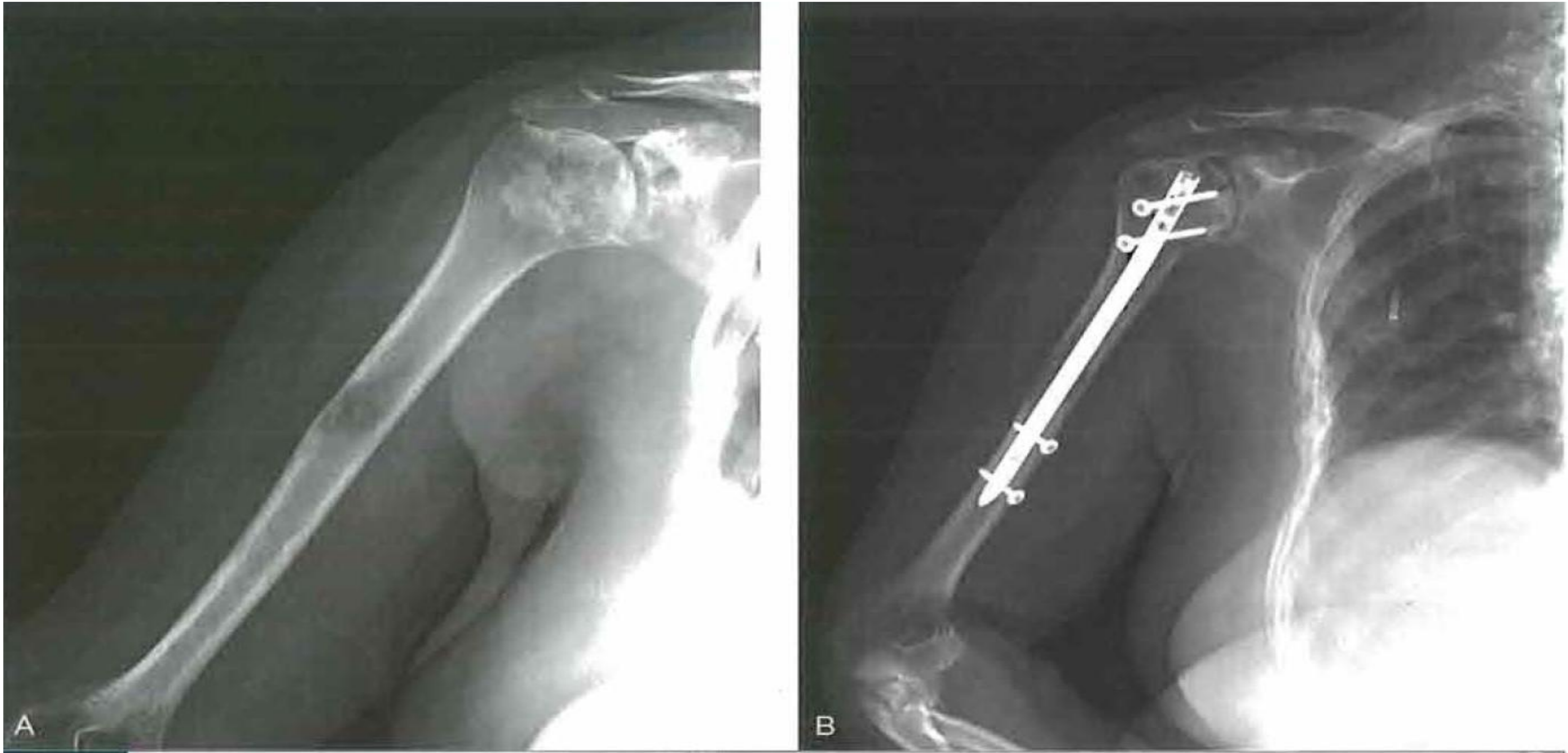


Figure 5 **A,** Preoperative radiograph of a diaphyseal metastases. **B,** Postoperative radiograph after antegrade intramedullary nailing.

igure 6 **A,** Preoperative radiograph showing multifocal metastatic disease of the humeral shaft. **B,** Postoperative radiograph showing use of a long plate with polymethyl methacrylate augmentation.

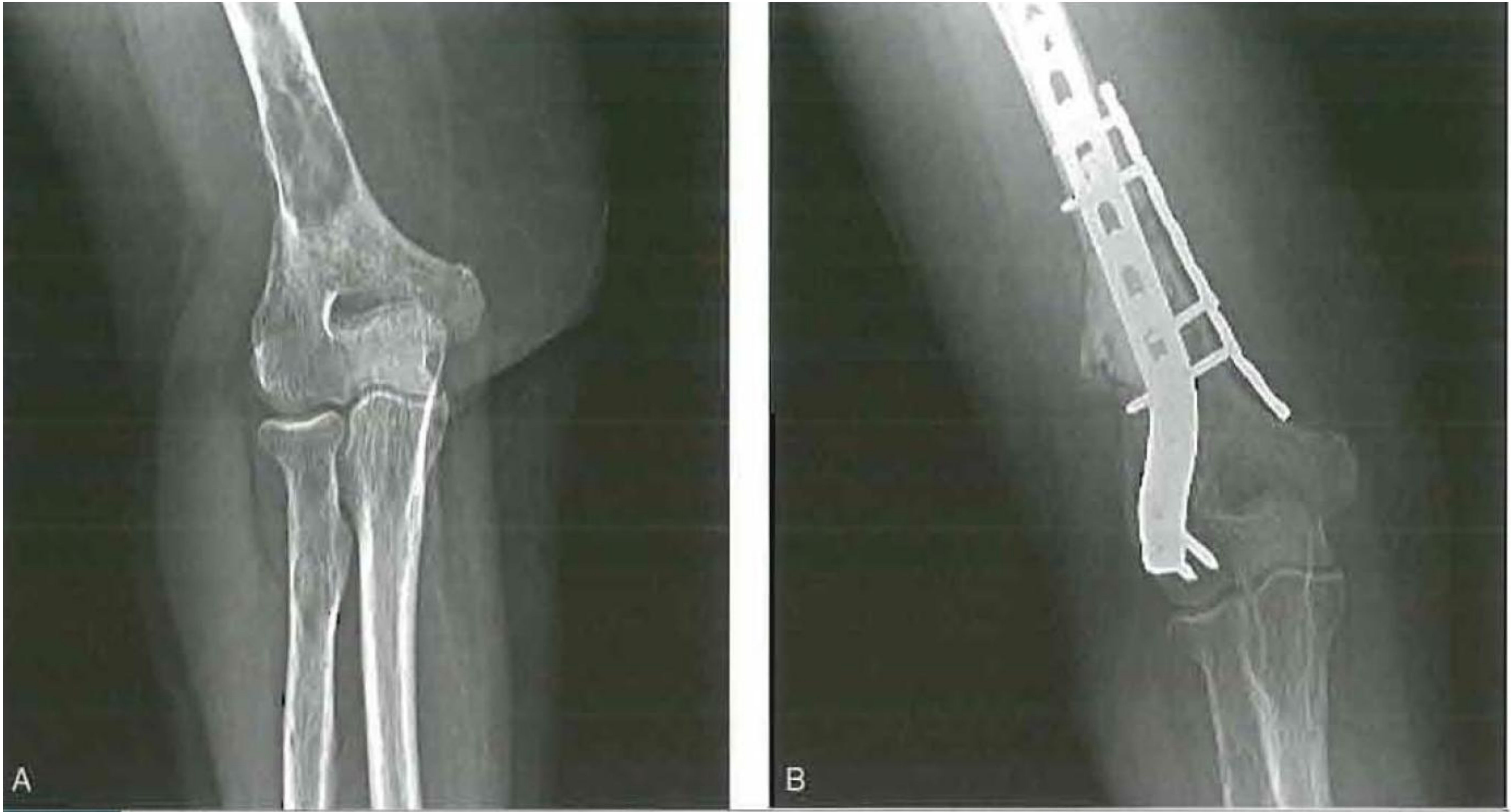


Figure 7 **A,** Preoperative AP radiograph of a distal humerus lesion. **B,** Postoperative image showing orthogonal plating with polymethyl methacrylate augmentation.

Surgical Management of Lower Extremity Metastatic Disease

- **Pelvis**

- These lesions can be divided into **non-weight-bearing portions**, such as the iliac wing and the pubis, from the weight-bearing columns and the periarticular area

- Non-weight-bearing portions rarely require surgery, whereas selected patients may benefit from surgical intervention for lesions around the acetabulum

- Nonsurgical approaches in the pelvis including external beam **radiotherapy**, minimally invasive **ablative** therapies such as radio frequency ablation, and **cryotherapy** may provide relief in selected patients, although they do not confer structural restoration

- CT with three-dimensional reconstructions can help simplify the complexities of the lesion and the structural areas that might be affected

- Appropriate fluid and blood management including other components (platelets and coagulation factors) should be available for surgery
- Soft-tissue coverage can be tenuous, and plastic surgery consultation may be helpful
- Placement in the intensive care unit should be considered for close postoperative management because of the massive fluid shifts that occur during this period
- Physical therapists need to be carefully instructed on postoperative care, because this may differ from that conventional arthroplasty patients

- **Periacetabular lesions**

- Recent advances have been made in less invasive percutaneous techniques, in conjunction with interventional radiologists, which may improve pain or function

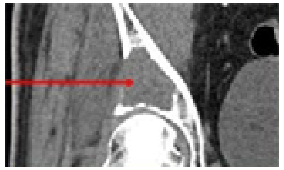
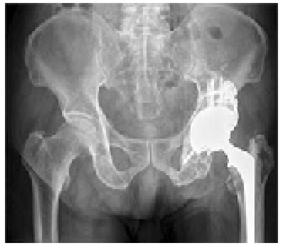
- Pathologic fractures remain a relative indication for surgical treatment in a patient whose performance status and prognosis do not contraindicate a large surgery

- **Osteosynthesis** alone in patients with metastatic disease is often not sufficient, as lesions in metastatic bone are less likely to heal and are best treated in conjunction with **arthroplasty** and **acetabular reconstruction.**

- The goals of acetabular metastatic tumor treatment remain maintenance of ambulatory status and pain control

Periacetabular lesions

Harrington Classifcation		Treatment
Class I	Disruption of lateral cortices with intact superior and medial wall	Conventional acetabular component +/- cement
Class II	Deficient medial wall	Antiprotrusion device/medial mesh
Class III	Disruption of lateral cortices and superior wall	Acetabular cage with long screw fixation into pubis, illium, or ischium +/-cement and Steinmann pins
Class IV	Pelvic Discontinuity	Saddle prosthesis versus resection arthroplasty

Type	X-rays	Description	Management
I		Segmental/cavitary defects Intact acetabular dome Intact anterior and posterior columns	Tumor curettage Cemented acetabular cup Bone grafting
II		Medial wall defect Intact anterior and posterior columns	Antiprotrusio cage ±Cementation of medial wall ±Bone graft to medial wall acetabular socket
III		Combined dome and column defects Intact posterior column	Antiprotrusio cup Stabilization with retrograde screws into intact iliac wing
IV		Pelvic discontinuity Posterior column integrity disrupted	As type III +Antegrade Steinmann pins via iliac wing into the ischium and/or the anterior column Columns should be stabilized first

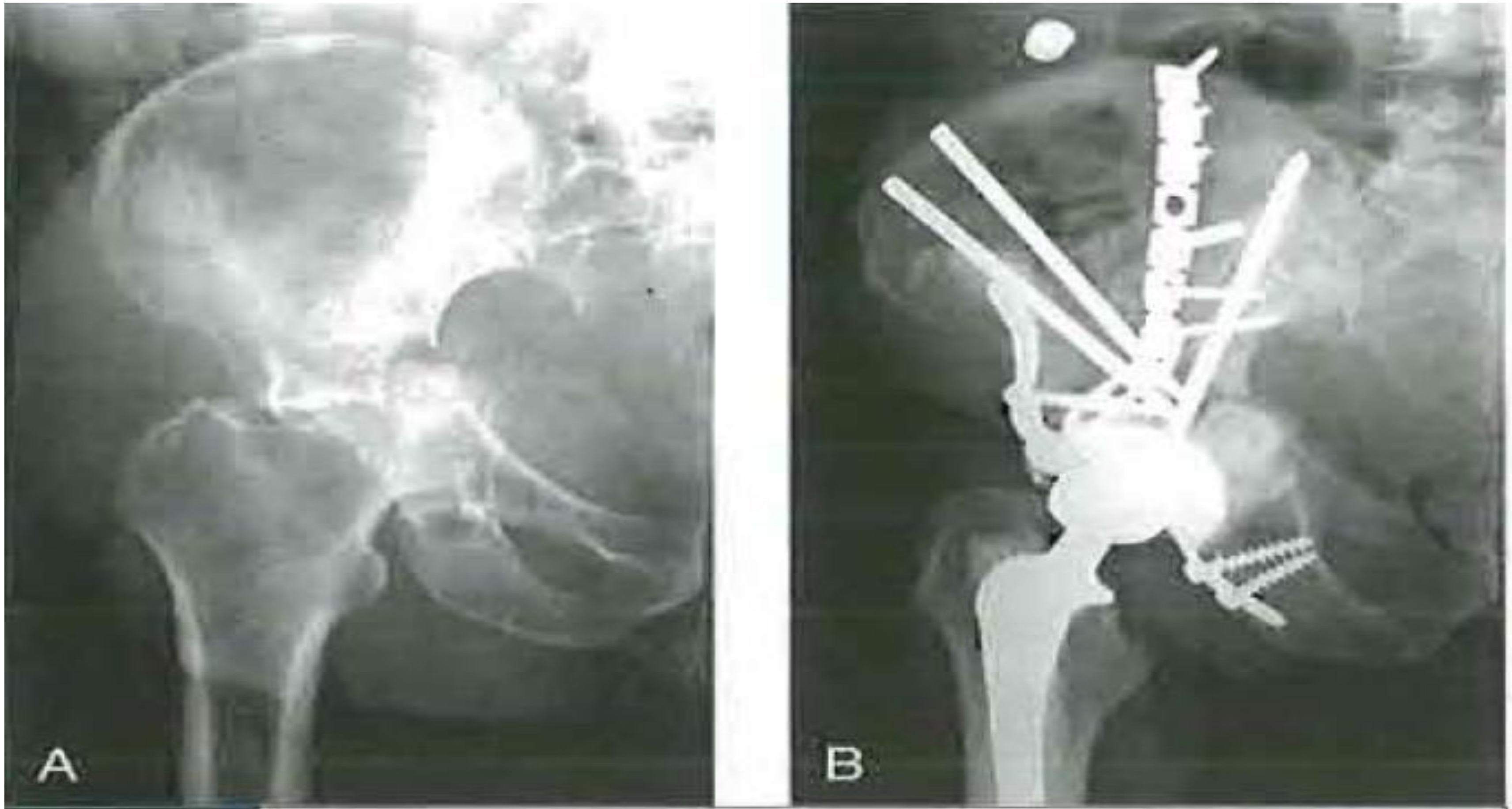


Figure 1 **A,** AP radiograph shows metastatic renal cell carcinoma lesion of the right acetabulum confirmed by percutaneous biopsy with pathologic fracture and protrusio deformity. **B,** Postoperative radiograph following complex reconstruction consisting of a total hip arthroplasty cemented into an antiprotrusio cage. Steinman pins and a reconstruction plate add support and disperse weight-bearing stresses to remaining pelvic bone.

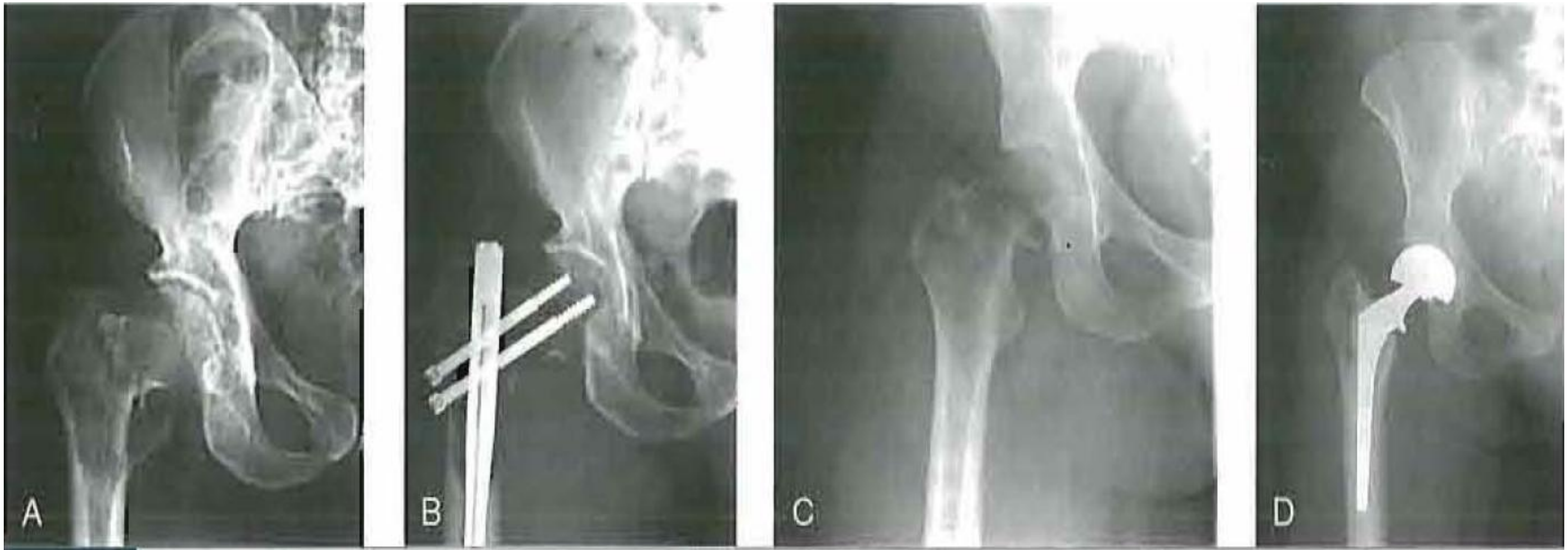


Figure 2 **A,** AP radiograph shows a metastatic lesion of the proximal femur with pathologic fracture and significant bone destruction. **B,** Postoperative AP radiograph following surgical management with reconstructive intramedullary femoral nail. This led to hardware failure and continued pain. **C,** AP radiograph of a different patient with proximal femoral head and neck lytic destruction with femoral neck fracture due to metastatic disease. **D,** Postoperative AP radiograph showing cemented hemiarthroplasty. The patient was able to bear weight immediately postoperatively. Treatment of pathologic fractures should allow for immediate weight bearing, and durability of the surgical fixation should be sufficient to minimize the need for future operations.

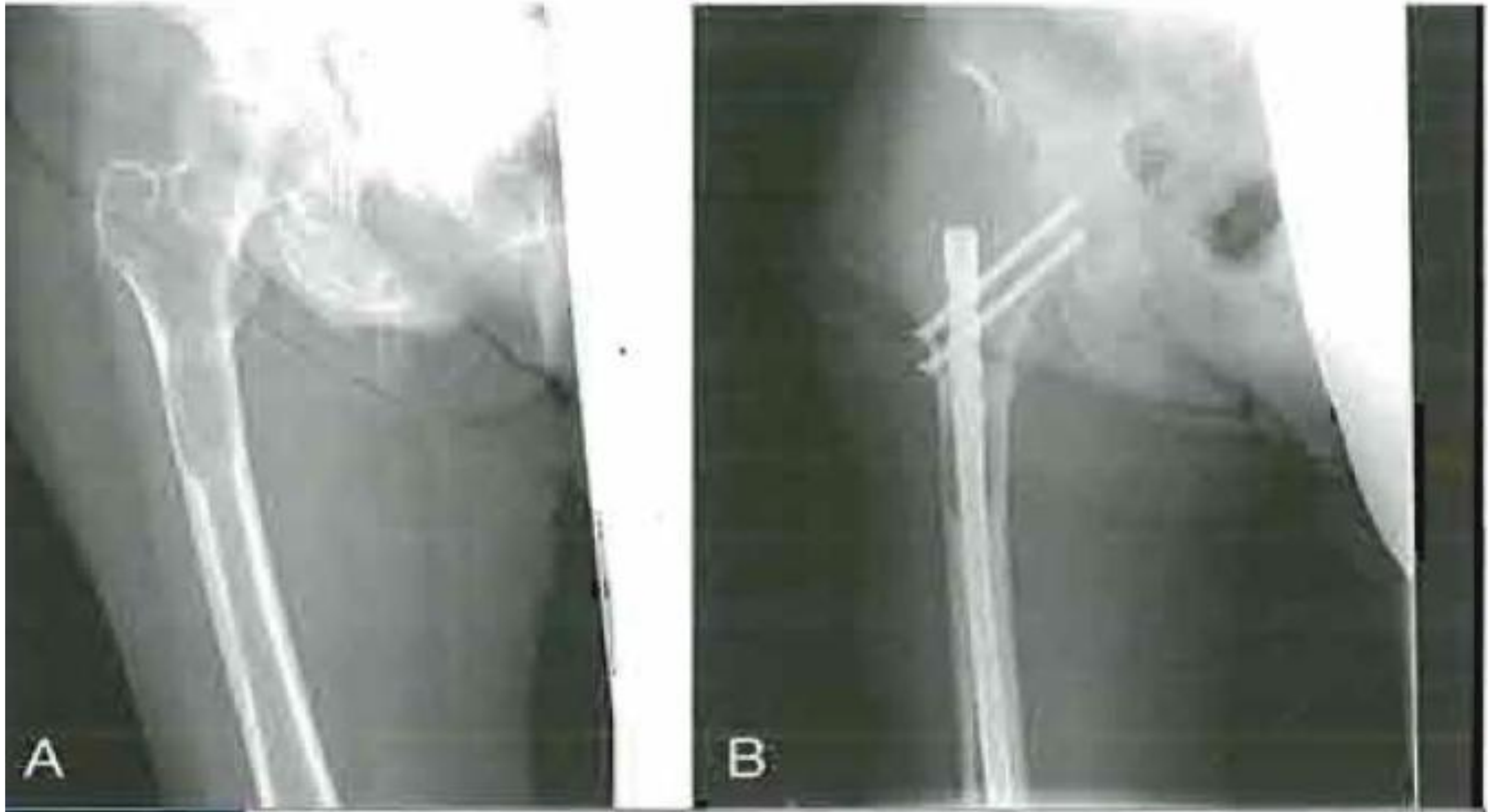


Figure 3 A 70-year-old woman presented with increasing pain with weight bearing. **A,** AP radiograph showing a lytic destructive lesion in the proximal femoral diaphysis. Biopsy confirmed metastatic lung cancer. **B,** AP radiograph following prophylactic stabilization of the lesion with an intramedullary nail. The patient underwent postoperative radiation therapy.

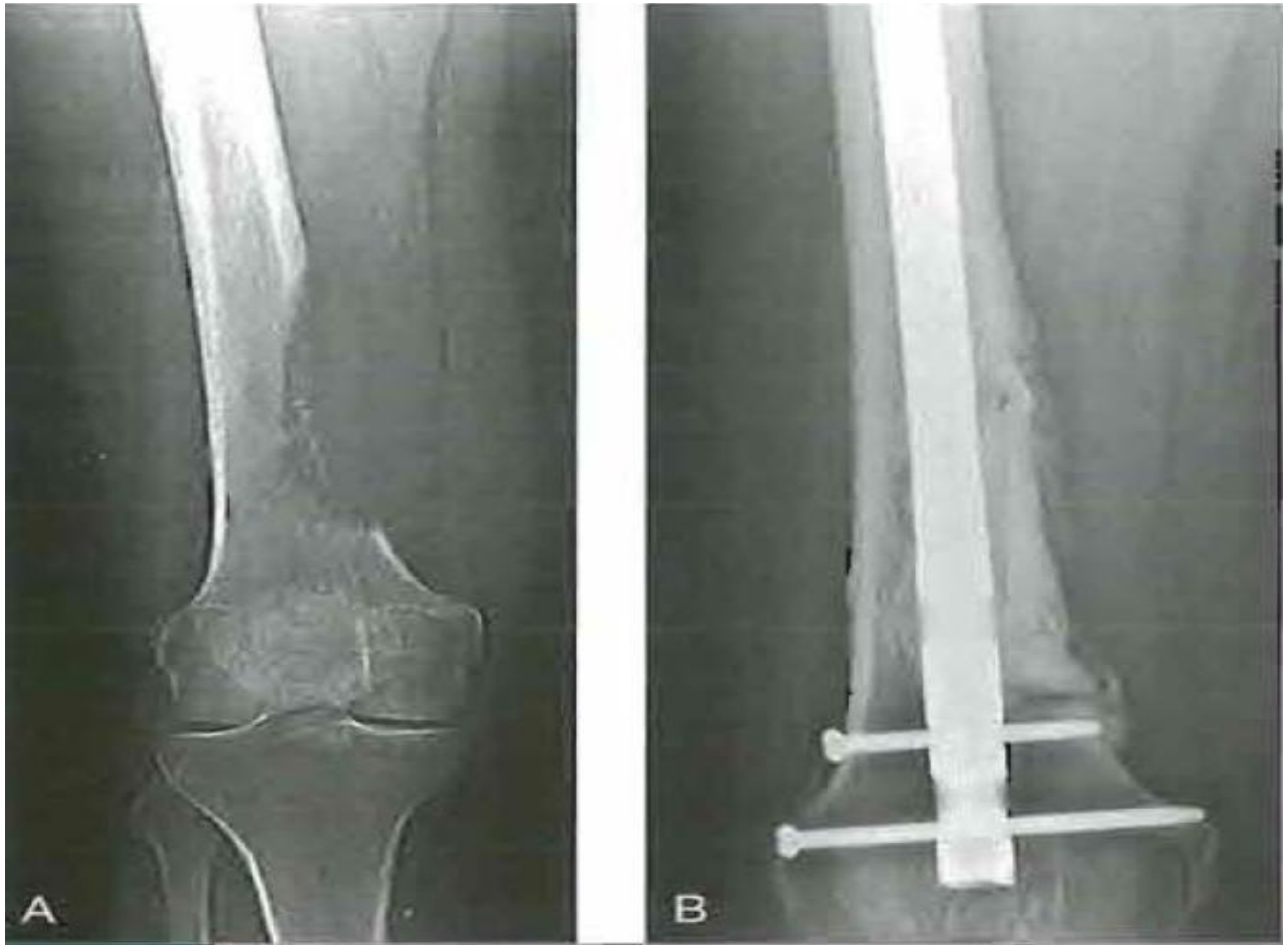


Figure 4 **A,** Radiograph of a distal femur metastatic lung lesion and impending pathologic fracture. **B,** Postoperative radiograph illustrating curettage followed by intramedullary prophylactic fixation and polymethyl methacrylate cement augmentation. This construct allowed immediate weight bearing with good pain relief. External beam radiation to the femur for the entire length of the femur was performed post-operatively to minimize risk of progression.

- The goal of surgical treatment is to provide palliative symptomatic relief and immediate function for patients with shortened life expectancies

- When these goals cannot be met, the physician, patient, and family should discuss medical treatment, nonsurgical options, or best supportive care