Osteomyelitis

14

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Osteomyelitis is a relatively common condition in lesser developed nations, as compared to developed nations. However, there are few figures for incidence and prevalence of the disease. A study from the Gambia showed chronic osteomyelitis accounts for 15 % of all surgical admissions [1] and in Malawi accounts for 6.7 % of all operations in an orthopaedic unit [2]. The reported incidence of acute osteomyelitis in New Zealand aborigines is 200 in 100,000 [3].

The increased incidence of osteomyelitis in austere environments is secondary to both adverse patient and environmental factors [4]. Patient factors include malnutrition, immunodeficiency, poor dental care, prevalent skin lesions, anaemia and lack of healthcare knowledge. Environmental factors include poor access to clean water, poor infrastructure and lack of access to quality healthcare (Fig. 14.1). These factors contribute to frequent bacteraemias, lowered host immunity and delayed presentation, which in turn result in an increased incidence of bone infection. Even if diagnosed, treatment is often inadequate, and this compounds the already difficult-to-treat nature of osteomyelitis.

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Osteomyelitis can arise via haematogenous spread from a distant site, via direct inoculation through a wound adjacent to the bone (e.g. open fractures, post surgery) or via spread from the adjacent infected soft tissue (e.g. cellulitis) [4]. It can be classified according to duration of symptoms into acute (days to weeks duration), subacute (weeks to months) and chronic (>3 months).

14.1 Pathophysiology

Haematogenous osteomyelitis is an infection of the bone occurring secondary to a bacteraemia. It is the most common form affecting children in the developing world. Causative organisms are *Staphylococcus aureus*, *Streptococcus pyogenes*, *Haemophilus influenzae* and *Escherichia coli* [2]. Atypical organisms (salmonella, tubercle bacillus (TB) and fungi) should also be considered. The most common bone affected is the tibia, followed by the femur and humerus [2] (Fig. 14.2). Bacteraemic emboli typically become lodged in the metaphyseal region of a bone where the organisms proliferate. The reason for this metaphyseal seeding is multifactorial. It is related to the slowing of the blood flow in this area and the deficient phagocytosis in these vessels. The fact that the capillary loops are 'end-vessels' also means that occlusion causes a localised necrosis, a further contributing factor [5]. As bacteria proliferate, pressure increase causes ischaemia,

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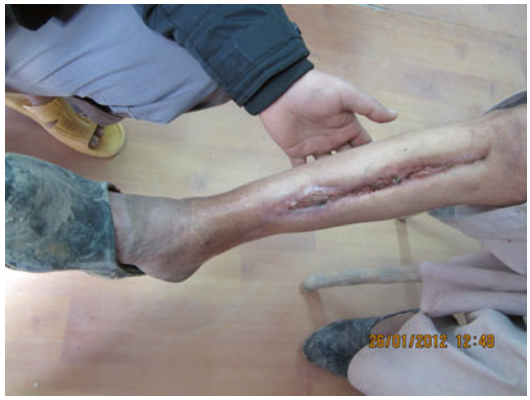

Fig. 14.1 This man had an open fracture of the tibia many years ago. The injury was probably mismanaged, sentencing him to a life with chronic osteomyelitis

acidosis and disruption of endosteal blood supply to the cortex.

At this stage the intramedullary abscess is painful and patients may present (acute osteomyelitis). If the host response (+/− antibiotics) is sufficient to arrest further bacterial proliferation and the abscess is 'walled-off', the infection may be remarkably well tolerated by the patient (subacute osteomyelitis) or indeed subside.

As the infection progresses, the pus follows the path of least resistance and flows out through the Volkmann canals and haversian system eventually emerging under the periosteum. The subperiosteal pus strips the cortex of its exosteal blood supply. As a result the cortical bone is completely cut-off from both endosteal and exosteal blood supplies, resulting in its death. This dead, devascularised bone is known as sequestrum.

The pus may track circumferentially around the bone, burst through the periosteum into the soft tissues or continue down the bone in an intramedullary fashion (Fig. 14.3). The elevated periosteum then begins to lay down new bone, surrounding the sequestrum. This new, reactive bone is called involucrum and is key to the maintenance of structural integrity of the affected bone. The sequestrum (dead bone) and involucrum (new bone) are the classical hallmarks of chronic osteomyelitis. If left untreated the sequestrum may undergo partial resorption, but often acts a nidus for persistent infection.

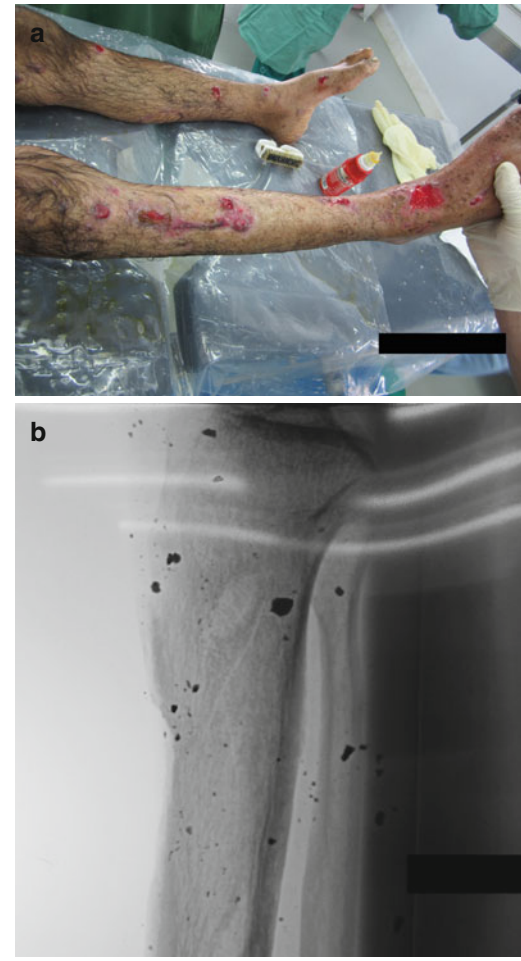

Fig. 14.2 (**a**) This young man was a casualty during a suicide bomber attack. Unfortunately, he developed multiple sinuses secondary to bone infection. (**b**) X-ray showing the shrapnel in the tibia

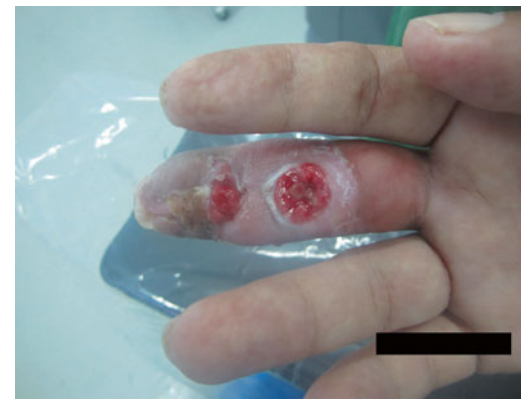

Fig. 14.3 Middle finger showing a draining sinus

14.2 Management ofOsteomyelitis: Review of the Evidence

High-quality research regarding osteomyelitis is sparse, with few prospective, randomised-controlled trials. However a recent systematic review of acute and subacute osteomyelitis has proposed the following recommendations [Level 1] [6]. In the early stages of acute/subacute osteomyelitis, medical treatment with initial intravenous antibiotics followed by a minimum 3-week oral course is advocated. Surgery is reserved for systemic sepsis, concurrent septic arthritis, failure to improve with antibiotics or pelvic abscess >2 cm [6].

The surgical treatment of chronic osteomyelitis is generally agreed [7, 8] [Level IV]. The removal of dead bone/sequestrectomy, debridement, drainage of pus and soft tissue care are the principals of infection control. The wider the margin of resection of the infected bone, the lower the recurrence rate [9] [Level III]. The role of antibiotics in treatment for chronic osteomyelitis (COM) remains a matter for debate. Some authors advocate that antibiotics should be used routinely [8], whilst others believe in selective antibiotic usage or only when patients are systemically unwell [2, 4] [Level IV]. Opinion on the treatment of bone defects also remains diverse [2] and is often influenced by surgical experience and availability of resources. From my own experience, bone defects should be addressed as simply as possible, with vascularised grafting and bone transport being more successful than non-vascularised graft options [10] [Level III].

14.3 Acute Osteomyelitis

Acute osteomyelitis (AO) typically presents with pain +/− malaise +/− fever and loss of use of the affected limb. This is sometimes attributed to trauma. Examination may reveal swelling, warmth and tenderness over the affected area. Blood tests (if available) may reveal high white cell count (WCC) and inflammatory markers – erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP). Plain radiographs are usually unremarkable. Magnetic resonance imaging (MRI) is the most sensitive and specific test, however is rarely available in the areas where osteomyelitis is most common.

Early treatment of AO is nonoperative. Blood cultures should be taken before starting antibiotics. Intravenous antibiotic for 3–4 days followed by an oral course for 3–6 weeks is advocated [6]. As *Staphylococcus aureus* is the most common organism [2], flucloxacillin is the most appropriate choice, with a low threshold for adding in benzylpenicillin to cover *Haemophilus influenzae*, especially for patients who have not received the Hib vaccine. Patients need to be monitored closely, and if there is no clinical improvement within days of starting antibiotics, surgery is indicated. Surgery is also indicated in the case of a systemic sepsis in a child, concurrent septic arthritis, failure to improve with antibiotics or pelvic abscess >2 cm [6]. If there is concern regarding access to antibiotics, compliance or attendance at follow-up, then surgery should be considered, as this gives the best chance of eradication of infection in the absence of suitable ongoing care. Importance of follow-up must be stressed to the patient, and their guardian, as prompt treatment of complications and recurrence greatly reduces the risk of developing long-term problems.

14.3.1 Surgery for AO

A longitudinal incision is made over the point of maximal tenderness/swelling. Careful soft tissue inspection and drainage of collection is performed. Drilling the bone over the affected area should reveal pus. Multiple drill holes can be joined to create a window 1–2 cm across to allow adequate lavage and drainage. Wounds may be closed primarily at a second procedure if the wound bed looks entirely healthy, though leaving them open to heal by secondary intention is the safer option. Antibiotics should be continued for at least 3 weeks to give the best chance of first time eradication of infection.

14.3.2 Tip

If a child presents with bone pain, specifically in the tibia, blood tests are not available and x-ray shows no changes, specifically assess for percussion tenderness over the point of pain. If this is present, treat for AO as described as above. If in doubt treat as AO and monitor.

14.4 Subacute Osteomyelitis

Subacute osteomyelitis (SAO) is described as bone infection with insidious onset of symptoms >2 weeks, mild to moderate pain, little or no functional impairment, no systemic symptoms, negative blood cultures and positive x-ray findings [11].

Examination may reveal a slight limp, swelling and tenderness but joint movement is typically normal. Blood tests may be normal or reveal mildly raised ESR, WCC and CRP. Cultures are typically negative. X-rays characteristically show a radiolucent lesion most commonly in the metaphysis or diaphysis, but may also be found in the epiphysis. Occasionally a nidus or periosteal reaction is visible [12].

Treatment is surgical as described for surgical treatment of AO. Histological and microbiology samples should be sent if these resources are available. Differential diagnosis for SAO includes primary bone tumours, TB and atypical infection (e.g., fungal).

14.4.1 Tip

Lesions close to the physis should be monitored carefully due to risk of growth arrest that can later cause angular limb deformity or limb length discrepancy.

14.5 Chronic Osteomyelitis

Chronic osteomyelitis (COM) is a bone infection that has been present for >3months. Patients present with pain and disuse of the affected limb. Usually, there will be discharging sinuses, occasionally an exposed bone. Systemically, the patient will be unwell, often malnourished and will have suffered stigmatisation as a result of their condition. Patients sometimes present with complications of COM such as pathological fracture, limb deformity, joint stiffness or septic arthritis.

On examination there are often discharging sinuses, old surgical wounds, healed wounds, joint contractures, muscle wasting, limb deformity/shortening and cachexia. Blood tests often reveal anaemia and mildly raised WCC, ESR and CRP.

X-rays performed reveal the extent of bony involvement. Over-penetrated films are most useful in identifying sequestrum present [13]. Typical x-ray findings include sequestra, involucrum, periosteal reaction, bone abscesses, sclerosis and deformity.

Cross-sectional imaging can be used if available. MRI is good at defining extent of inflammation and collections, whilst computed tomography (CT) is better at illustrating bony anatomy and localising sequestra. COM almost always requires surgical treatment and cannot be cured with antibiotics alone. Removal of all dead bone and thorough debridement of infected tissue is essential.

14.6 Preoperative Care and Investigations

Patients need to be thoroughly assessed preoperatively. A full history and examination is mandatory, as multiple pathologies often coexist. Multifocal osteomyelitis must be considered. AP and lateral x-rays of the affected limb need to be performed.

Blood tests are useful if available. The most important are:

- Haemoglobin – to assess for anaemia.
- Malarial parasites – concurrent infection needs prompt treatment.
- HIV – retroviral treatment will be required if positive.
- Sickle cell – will affect perioperative care. Tourniquets must not be used.

Antibiotics should be given to patients with systemic signs of sepsis, as well as fluids and oxygen, if available. The limb should be splinted if bony stability is compromised.

14.6.1 Preoperative Planning

Infection control is achieved through removal of all dead bone and infected tissues, dead-space management and care of soft tissues. COM is a disease of the bone, and therefore the bony component must be understood and addressed. Surgical planning should include identification of all active sinuses, examination of the joints above and below preoperatively to assess for septic arthritis and the identification of any soft tissue collections.

AP and lateral x-rays (over-penetrated ideally) are used to identify sequestra for removal and bone abscesses for curettage. The Beit CURE classification [14] is a radiological classification that is useful in the surgical planning of disease. Though less well known than the Cierny-Mader classification [15], it has been developed specifically for use in resource-poor environments and is a valuable tool in surgical planning as well as comparative research.

14.6.2 Surgical Equipment

Theatre equipment can be sparse and of poor quality, and often adaptation and improvisation of equipment is required. The following constitute a good basic instrument set:

- Scalpel
- Tissue forceps
- Needle holders
- Scissors
- Soft tissue retractors (Langenbeck/self-retainers)
- Periosteal elevator
- Elevator (Penfield/Freer/Watson Cheyne)
- Osteotomes
- Curette
- Bone drill (hand-powered/electrical)
- Bone nibbler (Rongeur)
- Dental hook/probe

14.7 Infection Control Surgery

Infection control goals of surgery:

- Dead bone removal/sequestrectomy
- Pus drainage
- Debridement
- Dead-space management/drainage of cavities
- Soft tissue care
- Bony stabilisation

A ‘social wash’ with soap and water is essential prior to formal skin preparation; an initial wash on the ward is also advised. A tourniquet can be used to control blood loss and give a dry field; however, this is not essential. It must be deflated before the end of the procedure however to assess bone viability, through observation of punctate bleeding.

The incision should be planned to allow adequate access to the bone with minimal disruption to the periosteum and its blood supply.

Where it is necessary to incise the periosteum this should be done longitudinally, hard down to the bone and be elevated as a continuous flap with as much soft tissue continuity as possible. Whenever possible, soft tissue cover of the bone should be preserved unless plastic surgical input is available.

To access the medulla for sequestrectomy, windowing is often necessary. Pre-op planning of windows is essential, and measurements from x-rays and relations of bony landmarks are useful. Windows are made through removal of a rectangular piece of bone. This is done with an osteotome. Drill holes can be also used to guide the passage of the osteotome and to prevent propagation of cracks past the desired site. Drills should only be used on a low speed to prevent thermal bone necrosis. No more than one-third the circumference of the bone should be removed in a window, to prevent fracture.

Abscess drainage can be performed by enlarging sinuses or drilling and windowing the bone as necessary. Curettage of cavities is essential to remove infected material. Thorough lavage of all wounds, curettage/excision of active sinuses is also required. Lavage using syringes with cathe-

ters/feeding tubes attached is a good technique as this allows focused washing and retrograde lavage of blind-ending cavities. Cavities often communicate, so it is possible to wash through one and out of another. Samples for microbiology should be sent where this facility exists.

When the sequestrum is identified, a plane between it and viable bone should be developed using an elevator or probe to loosen it, which can then allow removal in one complete piece using haemostats. There is controversy as to the timing of sequestrectomy in those cases where the sequestrum provides stability, when the involucrum is not structurally sufficient.

Some advocate leaving the sequestrum in place until the periosteum has laid down sufficient structural involucrum. The advantage of this approach is that the sequestrum is ideally located to provide structural support whilst waiting for involucrum to form. The disadvantage is that the longer the infected sequestrum remains in situ, the more likely the periosteum will be damaged, potentially jeopardising formation of quality involucrum.

Others advocate removal of the 'structural sequestrum' at the earliest opportunity, leaving a bone defect that requites stabilisation either with plaster or frame. The advantage of this approach is that infection control is achieved at an earlier stage, and this potentially protects the periosteum. The disadvantage is this destabilises the bone segment that then requires stabilisation. The jury is still out on this particular point.

However, if there no structural involucrum after 3 months of monitoring, then sequestrectomy should be performed, and the bone defect dealt with subsequently.

Similarly, if sequestrectomy is performed (leaving a bone defect), then the bone should be stabilised for 3 months to allow for formation of structural involucrum. If this does not occur, then bony reconstructive surgery is required.

14.8 Soft Tissue Management

Soft tissue management can be problematic in the treatment of chronic osteomyelitis. The affected limb often has multiple wounds and discharging sinuses. Wounds should be left open to allow free drainage following infection control procedures. Negative pressure dressing are effective devices in wound management but are not always available; local adaptations are however possible [16]. Honey dressings have been shown to be more effective than sugar dressing, and this is generally widely available even in the most austere setting [17]. Patients should be encouraged to position themselves so as to allow dependent drainage of their wounds. Daily washing of wound with soap and water is also advocated. Soft tissue cover with skin grafts/soft tissue flap is sometimes required.

14.9 Dead-Space Management

This refers to the management of the void that is left following resection/debridement of tissue. This can be managed by

- Free drainage – this allows the tissue to heal by secondary intention.
- Packing with swabs.
- Negative pressure dressings.
- Prosthetic spacer (e.g. cement spacer, antibiotic beads).
- Nonvascularised graft (e.g. Papineau technique, cancellous bone graft).
- Vascularised graft (e.g. rotational/free flap).

The vascularised graft is the gold standard as this covers defects with viable, infection resistant tissues. Nonvascularised grafting requires a sterile bed prior to grafting and is a surgically demanding option. Prosthetic spacers have been used to good effect to sterilise a cavity; however, they do require removal with further procedures. Negative pressure dressings are effective but can be difficult to source and maintain. Free drainage is easily achieved, but the scar tissue that forms is relatively avascular and therefore more susceptible to infection.

14.10 Bony Stabilisation

Bone infection is difficult to treat. Bone infection in the presence of instability is impossible to treat. Prior to surgery, bony stability need to be assessed

radiologically. There should be good quality cortical continuity in 3-out-of-4 of the cortices on the AP and lateral x-rays to ensure stability. If more than one-third of the bone is resected in any one segment intraoperatively, then the limb should be immobilised and weight-bearing restricted for 6 weeks, to manage the risk of fracture.

14.11 Bone Defects

Bone defects are present in 20 % of cases of COM [18] and can range from a pathological fracture to large segmental defects. The management of these is difficult. Infection control must be complete prior to reconstruction. Prerequisites to reconstruction surgery are fully healed skin, absence of sequestra on x-ray and no antibiotics for 2 months. Decision on the method of treatment of defect should be made depending on: patient age, defect size, viability of periosteum and physes, condition of soft tissues and coexisting deformity.

Treatment options include: plaster stabilisation, frame stabilisation, free fibula structural bone grafts, [staged] ipsilateral vascularised fibular graft, nonstructural [cancellous] bone graft, bone transport and amputation. The simplest method with a reasonable chance of success is the most appropriate choice. Options that involve vascular tissue (stabilisation, vascularised grafts and bone transport) are more infection resistant and more likely to succeed.

14.12 Postoperative Care

Patients should receive fluids and analgesia. All patients with systemic sepsis should be continued on antibiotics. Routine antibiotic prescription is not mandatory. The affected limb should be elevated to reduce swelling.

Post-op x-rays to ensure the entire sequestrum has been removed are essential. If sequestra remain in situ, then infection will persist unless it is removed. Dressings should be changed every 24–48 h, and patients and their carers should be educated as to wound management/hygiene from an early stage. If wounds are not settling, then further infection control procedures are required.

Patients should be encouraged to weight-bear (if appropriate) and move surrounding joints to try and prevent further muscle wasting, contractures and loss of bone density. Nutrition is vital to healing and prevention of reinfection. This should be assessed and addressed. Patients are often stigmatised due to their infection and can be excluded from social interaction and schooling. It is vital that this is addressed as best as possible as this can lead to long-term difficulties. Concurrent illnesses such as HIV, TB, malaria and diabetes need to be treated.

14.12.1 Follow-up

Early follow-up should be conducted to assess for infection control. Longer-term follow-up is desirable to monitor for recurrence of infection and complications such as contractures, fracture, deformity and growth arrest. Patients should be followed up for a minimum of 1 year, and if concern exists regarding growth arrest and deformity, then patients should be followed up until skeletal maturity.

14.12.2 Rehabilitation

Access to formal rehabilitation in austere environments is generally very limited. It is vital to educate patients as to their condition and rehabilitation goals whilst they are an inpatient or under medical care. The emphasis on follow-up is essential, as often patients will require further treatment.

14.13 Complications

Broadly speaking, these can be divided into infection related and musculoskeletal:

- Recurrent/persistent infection
- Septic arthritis
- Systemic infection
- Polyostotic osteomyelitis
- Joint contractures
- Muscle wasting
- Fracture

- Bone defects
- Angular limb deformity
- Growth arrest

14.13.1 Cautions

Though osteomyelitis is common in austere environments, other diagnoses need to be considered. Here are a few not to miss:

- *Bone infarction* – secondary to sickle cell disease. This can present in a very similar fashion to AO.
- *Bone tumours* (*primary and secondary*) – can present in a very similar fashion to osteomyelitis, and can have very similar x-ray appearances.
- *Malignant transformation* – this can occur in longstanding infection (e.g. Marjolin ulcers).
- *TB* – can cause atypical osteomyelitis/septic arthritis of a more indolent course.
- *Resistant/atypical bacteria* – though less common in the developing world, resistant bacteria (e.g. MRSA) can still occur. Atypical infections (e.g. fungal) are more prevalent due to host deficiencies and environmental factors.

14.14 Tutorials

14.14.1 Tutorial 1

An 8-year-old boy attends with a 6-month history of leg pain. He has the following x-ray (Fig. 14.4).

What is the likely diagnosis? [Subacute/chronic osteomyelitis]

What are the differential diagnoses? [Primary bone tumour]

The patient is systemically well and no blood tests are available, how would you treat him? [Initially 2–3 days IV, then minimum 3-weeks oral antibiotics and finally surgery if no improvement/lack of access to antibiotics.]

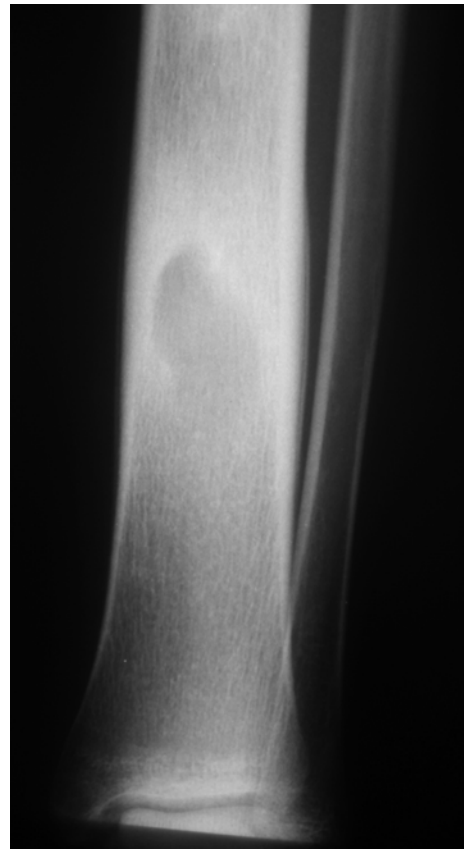

Fig. 14.4 X-ray of an 8-year-old boy with a 6-month history of leg pain

14.14.2 Tutorial 2

A 10-year-old girl presents with a year's history of malaise, leg pain and discharging sinuses. She has had two previous procedures performed. Her leg looks as shown in Fig. 14.5.

What can you identify? [Active sinuses, old surgical wound, healed wounds].

Her preoperative x-ray is shown in Fig. 14.6a. What are the 'classical features' that you can see? [Expanded tibia due to involucrum. Intramedullary sequestrum]

How has this been treated? [Sequestrectomy and debridement]

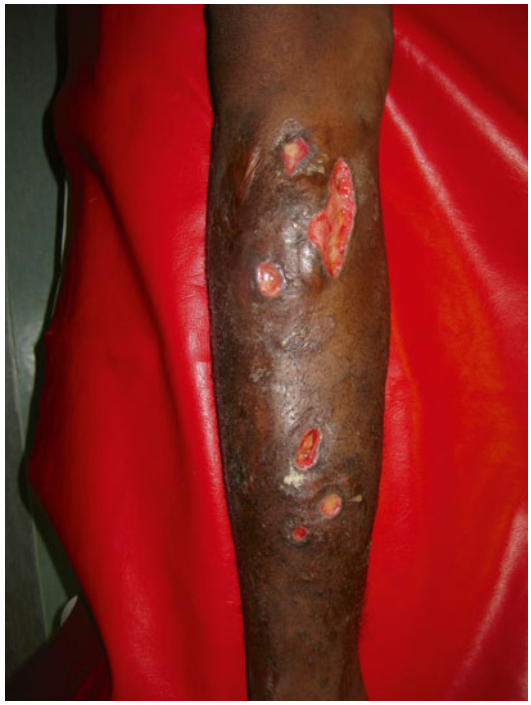

Fig. 14.5 A 10-year-old girl presents with a year's history of malaise, leg pain and discharging sinuses

The intraoperative picture shows the yellow sequestrum surrounded by the healthy looking 'pinkish' involucrum (Fig. 14.6b). Figure 14.6c shows the same field post sequestrectomy. Note the windowing of the bone and the creation of an intramedullary trough. Figure 14.6d shows the removed sequestrum. This x-ray (Fig. 14.6e) has been taken post-op. Note the creation of a window in the medial border of the tibia and the absence of the sequestrum evident on the previous x-ray. Always take a post-op x-ray to assess completeness of sequestrectomy.

14.14.3 Tutorial 3

A boy presents after a 2-year history of illness, leg pain and previously discharging sinuses. He has had no discharging wounds for 6 months but he is now unable to fully weight-bear. His x-ray is shown (Fig. 14.7).

What can you see? [Bone defect of the middle one-third of the tibia. Note the hypertrophied fibula.]

He undergoes an operation. What are the requirements before performing a reconstruction procedure? [Fully healed soft tissues, absence of sequestra on x-ray and no antibiotics for 2 months.]

What procedure has he had (Fig. 14.7b)? [Contralateral free fibula graft with ipsalateral fibula osteotomy and augmentation] What other procedures would have also been acceptable? [Ipsalateral, vascularised or staged fibula graft. Bone transport.] He requires plaster immobilisation for many months but goes on to heal (Fig. 14.7c).

14.15 Summary

Osteomyelitis is a common condition in resource-poor countries. Successful treatment is demanding. Surgery should be focused on a thorough debridement. Patient education about dressings, wound management and follow-up is essential.

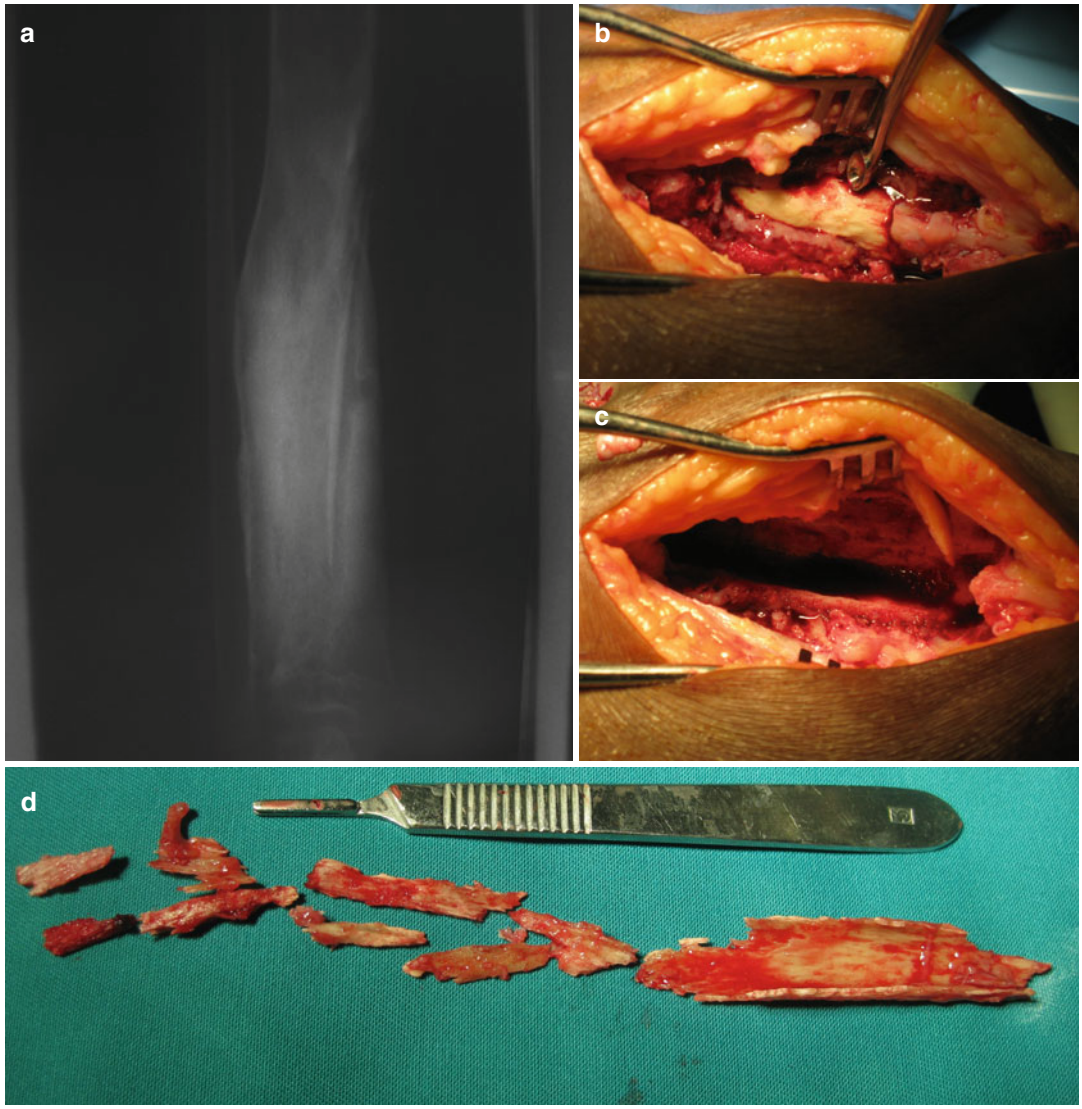

Fig. 14.6 (**a**) The preoperative x-ray of the patient's leg from Fig. 14.5. (**b**) This intraoperative picture shows the yellow sequestrum surrounded by the healthy looking 'pinkish' involucrum. (**c**) This picture shows the same field post sequestrectomy. Note the windowing of the bone and the creation of an intramedullary trough. (**d**) This is the removed sequestrum. (**e**) Postoperative x-ray. Note the creation of a window in the medial border of the tibia and the absence of the sequestrum evident on the previous x-ray

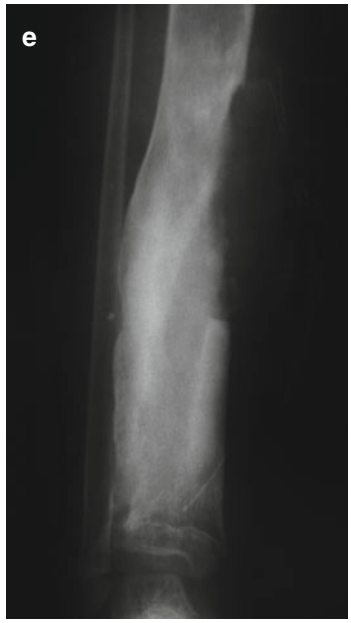

Fig. 14.6 (continued)

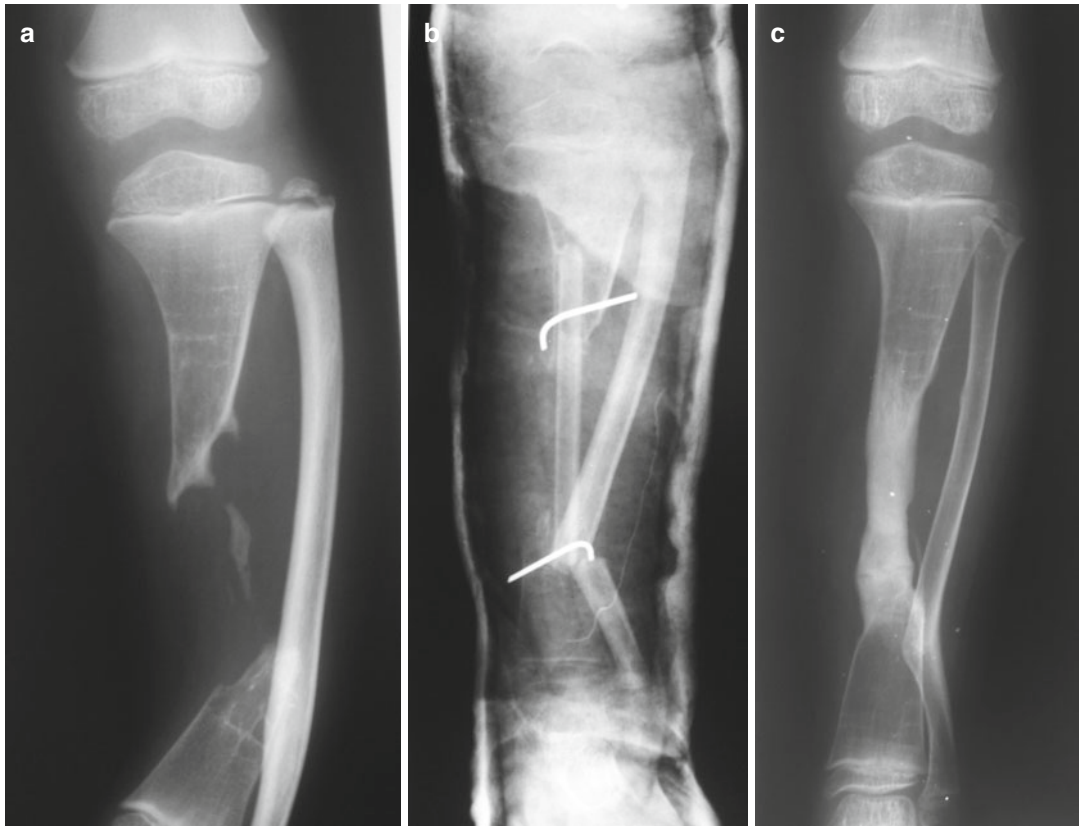

Fig. 14.7 (**a**) X-ray of a boy who presented after a 2-year history of illness, leg pain and previously discharging sinuses. (**b**) Contralateral free fibula graft with ipsalateral fibula osteotomy and augmentation has been performed. (**c**) X-ray after healing

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