

Palliative Orthopaedic Surgery for Skeletal Metastases

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Abstract

Advances in oncological therapies have resulted in improved survival in patients with skeletal metastases. The resultant effect is that the skeletal metastases result in an increased incidence of pathological fracture and bone pain. This article focuses on the options available to the orthopaedic surgeon in the treatment of patients with skeletal metastases. It covers the controversial area of prophylactic fixation and the roles of conventional internal fixation, cement, arthroplasty and endoprosthetic replacement. The role of radiotherapy in the management of patients with surgically treated skeletal metastases is highlighted. Treatment for these patients is always individualised and should always be subject to a multidisciplinary approach. Despite the prognosis, satisfying results can be obtained that achieve the aims of palliative surgery, namely pain relief and maintenance of or improvement in function.

Keywords

Skeletal metastases, palliative, surgery, pathological fracture

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The majority of surgery performed for cancer by orthopaedic oncologists is curative surgery for primary bone and soft-tissue sarcomas. The principle is resection achieving wide margins in order to save lives, then worrying about saving the limb, then limb function and, finally, cosmesis and limb-length equalisation. On occasion, surgery for isolated renal or thyroid metastasis may be along these lines, but more often surgery for metastatic disease has different goals. It is palliative rather than curative. Function and pain relief are the major aims, resulting in an improvement in quality of life.

Advanced skeletal disease is common with many malignancies. Bone is the third most common site of metastasis after the lungs and liver. Figures for the worldwide incidence of skeletal metastases range from 100% in multiple myeloma to 25–30% in renal and lung cancer. The most frequent skeletal metastases an orthopaedic surgeon will meet are in breast and prostate cancer, where figures are estimated at around 65%. In a series of over 300 pathological fractures and impending pathological fractures, four primary tumours were found to account for 85% of pathological fractures (breast 56%, kidney 11%, multiple myeloma 9.5% and lung 8.5%).¹ Approximately 9,000 patients in the UK develop skeletal metastases from breast cancer each year.²

The majority of skeletal metastases occur in the spine, pelvis and long bones. Virtually any malignant tumour can metastasise to any bone and cause a pathological fracture. In the appendicular skeleton, approximately two-thirds of pathological fractures occur in the femur and the majority of the remainder are in the humerus.³

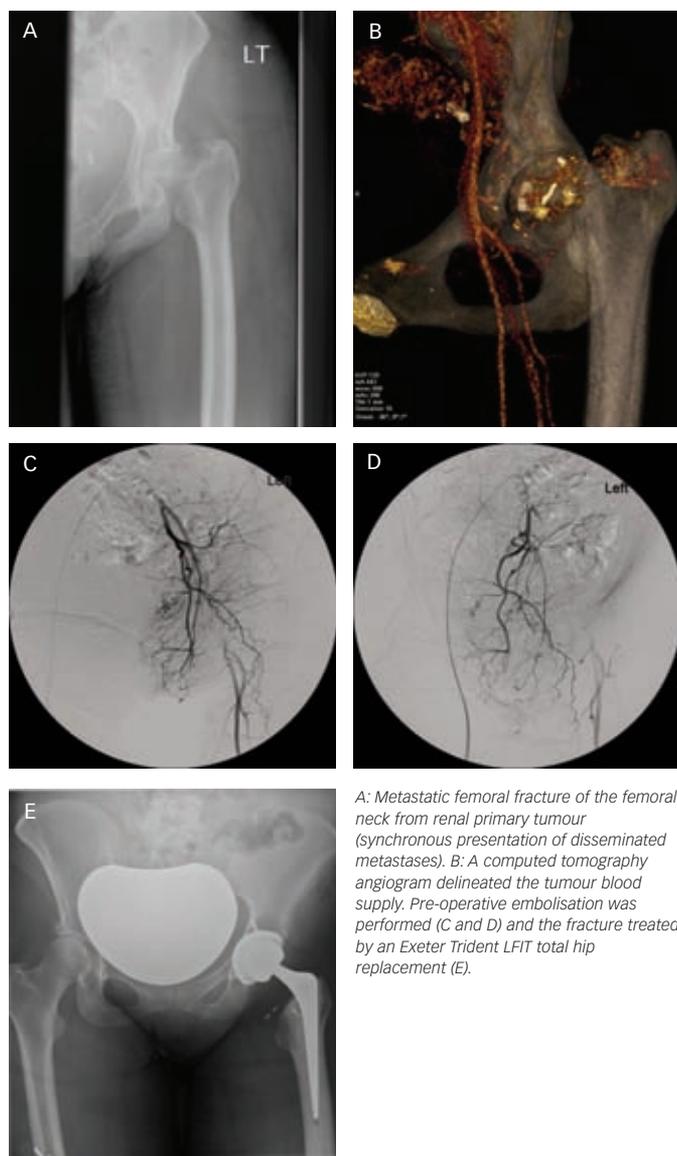
Improvements in modern oncological treatment of primary and metastatic tumours have resulted in increased survival and therefore an increased role for the orthopaedic surgeon in the evaluation and treatment of skeletal metastatic disease.⁴ Despite this, the use of orthopaedic procedures in terminal care patients remains limited.⁵ Orthopaedic interventions can be justified for pain, pathological fracture, impending fracture and spinal metastases.⁶ In a review of palliative surgical procedures performed at the City of Hope Cancer Centre in Duarte, California, of the 240 palliative surgical procedures performed only 10 were orthopaedic.⁷

Complications of Skeletal Metastases

Morbidity from skeletal metastases takes a number of forms. Bone pain can necessitate bisphosphonate therapy or radiotherapy. Hypercalcaemia requires rehydration and medical treatment. Spinal cord compression will require either surgery or radiotherapy. However, pathological fractures account for significant pain and impairment in quality of life. Pathological fractures are most common in breast cancer, reflecting the lytic nature of the metastasis and the relatively long survival. This article focuses on the role of the orthopaedic surgeon in the management of non-vertebral metastases.

Damron and Sim⁸ identified four main principles in the surgical management of metastatic bone lesions. First, patient selection is critical, such that the operation is appropriate for the predicted survival of the patient. Second, the construct must be stable enough to allow immediate full weight-bearing. The third principle is that all areas of the bone that are affected by the tumour are

Figure 1: Pathological Fracture of Left Femoral Neck from Metastatic Renal Cancer



addressed in any planned reconstruction. Finally, post-operative radiotherapy is utilised to minimise disease progression. Where the bone has been reamed (inserting an intramedullary nail), the entire bone should be irradiated.

The aims of surgery are to maintain or regain mobility, to improve quality of life and to maximise pain relief.⁹ In breast cancer, the most common primary for which skeletal metastases are surgically managed, the median survival from diagnosis of bone metastasis is 22 months.¹⁰ This is the length of time that any reconstruction should be anticipated to last.¹⁰

It should be remembered that surgery is not appropriate for all skeletal metastases or pathological fractures and that non-surgical management has an important role to play. It may be appropriate to obtain a biopsy to confirm the diagnosis. A well-performed needle biopsy by an orthopaedic oncologist or radiologist will usually suffice.^{11,12} Inadvertent fixation of a primary sarcoma can lead to mutilating proximal amputations, for example hindquarter amputation for intramedullary nailing of a pathological fracture from a primary femoral malignancy.

Figure 2: Destructive Lesion in Acetabulum 21 Years After a Malignant Melanoma Was Excised



A confirmatory computed tomography (CT)-guided biopsy was performed and the histology was that of dedifferentiated chondrosarcoma.

A detailed review of non-surgical management of skeletal metastases is outside the scope of this article. Suffice to say, treatment modalities include chemotherapy, hormone therapy, radiotherapy (conventional and hemibody techniques), bisphosphonates, immunotherapy, analgesics, radionuclide therapy, radiofrequency and laser ablation.

Preparation for Surgery

The first consideration is whether the patient is a surgical candidate. If the patient is not fit for surgery and has uncorrectable comorbidities, palliative treatment is the only option. If the patient is fit for surgery and has an established fracture, the fracture should be surgically addressed (either resected or stabilised). If the patient has an impending fracture or is deemed to be at high risk of fracture (see below), again this should be surgically addressed. If the fracture risk is deemed to be minimal, non-operative treatment is again appropriate.⁴

Surgery for metastatic bone disease is rarely an emergency, except for spinal cord compression. A thorough evaluation prior to surgery is mandatory and should include haemoglobin, calcium and electrolyte measurements. Correction of anaemia and hypercalcaemia will reduce mortality and morbidity. Respiratory function may be compromised by the presence of lung metastases, and cervical spinal metastases may cause the anaesthetist anxieties.

The whole of the affected bone should be imaged to avoid metachronous lesions, which if missed would compromise outcomes. Imaging of the skeletal metastases can take the form of one or more of plain radiography, isotope bone scanning and cross-sectional imaging (computed tomography or magnetic resonance imaging). A solitary bone lesion should provoke caution, especially if the history of malignancy is distant and there is no other evidence of metastatic disease (see Figure 1). A biopsy prior to definitive surgery should be considered.⁴

Finally, the underlying primary should be considered. Renal and thyroid metastases and multiple myeloma have a propensity for being highly vascular, and pre-operative embolisation should be considered (see Figure 2).

Table 1: Harrington Criteria for Predicting Fracture Risk¹⁵

Cortical bone destruction greater than 50%
A lesion of more than 2.5cm in the proximal femur
A pathological avulsion fracture of the lesser trochanter
Persisting stress pain despite irradiation

Table 2: Mirels' Scoring System for Risk of Pathological Fracture¹⁶

Variable	Score		
	1	2	3
Site	Upper limb	Lower limb	Peri-trochanteric
Pain	Mild	Moderate	Functional
XR appearance	Blastic	Mixed	Lytic
Size	<1/3	1/3–2/3	>2/3

XR = plain radiograph.

Table 3: Femoral Reconstruction Options by Location of Metastases

Femoral head
Conventional hip replacement or hemiarthroplasty if no acetabular involvement
Peri-trochanteric
Conventional/long-stem hip replacement
Calcar-replacing prosthesis
Subtrochanteric
Proximal femoral replacement
Cephalomedullary nail
Diaphyseal
Intramedullary nail ± cement augmentation
Diaphyseal intercalary endoprosthetic replacement*
Supracondylar
Cement augmentation of internal fixation
Distal femoral replacement

*Diaphyseal endoprosthetic replacement indicated for disease progression or solitary metastasis.

The surgical plan should be to achieve a construct that provides sufficient stability to allow immediate weight-bearing for the duration of the patient's life.⁴ Without appropriate planning, re-operation rates can be high,^{13,14} often for disease progression. Pre-operative planning must take into account the extent of bone destruction.

Prophylactic Fixation of Impending Fractures

Prediction of fracture risk and prophylactic fixation of impending fractures is controversial. If an impending fracture can be accurately predicted, the morbidity, length of stay and quality of life can all be improved compared with reactive fixation of a pathological fracture.

The primary tumour, size, location and extent of the tumour all play a role in determining fracture risk. There are two methods in common usage that predict fracture risk: the Harrington criteria and Mirels' score^{15,16} (see *Tables 1 and 2*).

The presence of one or more of Harrington's criteria is considered an indication for prophylactic internal fixation.¹⁵ Mirels' scoring is a weighted scoring system to analyse the risk of pathological fracture in long weight-bearing bones.¹⁶ It combines four radiological and clinical risk factors. A score of less than 6 indicates that a lesion has a low risk of fracture and can be irradiated safely, but a score of 9

or higher demands prophylactic internal fixation prior to irradiation (see *Table 2*). There was a 33% fracture risk in patients with a score of 9 or more in Mirels' study compared with only a 4% fracture risk in patients with a score of 7 or less.¹⁶

Once a decision has been made in terms of the need for prophylactic fixation, for femora the implant of choice is a cephalomedullary nail. Surgical technique is important as it has been demonstrated that there is an increased risk of cardiopulmonary complications, including death, with prophylactic nailing.¹⁷ Strategies to reduce the risk of adverse cardiopulmonary events include the use of pulse lavage, smaller reamers used at lower speeds, intraoperative venting of the femur and supportive therapy. When both femora are involved, prophylactic nailing should be staged.¹⁸ Prophylactic fixation of other long bones (namely the tibia and humerus) will usually be achieved with a locked intramedullary nail. Radiotherapy of the whole bone following prophylactic internal fixation is mandatory.

Conventional Internal Fixation for Metastatic Fractures

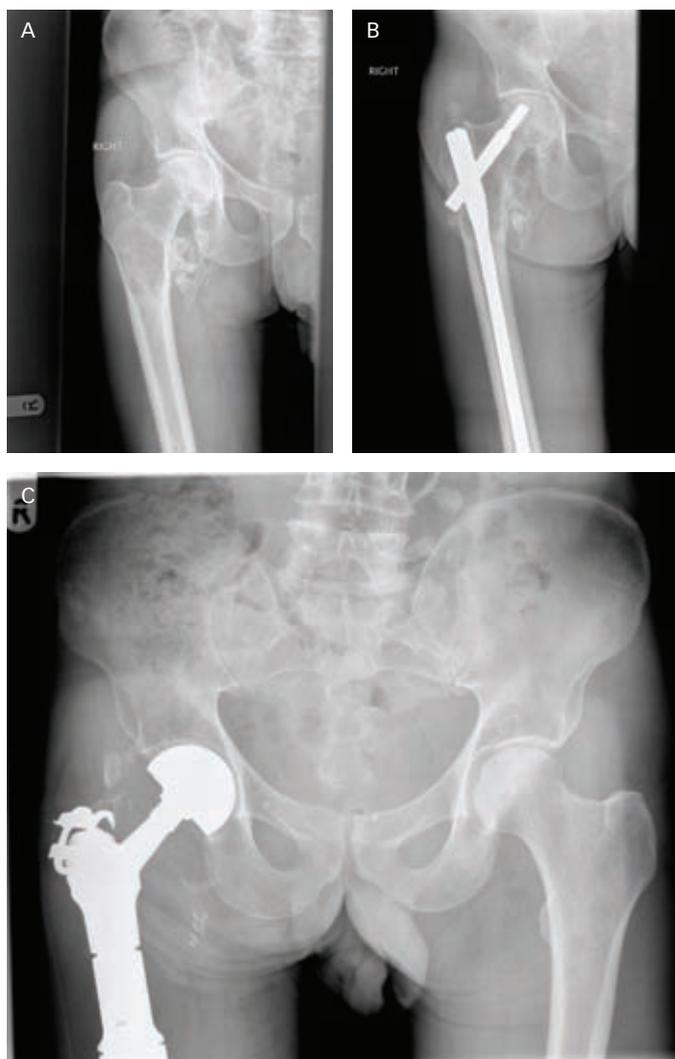
While it is desirable to stabilise impending fractures prior to them fracturing, it is not always possible. Commonly, the first presentation of metastatic bone disease is when the fracture occurs. A pathological fracture is rarely an emergency (usually only when associated with cord compression). There is most often time to assess the patient, the fracture and the disease load properly. This may involve re-staging the patient and obtaining cross-sectional imaging of the fracture. Management of metastatic fractures must be individualised. In a number of situations conventional internal fixation may be appropriate. For example, diaphyseal humeral or tibial pathological fractures can be treated by locked intramedullary nails and pathological forearm fractures treated by conventional plating techniques. Radiotherapy is again mandatory after internal fixation. If an intramedullary nailing device has been utilised, the whole bone needs to be irradiated due to the dissemination of the medullary tumour contents by the reamer and nail.

The Role of Cement

Bone cement can be used either alone or in conjunction with internal fixation. When used alone it lends itself to percutaneous insertion techniques. De and Rennie have covered in detail the armamentarium that is available to the interventional radiologist for advanced musculoskeletal malignancy. Those patients who may not be suitable for major orthopaedic surgical reconstruction may still be appropriate for percutaneous techniques (see *Table 3*).

Cement as an adjunct to internal fixation is not a new technique. Harrington described methyl methacrylate as an augment to internal fixation back in 1972.¹⁹ The aim was immediate and secure stabilisation of pathological fractures allowing immediate mobilisation and weight-bearing, hence preventing complications of skeletal metastases. In his larger series of 375 pathological fractures or impending fractures, 94% of patients maintained the ability to walk and 85% had good pain relief. Twenty patients died within four weeks of surgery (5%) and there were four fixation failures and six functionally poor results.²⁰ In the proximal tibia, cement can be utilised in conjunction with plating of the bone. In diaphyseal lesions, intramedullary cement can be used with a locked intramedullary nail. Where there is a large bone lesion this

Figure 3: Disease Progression in Metastatic Thyroid Cancer



A: Metastatic pathological fracture of proximal femur from thyroid metastasis, stabilised by cephalomedullary nail (B). Disease progression resulted in increasing pain, and an endoprosthetic proximal femoral replacement was performed resulting in improved symptomatology and mobility (C).

can be curetted out and filled with cement prior to inserting locking screws. Focal osteolytic metastases can be treated by curettage and cementation alone. This can be appropriate in bones such as the talus or os calcis.

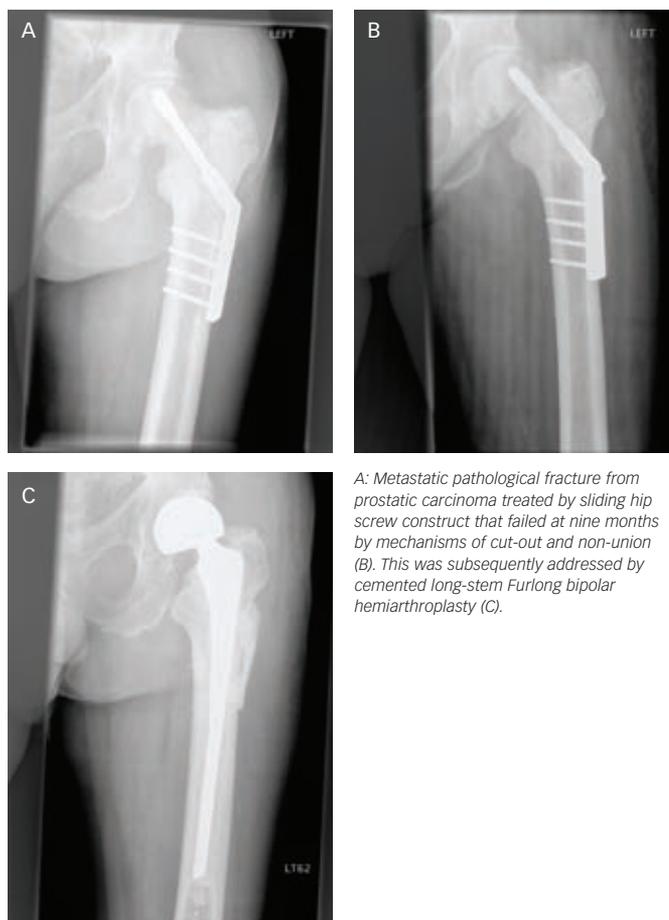
Prior to the insertion of bone cement, the use of adjuncts may help to slow disease recurrence or progression. These include cryotherapy, phenolisation, argon beam coagulation and radiofrequency ablation.²¹

Arthroplasty and Endoprosthetic Replacement

Poor bone quality, the lack of predictable healing, the high stresses across the proximal femur, the risk of tumour progression and previous radiotherapy are all reasons why total hip arthroplasty is often preferred to internal fixation for tumorous deposits of the proximal femur.²² Half a per cent of all total hip replacements performed in Sweden are for tumours.²³

Approximately 40% of pathological fractures are of the proximal femur and many of these will present to local orthopaedic units. They will often be managed much as non-pathological fractures,

Figure 4: Pathological Fracture of Left Femoral Neck from Metastatic Prostate Cancer



A: Metastatic pathological fracture from prostatic carcinoma treated by sliding hip screw construct that failed at nine months by mechanisms of cut-out and non-union (B). This was subsequently addressed by cemented long-stem Furlong bipolar hemiarthroplasty (C).

utilising implants such as hemiarthroplasties. Hemiarthroplasties offer the advantage of being a faster procedure with less blood loss and a lower dislocation rate than total hip replacements.

Orthopaedic surgeons need to be aware of the possibility of there being co-existent acetabular metastases so that hemiarthroplasties are avoided in the presence of acetabular malignancy, otherwise a peri-prosthetic central fracture dislocation may occur. Pre-operative computed tomography or magnetic resonance imaging scan may be useful in determining acetabular involvement as well as intraoperative findings.

In the presence of acetabular metastases, at the very least it will be necessary to curette them out and fill the defect with polymethyl methacrylate bone cement. However, in many cases more complex acetabular reconstruction may be necessary that incorporates threaded pins,^{24,25} a roof reinforcement ring²⁶ or a cage-type reconstruction.²⁷

The type of reconstruction of the femur that is utilised is dependent on the location of the metastatic disease. Cemented long-stem implants should be used to address the whole femur and to allow immediate weight-bearing. The use of cement should also prevent loosening (due to disease progression) during the patient's remaining lifetime.

Where metastatic disease is peri-articular, intramedullary fixation (cephalomedullary nails) should be avoided and reconstruction should be focused along the lines of arthroplasty techniques.

Endoprosthetic replacement is usually performed either for a solitary metastasis, where cure is the intention, or where bone destruction is so marked that there is no other option.²⁸ Failure of internal fixation is a further indication, usually for tumour progression or non-union²² (see *Figure 3*). Proximal femoral replacements are usually used if the palliation is likely to be suboptimal if the bone is left.²⁸ Suggested guidelines for the performance of endoprosthetic replacements were proposed by Chan in 1992.²⁹ They were as follows:

- anticipated survival of at least six months;
- inability to achieve long-standing stability and good function by other methods;
- patient prepared to co-operate with the proposed rehabilitation programme; and
- failure of previous attempts at stabilisation of bone by other methods.

These guidelines still hold true, although patient co-operation is not usually a concern, and particularly in the proximal femur orthopaedic oncologists will go straight to endoprosthetic replacement rather than employing inferior reconstruction techniques.¹⁴ The proximal femur is the most common site of failure and re-operation¹⁰ (see *Figure 4*). The failure and re-operation rate is lower with prosthetic replacement of the proximal femur than with osteosynthesis techniques (failure rate 16.2 versus 8.3%).¹⁴ The availability of modular endoprosthetic replacements facilitates this reconstruction option.

The majority of massive endoprosthetic replacements are performed for renal cell cancers and metastatic breast cancers where the prognosis is in excess of six months.²⁹ Retaining the greater trochanter and re-attaching it using either screws or wires to the prosthesis will enhance the stability of the construct. This is possible for metastases where the surgery is palliative, whereas for primary tumours it would compromise the resection. Functional outcome

following endoprosthetic replacement for metastases is usually highly satisfactory.³⁰ In a large series of patients with surgically treated skeletally metastatic breast cancer, Wedin and colleagues looked at where the surgery was performed. The failure rate at the regional orthopaedic oncology service was 6% compared with a combined failure rate of 16% at the non-specialist centres.¹⁰

Amputation

Amputation is often thought of as a last resort. However, there are circumstances where amputation can result in both an improved quality of life and, in some cases, an improved quality of death. Indications for amputation include fungating tumours, locally recurrent tumours and neurovascular involvement. They can provide predictable wound healing and good analgesia. Acrometastases (hand and feet), typically from lung cancer, that are symptomatic can be rapidly addressed by local amputations without major functional deficit.

Summary

The role of the orthopaedic surgeon can be varied in the management of advanced musculoskeletal malignancy. Metastatic disease should not be thought of as inoperable, but rather that it needs an innovative approach to surgical management. It should be remembered that a multidisciplinary approach to the tumours is desirable. Surgical treatment should be aimed to palliate symptoms, maintain or regain mobility and improve quality of life. ■

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