Part I

Orthopaedics

Chapter 1

Principles of orthopaedic surgery

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Introduction

In this chapter we will explore some of the more recent developments in orthopaedic surgery, in particular, those aspects that form the basis of everyday practice. In recent years there has been a rapid expansion in the treatment options available to people with musculoskeletal disease. This has resulted from the development of safe anaesthesia, improved engineering of implant materials and refinement of surgical techniques. With this improvement, a greater emphasis has been placed on the person's recovery from surgery which, in turn, has led to the development and importance of rehabilitation and the multi-disciplinary approach to people's care.

History and early development

Orthopaedics derives from the Greek words 'straight' and 'child' and was a term described by Nicholas Andry (1658–1759) in his book *Orthopaedia: or the Art of Correcting and Preventing Deformity*. Much of the early practice of orthopaedics was concerned with the correction of deformity. More recently, as our population age has changed, the conditions that form part of our everyday practice have changed too. To mention all the important developments in the process of orthopaedic history would be exhausting, but some names of interest follow.

Ambroise Pare (1510–1590) was a prominent surgeon in France in the sixteenth century and published on anatomy and physiology and later on surgery. He described a number of surgical techniques relating to amputation such as the use of ligatures for large vessels, and tourniquets. He also designed a number of surgical instruments and artificial limbs. At times of conflict, limb amputations were common and often the only treatment for limb injury and deformity. Limb amputation skills were displayed with amazing speed and precision in experienced hands.

Antonius Mathysen (1805–1878) invented the plaster of Paris (POP) bandage which remains part of everyday orthopaedic and trauma practice. Little has changed in the

principle of this form of splintage since its creation and only some of the indications have been altered to keep up with alternatives offered by surgery. Joseph Lister (1827–1912) became James Syme's (of Syme amputation fame 1942) house surgeon and later married his daughter. While working as assistant surgeon to the Royal Infirmary in England he introduced antisepsis, which had a dramatic effect in reducing infection, and infection related mortality. This paved the way for further developments in surgical techniques and is a crucial part of successful surgery and specifically to orthopaedic surgery today. Wilhelm Conrad Rontgen (1845–1923) was a professor of Physics at Wurzburg and discovered roentgen rays (X-rays). The first radiograph taken was of his wife's hand and this was allegedly offered to her as a Christmas present. Something he may not get away with today! In 1901 he received the Nobel prize for his work in this area.

Gathorne Robert Girdlestone (1881–1923) was the first professor of orthopaedics in Britain and has a long association with a number of prominent centres, including the Nuffield Orthopaedic Centre in Oxford. His technique of excision arthroplasty of the femoral head is a procedure now used mainly as a salvage procedure after failed hip replacement and carries his name. Originally it was commonly used to treat hip tuberculosis prior to the advent of antibiotic therapy and joint replacement surgery. In 1942, an American, Austin Moore (1899–1963), performed and reported the first metallic hip replacement. Although it involved replacing the entire upper portion of the femur with a vitallium prosthesis, this was the start of a rapid development in better designs and techniques. Sir John Charnley (1911–1982) improved the design of the total hip replacement and was also involved with the development of self-curing acrylic cement. Many of the hip joint arthroplasties performed in the 1960s by him are still surviving well. It is open to debate as to whether his excellent design was luck or brilliance, but it was to form the benchmark for total hip replacements for the next 40 years.

Other centres such as Exeter have now proven results of joint replacement while those such as Birmingham are in the early stages of producing promising long-term results with newer designs. The Birmingham hip resurfacing arthroplasty, designed by Derek McMinn and colleagues at the Royal Orthopaedic Hospital in Birmingham in the early 1990s has had widespread interest due to a successful return to early design principles but now with better manufacturing techniques and better results. Other designs of this metal on metal resurfacing arthroplasty have followed and these types of replacement are now widely used throughout Europe, the USA and Canada.

Although huge strides have been made in the past century in the field of orthopaedics, it is expected that similar ongoing advances will continue to be made. Developments in cartilage replacement options hold promise as alternatives to joint replacement and there is continued development in the field of stem cell research. These and many others offer tremendous therapeutic options for an ever-increasing population of people with orthopaedic problems.

Prevention of infection

Prevention and management of infection in orthopaedic surgery has been one of the most important advances over the past century, which has allowed rapid development in our practice. Over 70% of hospital-acquired infections occur in people who have undergone surgery and these lead to considerable morbidity and rise in surgical costs.

Treatment of infection in bone can be very difficult, and following implant surgery even more of a challenge, and so the prevention of infection is where we place a great deal of our efforts.

Definitions

- **Decontamination** – a process of removing microbial contaminants which can be carried out by cleaning, disinfection or sterilisation.
- **Cleaning** – a process that removes visible contaminants but does not necessarily destroy microorganisms.
- **Disinfection** – reduces the number of viable organisms to an acceptable level but may not inactivate some viruses, hardy organisms such as mycobacteria, or spores. A topical disinfectant that can be safely applied to epithelial tissue (like skin) is called an *antiseptic*.
- **Sterilisation** – this involves complete destruction of all viable microorganisms, including spores, viruses and mycobacteria. This may be accomplished by heat, radiation or chemical means and often the choice depends on the nature of the material being sterilised.

Prevention strategies

Handwashing has been shown to be the single most important method of controlling the transmission of hospital-acquired infection, as organisms are passed from one person to the next via staff caring for them. Washing the hands before and after physical contact with people and after activities where they are likely to become contaminated cannot be overemphasised.

Soaps, detergents or alcohol-based agents are now commonly provided in areas such as wards, clinics and outpatient departments where staff come into direct contact with people. A set of 'universal precautions' are typically taught and are available as a way of reminding staff of ways to prevent the transmission of infection. These include instructions on wearing gloves, dealing with wounds, sharp instruments and contaminated products. All staff should make themselves familiar with local policies and guidelines relating to these.

Screening of at-risk patient groups is important especially in the more controlled environment of planned or elective surgery. Organisms that can be detected and controlled, such as methicillin-resistant *Staphylococcus aureus* (MRSA), are important to detect prior to high-risk surgery and particularly in implant surgery. It is advisable to isolate a person found to be carrying these organisms so as to prevent the transmission to other people in the ward.

Antibiotics are used routinely in implant surgery and have been shown to reduce the risk of postoperative wound and deep infection. Broad-spectrum prophylactic antibiotics given prior to starting the surgical procedure are required for implant surgery and the choice of antibiotics is often dependent on local microbiological guidelines. The widespread use of antibiotics in all clinical settings, however, has led to certain organisms becoming resistant to various agents, for example:

- MRSA
- Vancomycin-intermediate *S. aureus* (VISA)
- Vancomycin-resistant *Staphylococcus epidermidis* (VRSE).

The appropriate use of antibiotics, however, is an essential part of prevention of infection in orthopaedic surgery.

Theatre strategies include sterile gowns, drapes, double gloves, and the use of masks and caps. Air-borne bacteria are a source of postoperative sepsis and now laminar-flow ventilation systems in theatres are becoming the norm to supply ultra-filtered air to the operative field and thereby reduce infection. Evidence exists to show that the use of ultra-clean air conditions will reduce the incidence of deep periarticular infections by half (from 3.4% to 1.6%). The addition of antibiotics will further reduce this to 0.19%. This is of particular benefit in prosthetic implant surgery (Lidwell et al. 1987).

All staff in contact with the operative field or instruments involved in surgery are required to disinfect their hands prior to placing sterile gloves on for surgery. This is aimed at reducing the volume of viable organisms, which may otherwise contribute to postoperative infection. A number of preparations are available, and many are alcohol or iodine based.

The surgical area is prepared with an **antiseptic solution** and care is taken that nothing contaminates this during surgery. Sterile drapes are used and all instruments used are sterilised to ensure no viable organisms are likely to contaminate the operative field.

Main conditions, diagnosis and treatment principles

Osteoarthritis

Osteoarthritis is a non-inflammatory degenerative joint disease. It is characterised by loss of articular cartilage and associated with new bone formation and capsular fibrosis that results when chondrocytes fail to repair damaged cartilage. The causes fit into two broad groups:

- **Primary/idiopathic** – no obvious cause
- **Secondary** – identifiable cause:
  - Previous trauma
  - Congenital deformity
  - Infection
  - Metabolic disorders.

Typically this condition is progressive and results in pain and stiffness in the joint involved. This may lead to:

- Alteration of limb length
- Fixed deformity in the joint limiting movement
- Progressive wasting of muscles as the limb is used less.

People who experience symptoms and signs of non-inflammatory arthritis have the clinical diagnosis confirmed with X-rays. Radiological signs include (Figure 1.1):

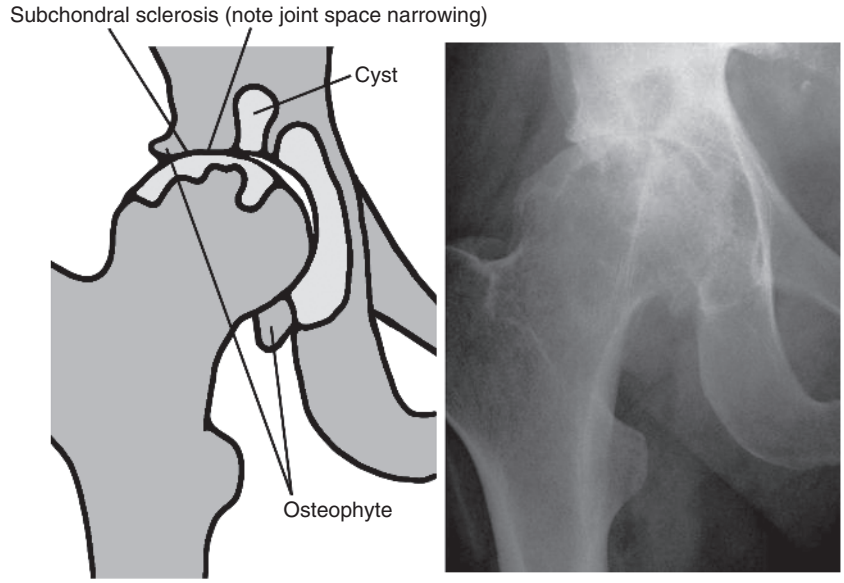

Figure 1.1 Radiological signs of osteoarthritis.

- Joint space narrowing – initially at maximal load area before progressing to the entire joint
- Development of osteophytes as the joint endeavours to repair itself
- Subcortical/ subchondral sclerosis indicated by thickening of the bone below the joint surface
- Subchondral pseudo-cyst formation.

Initially treatment should always involve conservative/non-operative options. Once non-operative measures have been exhausted, surgery may be considered. The non-operative/ conservative measures recommended are:

- Protection of joint overload by achieving weight loss and using walking aids
- Exercise of supporting muscles to avoid wasting and prevent stiffness
- Pain relief in the form of analgesics and anti-inflammatory drugs
- Intra-articular corticosteroid injections
- Intra-articular hyaluronic acid injections (Snibbe and Gambardella 2005)
- Glucosamine and chondroitin (Richy et al. 2003).

Operative measures (for people with persistent pain and symptoms despite conservative measures) include:

- Arthroplasty – unicompartmental or total joint arthroplasty
- Realignment osteotomies in younger persons.

Some treatments are being used but do not yet have convincing evidence to prove their benefit and at this stage should be considered experimental. For example, soft tissue grafts, such as:

- Chondrocyte transplants (Bentley et al. 2003)
- Mosaicplasty (Bentley et al. 2003)
- Fresh osteochondral grafts (Ma et al. 2004)

As this condition is such a large part of everyday practice in orthopaedics, it is also part of massive financial investment into newer forms of treatment, many of which do not have good evidence to prove their benefit. These do form an essential part of the on-going development of our practice but must be used in controlled environments and with caution.

Rheumatoid arthritis

Rheumatoid arthritis (RA) is a chronic systemic autoimmune disease with an unclear aetiology and a number of joint sequelae. The symptoms are that of an inflammatory arthritis and typically the person experiences acute or chronic episodes throughout their life. Much of the treatment is aimed at controlling the condition and preventing the chronic changes usually associated with RA. Early aggressive medical treatment can control the condition and limit joint damage and thus prevent or limit the chronic disability typically associated with rheumatoid arthritis in the past.

Usually RA progresses through three stages:

(1) Swelling of the synovial lining of the joint causing warmth, redness, joint swelling and pain
(2) Rapid division and growth of cells resulting in pannus formation/thickened synovium
(3) Damage to the cartilage and bone by the inflammation, throughout the joint causing stiffness, pain and deformity typical of the end stage.

Rheumatoid joint disease

Symptoms should be considered as either systemic or local to the joint. They are typically symmetrical and can affect any joint, although most commonly begin in the smaller joints of the fingers, hands, and wrists. People with RA are more susceptible to infection. Systemic symptoms include:

- Fatigue
- Early morning stiffness or stiffness after rest
- Flu-like symptoms
- Rest pain
- Flares in symptoms followed by disease inactivity
- Rheumatoid nodules (occur in one-fifth of patients)
- Loss of appetite, anaemia, weight loss
- Sjögren's syndrome – involvement of the glands around the eyes and mouth causes decreased production of tears and saliva.

Diagnosis of RA is based on a collection of information rather that one specific test. This includes the person's history, clinical examination, laboratory tests and radiological investigations; specific criteria must be met before a diagnosis is made.

Current treatment methods focus on relieving pain, reducing inflammation, slowing or preventing joint damage, and improving function. Medication/therapeutic categories are based on those that are aimed at controlling the progression of disease and those aimed at symptomatic relief.

- **Non-steroidal anti-inflammatory drugs (NSAIDs)** – reduce inflammation, pain and fever. A side effect is an increase in bruising and bleeding and care should be taken when handling patients with RA.
- **Analgesic drugs** – relieve pain.
- **Corticosteroids** – low doses to reduce inflammation and to prevent joint damage. These may be administered systemically or as local intra-articular injections. Oral steroids should never be stopped abruptly.
- **Disease-modifying anti-rheumatic drugs (DMARD's)** – used in combination with other drugs to slow joint destruction over time, e.g. methotrexate, penicillamine, azathioprine. Care needs to be taken due to known side effects and drug interactions.
- **Immunotherapies** – such as anti-tumour necrosis factor (TNF) drugs. These are biological agents and immunoactive drugs, which principally inhibit cytokines in the immune system to control inflammation. There are no long-term studies that have looked at the effects of these on disease outcome.
- **Alternative therapies** – many people may have been given advice, or may have done their own research, on alternative therapy strategies. Although there may not be good evidence to support many of these, an open mind should be kept regarding those which people choose to take. Medical practitioners should be careful not to advise on therapies unless they are knowledgeable or trained in this field.

We now know that combination therapy is usually most effective in controlling the disease and therefore a person will usually be on more than one form of medication. However, despite medication and orthoses, many people will eventually require some form of surgery and techniques often used are:

- **Synovectomy** – to reduce the amount of inflammatory synovium in the joint. This can usually be performed arthroscopically or as keyhole surgery in the knee, but as an open procedure in other joints. Imminent tendon rupture in the hands is best treated with early synovectomy rather than later reconstruction (Gibbons et al. 2002; Ryu et al. 1998).
- **Joint replacement/arthroplasty** is used when pain is not controlled by medication alone and a person is limited in their movement. Typically partial replacement of joint (e.g. unicompartmental knee replacement or hemiarthroplasty of the hip) is not suitable as the whole joint is involved in rheumatoid arthritis.
- **Arthrodesis/fusion** can be used to control pain although it does prevent movement in the joint. This is more commonly employed in the foot and ankle.

Osteomyelitis

Osteomyelitis is an acute or chronic infection of the bone, which is usually caused by bacteria. In children the source of infection is typically via the blood (haematogenous) from another site in the body in the form of a bacteraemia or septicaemia whereas in

adults the source is usually exogenous (e.g. after trauma or surgical intervention). Risk factors for development of osteomyelitis include:

- Local trauma, such as open fractures
- Previous orthopaedic surgery
- Diabetes mellitus
- Immunosuppression, such as in RA, chronic steroid therapy, human immunodeficiency virus (HIV)/acquired immune deficiency syndrome (AIDS) or chronic illness
- Drug misuse
- Malnutrition.

In children, the presentation is early and symptoms typically occur before radiological signs. Haematogenous spread may occur to any bone but the vertebral bodies are the most commonly affected. Symptoms and signs of acute osteomyelitis include:

- Systemic
  - Fever
  - Malaise
  - Weight loss
  - Sweating
- Local
  - Swelling
  - Redness
  - Heat
  - Drainage of pus through the skin
  - Pain and local tenderness with muscle spasm.

History taking and examination should elicit the symptoms and signs and the diagnosis can be confirmed by further special laboratory and radiological investigations.

Laboratory investigations are aimed at evaluating the systemic response to infection and include full blood counts, C-reactive protein levels (CRP), and erythrocyte sedimentation rate (ESR). Blood cultures may offer a microbiological diagnosis prior to commencing antibiotic treatment and are positive in up to 50% of people tested. These may also be used to monitor the response to treatment.

Radiological investigations include radiographs of the affected bone although in acute infection there may be a delay in radiographic appearances of up to ten days. Ultrasound may be useful in the early stages in children with increased fluid in an affected joint and periosteal lift-off from an affected bone. Magnetic resonance imaging (MRI) (almost 100% sensitive) and computed tomography (CT) can be used to provide additional information regarding the diagnosis and extent of spread; these investigations can also aid in aspiration procedures to gain a microbiological diagnosis prior to commencing antibiotic therapy. Two conditions, which may often feature in the differential diagnosis are malignancy and tuberculosis (TB) and should always be considered, especially if the history is not typical. Although TB is uncommon in developed countries its incidence is increasing with increases in population migration and immunosuppressive illnesses such as HIV.

Treatment strategies are aimed at either suppression or eradication of the infection. One of the difficulties in dealing with bone infection is that penetration of antibiotics

into bone is often limited and the environment of dead tissue further inhibits antibiotic penetration and activity. Bacteria can then live for prolonged periods causing recurrence of infection years after the initial infection is treated.

Eradication therapy may involve a combination of prolonged antibiotic therapy, together with surgical debridement. Debridement implies the removal of all dead material from the infection site as well as any foreign material (such as joint replacements). When involvement is extensive, surgery may result in large areas of bone loss, which will require further surgical correction when the infection is eradicated.

Septic arthritis

Joint infection is an important but less common cause of acute joint pain and is of vital importance to diagnose and treat early. A delay in the diagnosis can lead to rapid irreversible joint destruction and therefore treatment should be considered a surgical emergency. It is most common in the larger joints, and particularly in the adult it is often seen in the hand joints following hand trauma and in the foot in conditions such as diabetes mellitus. The clinical features in the infant are considerably different from those in adults, but here we will consider them together.

Symptoms and signs include:

- Children:
  - Septicaemia – which may be indicated by lack of progress, presence of septic focus such as umbilical stump infection, cyanosis with feeding, irritability or pyrexia
  - Failure to thrive
  - Local infection may be obscured by antibiotics given for another cause
  - Joint pain, swelling or lack of movement of the limb. The joint takes on the position of greatest capacity (hip: abduction, flexion, external rotation; knee: 20° flexion).
- Adults
  - Loss of joint motion due to pain
  - Swelling and joint tenderness
  - May have underlying rheumatoid or joint disease
  - Constitutional symptoms of fever, malaise, decrease in appetite
  - These may be absent in older patients or in patients taking steroids.
- Look for septic focus or history of recent illness.

In a child a high index of suspicion is required so as not to miss the diagnosis, whereas in the adult a clear history may steer one onto the correct path to a good clinical examination and then special investigations. Laboratory investigations are similar to those used to diagnose acute osteomyelitis but joint aspiration is essential to acquiring a microbiological diagnosis before starting antibiotic treatment. Aspiration of the knee is easy to perform in the clinic setting. As access to the hip is more difficult, the assistance of a radiologist may be required as an ultrasound-guided aspiration may be useful. This is particularly the case in a child, whereas in the adult this may simply be done under X-ray guidance.

Establishing the diagnosis early is crucial as the differential diagnosis may include much less serious conditions:

- Trauma
- Acute osteomyelitis
- Rheumatic fever
- Transient synovitis
- Gout
- Acute rheumatoid flare.

The treatment of this condition should always include a washout and antibiotics. The antibiotic course may be prolonged. When septic arthritis is complicating a joint replacement or other surgery involving a prosthesis or metal work, it may only be possible to clear the infection by removing the metal component.

Avascular necrosis

Avascular necrosis (AVN)/osteonecrosis/aseptic bone necrosis refers to a condition of bone cell death following loss of the blood supply. Although potential causes are multiple and in 25% not clearly defined, they more commonly include:

- Trauma
- Joint dislocation
- Steroid use
- Perthes' disease
- Fractures
- Heavy alcohol use
- Deep sea diving (Caison's disease) (Kenzora and Glimcher 1985).

Very often the true pathogenesis is unclear but the result is ischaemia at a cellular level followed by cell death and then a period of attempted repair, which may take place to varying degrees. Diagnosis can be difficult and early radiological features may be indistinguishable from other conditions. X-rays are therefore often of limited use. The advent of MRI has made the diagnosis much easier and features on MRI scan are typically present much earlier in the disease process.

Treatment is generally aimed at either helping the bone to repair itself or protecting the affected bone while the remodelling process occurs. When the diagnosis is made late or the remodelling process is inadequate, additional procedures may be required, aimed at reducing the pain in associated degenerated joints. This may take the form of fusion procedures, realignment operations or joint replacements and often depends on the joint affected and the age of the patient.

Bone grafting

Bone grafting involves the implantation of bone into an area of the skeleton for a specific surgical need. The sources of bone graft and surgical situations are mentioned in the list below but ultimately the aim is to encourage new bone formation.

Definitions

- **Autograft –** tissue grafted from one part of the body in the same individual to another part of the body in that individual (e.g. bone from the hip placed in the femur).
- **Isograft –** graft taken from a donor who is genetically identical to the recipient (tissue from one identical twin to another).
- **Allograft/homograft –** a graft of tissue from one individual to another of the same species with a different genotype (i.e. not from an identical twin).
- **Xenograft –** a graft of tissue taken from one species to a different species such as from a pig to a human.

There are a number of situations where bone grafting may be useful in orthopaedic and trauma surgery:

- Bone loss following trauma, infection, previous surgery where a space needs to be filled
- Delayed union/non-union of fractures, where bone with its various bone morphogenic proteins (BMPs) can be introduced into the site of poor healing to stimulate the formation of new bone
- Structural support in a bone defect such as revision joint replacement or a depressed articular surface in tibial plateau fractures
- Large bone defects where a large element of the bone is missing and another bone is harvested to bridge the defect/provide support and take over the function of the missing bone (bone tumours resulting in a large resection of bone such as vascularised fibular grafting following femoral resection for osteosarcoma)
- Encourage bone formation in arthrodesis/fusion surgery.

Most commonly autograft, and then specially prepared allograft, is used as this provides the least possible risk of tissue rejection. When only small amounts of bone are required, this can be harvested from the patients themselves with ease. This has the benefit of providing living tissue with all the bone stimulating factors that come with it. The iliac crest, distal femur, distal radius and fibula are commonly sources of donor bone tissue. Bone grafting is not without complications, however, and the risk of pain, nerve injury and infection are some of the things that must be taken into account when considering this procedure. This has led to research into newer bone substitutes being developed. Many of these are used purely for the structural element but some have the addition of bone stimulating proteins and other substances to encourage bone formation and therefore the additional benefits usually only provided with autograft.

Bone tumours

By far the most common tumour found in bone is that of a secondary deposit from a primary tumour elsewhere in the body. Typically malignant spread from lung, breast, kidney, prostate and thyroid occurs to bone but more uncommon metastatic tumours and haematological malignancies may also be found. We will mainly deal with primary bone tumours in the following text but for detail on specific tumours, the reader is referred to the recommended reading at the end of the chapter. Bone tumours are classified as follows:

- Benign:
  - Osteoid osteoma/osteoblastoma
  - Chondroblastoma
  - Enchondroma
  - Chondromyxoid fibroma
- Malignant – primary:
  - Osteosarcoma – 35%
  - Chondrosarcoma – 25%
  - Ewing's sarcoma – 20%
  - Spindle-cell sarcoma – 15%
- Malignant – secondary
  - Especially from bronchus, breast, prostate, kidney, thyroid
  - Haematopoietic tumours of the bone
  - Lymphoma
  - Plasmacytoma or myeloma.

People typically present with pain, which may occur with movement but also occurs with rest and at night. They may develop swelling and reduction of muscle bulk as the limb is used less. Systemic features of a tumour may exist, such as weight loss, anaemia, lymph node swelling, malaise, or those symptoms related to the primary elsewhere in the body. Temperature and sweating may suggest Ewing's sarcoma, but, of course, are also part of the clinical spectrum of infection and thus form part of the differential diagnosis. It is not unusual for the history to relate to a particular sporting or trivial injury and this risks a delay in diagnosis as health professionals, while treating it as a minor sporting or musculoskeletal injury, follow a conservative approach. (Musculo et al. 2003).

The first presentation may be of a pathological fracture or it may even be a coincidental finding. Following a good history and clinical examination some special investigations will offer further assistance in clarifying the diagnosis. Radiographs of the affected limb are mandatory and if concern is raised that a tumour is present then a chest radiograph should also routinely be requested. Tumours may be bone forming or bone destroying in nature. Further screening blood tests are aimed at diagnosis of the specific lesion and also to search for other causes, bearing in mind that bacterial osteomyelitis and TB infection should always form part of the differential diagnosis. Full blood counts, ESR, CRP and biochemical profiles are routine. If one is considering prostate carcinoma in men, then a prostate specific antigen (PSA) level is necessary and in older people being screened for myeloma, protein electrophoresis is requested. In searching for a primary tumour, a CT scan of the bone and other body regions can be useful and an MRI can determine the extent of the lesion within the bone. MRI is also the study of choice for soft tissue lesions and when the extent of soft tissue involvement is to be evaluated. Unless the diagnosis is certain, a biopsy is obtained for confirmation of the diagnosis and to assist in staging and planning surgery. When a specialist centre is available, this is best done under the supervision of an experienced surgeon or radiologist. Staging of tumours is necessary to determine the prognosis. The various prognostic factors used to define tumour stage include:

- Location and relative size
- The presence or absence of regional or distant metastases
- The histologic grade of the tumour.

Good histopathological and microbiological expertise is vital. In children cytogenetic samples can be useful and this requires the necessary backup to be available. Once staging is complete, a treatment plan can be devised and this is specific for the tumour type.

The three modalities available to treat bone tumours are chemotherapy, radiotherapy and surgery. The tumour variety will dictate the regimen and timing of surgery. Osteosarcoma for instance responds to chemotherapy which is offered prior to surgery and again following excision whereas chondrosarcomas do not respond to chemo- or radiotherapy and complete excision is the treatment offered. Ewing's on the other hand is treated by a combination of chemotherapy and surgical resection and if the response is incomplete it is treated with radiotherapy. Following surgical resection of a tumour, consideration must be given to reconstruction if necessary. Excision also often involves an envelope of soft tissue (muscles, tendons, etc.) which is important in ensuring a good prognosis and minimising recurrence; this will also be important in the reconstructive options available (Les et al. 2001). Endoprostheses, vascularised fibula grafts, bone grafts in combination with muscle flaps are options and good plastic surgical backup is often a prerequisite to satisfactory treatment. When the tumour is a secondary deposit, the aim of surgery in these circumstances is to improve the person's function to as near to normal as possible, to control pain and the treatment or prevention of pathological fractures. Plates and screws are seldom adequate as the bone is not expected to heal and therefore bridging of the diseased part of the bone with an intramedullary device is often required. A number of other devices are available and the best option depends on the specific site and tumour being treated. The life expectancy of a person presenting with a secondary metastatic lesion to the bone is 12 months in the UK but this is worse in people with lung metastasis and much better in carcinoma of the breast and kidney.

Nerve injury

Nerve injury is a common presentation of trauma but unfortunately is also a realistic risk following a number of therapeutic interventions and surgical procedures. In trauma the risk of an associated neurological injury increases in open injuries but even in closed injuries may occur at the time of injury or later from conditions such as compartment syndrome.

Aetiology of nerve injury may include:

- Trauma
- Metabolic
- Malignancy
- Toxins
- Thermal
- Infection
- Scarring
- Callus in fractures
- Ischaemia
- Arteriovenous malformations.

Some terms to be familiar with, which provide a useful classification, are as follows.

- **Neuropraxia** – this is a physiological interruption in function in a nerve that is anatomically intact. The axons remain intact but conduction stops because of segmental demyelination. The lesion is transient and full spontaneous recovery is expected within weeks to months.
- **Axonotmesis** – in this lesion the axons are separated and this results in the distal end of the axon degenerating by a process called Wallerian degeneration. Because the myelin sheath remains intact, the nerve regenerates along the previous path and recovery is likely, although slow. Sensory recovery is better than motor.
- **Neurotmesis** – this is complete transaction (by neurotmesis) of the nerve such as would occur in a surgical transection. There is a limited ability for nerve regeneration in peripheral nerves if the two cut ends are brought into apposition as would occur with surgical repair. Even after a good repair, only partial recovery can be expected.

Following an injury, the nerve goes through four pathological phases:

- Retraction
- Inflammation
- Degeneration – *retrograde* (primary) to the next proximal node of Ranvier but histologically the same as Wallerian; *Wallerian* (secondary) distal to point of injury
- Regeneration.

Diagnosis requires a good knowledge of the nerve anatomy and testing of the motor, sensory, and autonomic function of the nerve involved, bearing in mind that different signs are present during the various stages of the nerve injury process.

Although a good history and clinical examination may provide most of the information necessary to determine the type of injury present, when there is doubt, further information may be provided by neurophysiological studies. These are best performed two to three weeks after injury to distinguish a neuropraxia from an axonotmesis/neurotmesis. This therefore may provide useful information on the extent of the lesion and also the prognosis but prior to this has a limited role. Usually neurophysiological testing is reserved for those injuries which at six to eight weeks are not showing the recovery that was expected. MRI investigation of nerves is currently a research tool. Surgical exploration early in the course of a lesion may however be of more use, in that a conclusive diagnosis will be provided and repair may be undertaken at the same time. This is particularly true in trauma where neurotmesis is more likely and in this situation early repair is likely to be easiest and provide a better long-term result. When there is a delay to surgery, retraction often makes primary repair impossible and nerve autografts are considered. This of course means loss of a nerve elsewhere and also is not always as successful as could be expected if the repair was performed early.

Following repair it may be necessary to protect the soft tissues and the repair, and splinting may be required. This may also be necessary for the associated injuries and much of the treatment relies on good rehabilitation support while recovery occurs. When repair of the nerve is not achievable the emphasis may shift to tendon transfers to improve joint movement and prevent contractures or procedures directly aimed at the control of pain secondary to nerve injury.

Surgical approaches to symptomatic joint disease

Joint disease forms a prominent part of general orthopaedic practice and as the population ages this becomes even more the case. Conditions of the joints are not confined to older people, and this should become clear in the following chapters.

Surgery in the young is very often aimed at preventing the later development of joint degeneration such as in developmental dysplasia of the hips (DDH) and creating mobile painless joints. In older patients, however, surgery is usually reserved for failure of medical control of painful degenerative changes or inflammatory joint disease such as RA. Broadly, procedures are grouped into:

- **Joint debridement** – this may be aimed at removing inflamed synovium in inflammatory conditions to prevent destructive changes (RA) or removing bony osteophytes (OA), which through impingement may cause pain or impair movement. The true benefit of debridement and joint washout in OA is of some debate. This can usually be performed arthroscopically in larger joints.
- **Arthrodesis/fusion** – as pain in the joint can be caused by two degenerative surfaces rubbing against one another, fusing the joint prevents any movement and therefore stops pain, and is particularly useful in the small joints of the ankles, feet and hands and in the spine. It can also be used in specific situations in the hips and knees. One must bear in mind, however, that loss of movement in one joint may have an effect on adjacent joints, which may therefore later also require additional procedures.
- **Joint excision/excision arthroplasty** – This was practised historically in the treatment of infected and degenerate joints, and in the 1940s for the treatment of tuberculosis of the hip. The modern indications include failed infected joint replacement, recurrent dislocation of hip replacement and in specific cases of rheumatoid arthritis where a painful joint may be excised and the joint space filled with soft tissue which will eventually fibrose and thereby reduce and treat pain. The loss of stability and movement need to be considered and this is only suitable when a limited functional demand exists. In the large joints it is generally a salvage procedure and function is usually poor. Girdlestone described an excision arthroplasty of the hip, which bears his name (Horan 2005).
- **Osteotomy** – an osteotomy is a surgical technique involving a cut through the bone to realign or change the orientation of the axis of the bone. In joint disease this may be useful when trying to offload a particular articular surface such as to realign the joint. The chances of success are greater in younger patients; examples include high tibial osteotomies in unicompartmental arthritis of the knee where joint replacement may be less desirable. Osteotomies, however, can be used in a number of other circumstances and this will be highlighted in other chapters too.
- **Arthroplasty** – successful joint arthroplasty or replacement is one of the major advances in orthopaedic surgery and forms a prominent part of routine work performed in all units. The replacements are typically manufactured from a combination of metal alloys depending on the metal properties desired such as stainless steel and titanium. These are combined with an articulating component of polyethylene, metal or ceramic; the benefits and disadvantages of each are large discussions on their own. The prosthesis can be cemented or uncemented and design elements are

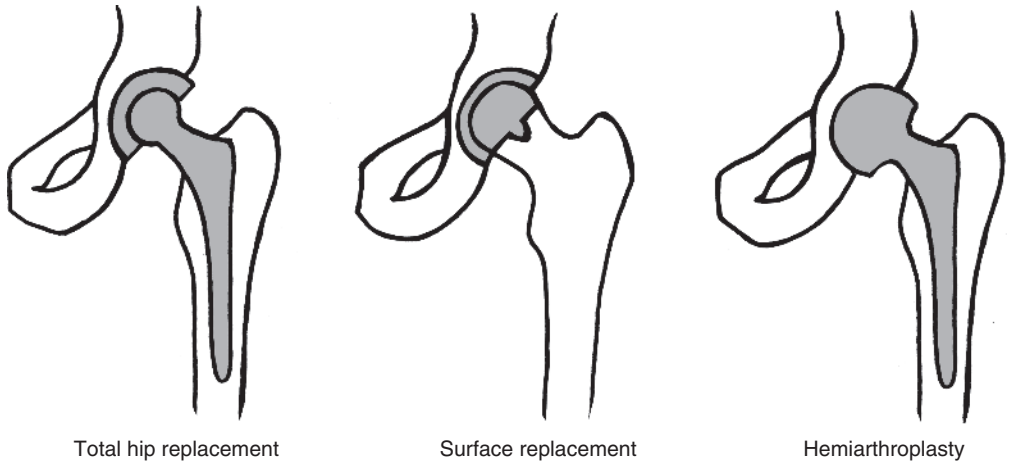

Figure 1.2 From left to right: examples of total hip replacement, surface replacement and hemiarthroplasty of the hip.

used to ensure a good, firm contact with the bone. A variety of terms are used to indicate which and how much of the joint is removed and replaced (Figure 1.2).
  - **Hemiarthroplasty** – only one articular surface is replaced and these are most commonly used in hip fractures and arthritis or fractures of the glenohumeral (shoulder) joint.
  - **Unicompartmental arthroplasty** – in the knee we often find that the degenerative changes are confined to either the medial or lateral half of the joint and in these cases good results can be achieved by only replacing the degenerative part.
  - **Total joint replacement/arthroplasty** – this is perhaps the gold standard for joint replacement and the form of arthroplasty that is most commonly performed. The whole (both sides) articular surface is removed and replaced with a prosthetic implant. Examples include replacements of the hips, knees, and ankles.
- **Surface replacement** – a modification of a total joint replacement involving only removing the articular cartilage and a minimal amount of subchondral bone. This provides the benefit of making further procedures and revision surgery easier as more bone is preserved. This is a refinement of an early technique made possible by better manufacturing methods in the production of prosthetic materials and articular surfaces. More detail will be provided in individual chapters.

Although joint replacement is a prominent part of orthopaedic practice, it is not without risk and these need to be considered carefully. The potential need for revision surgery in the future needs to be considered and in younger patients this may be required on more than one occasion. General risks of joint replacement include:

- Infection (1–5%)
- Dislocation
- Loosening (5%)
- Periprosthetic fracture
- Future revision

- Reduced movement
- Persistent pain
- Neurovascular injury.

Bearing in mind that none of the surgical options available are without risk, careful consideration should be given to the best option for each individual with the patient and multi-disciplinary team being actively involved in the decision-making process.

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