There is some crossover in this section and the previous one covering the complications of fractures. In this section we will concentrate on surgery specific complications.

When thinking about the complications of fracture surgery, these should be divided into pre-operative, intra-operative and immediate, early and late post-operative complications. The pre-operative complications are the same as those discussed in the previous section.

ASA Classification
When considering a patients’ fitness for theatre a tool commonly used is the ASA (American Society of Anaesthesiologists) grading system, which categorises patients into 6 groups according to ascending risk.

1. A normal healthy patient.
2. Patient with mild systemic disease such as mild diabetes or moderate anaemia.
3. Patient with severe systemic disease such as uncontrolled severe diabetes or cardiorespiratory disease.
4. Patient whose life is under constant threat from a severe systemic disease.
5. Patient is moribund and not expected to survive without surgery. An example would be a patient with active bleeding from a ruptured abdominal aortic aneurysm.
6. This is reserved for a patient who has already been declared brain dead and whose organs are being removed for donation.

There may be the addition of the letter E after these numbers. This is used to signify that the operation should be performed as an emergency where a delay in treatment would put the patient at significant risk of loss of life or limb.

Intraoperative Complications
The major potential intraoperative complications are nerve and vascular injuries. It is critically important that any pre-operative neurovascular compromise is well documented as its presence will be attributed to the surgery if it is not. Anaesthetic complications are also possible but these will not be discussed here.

Postoperative Complications
Immediate
These are complications which arise in the hours following surgery. One of the most important to recognise is compartment syndrome. This is discussed in full in the chapter on fracture complications.

Other complications relate to intraoperative blood loss which can be quite significant and may need early transfusion. A patient should receive a blood transfusion if their haemoglobin is less than 8g/dL or 9g/dL if they are symptomatic from the anaemia.

Early
Over the days following surgery a number of complications may occur. The most important are discussed below:

Infection: Bacterial colonisation of a fracture can occur at any time after the initial injury. Despite the significant precautions taken in theatre to minimise the risk of infection it still develops in 1-2% of cases. Special consideration should be given to open fractures whose risk of subsequent infection is much higher due to inoculation of bacteria through the wound at the time of injury.

Infections are considered as presenting in three stages. Early infections occur in the first two weeks following surgery. Delayed (2 - 10 weeks) and late (>10 weeks) infections will be considered later in the chapter. In the early stage around half of infections are due to Staphylococcus aureus with coagulase negative Staphylococcus and Enterococcus being the next most common organisms.

How infection is treated depends on the severity of the infection and the type of operation performed. If an infection affects the superficial layer of wound closure it can usually be successfully treated with antibiotics and often a superficial washout in theatre.

Deep infection can be significantly more problematic. If an implant has been inserted, infection can be a devastating complication which will always need a surgical washout and possibly removal of the implant. In the worst cases, where infection cannot be controlled, amputation of the affected limb is occasionally required. The reason infection is so difficult to treat in the presence of an implant is that it forms a biofilm on its surface which resists the penetration of antibiotics.

The image shows a biofilm formed by Staphylococcus aureus on the surface of an implant. Note the organisms surrounded by the extracellular polymeric matrix.

Image courtesy of the Centre for Disease Control: http://www.cdc.gov/ncidod/dq/decon/staph/index.html
When a patient has a surgical wound washed out samples of fluid and tissue should be taken before antibiotics are given and sent for microscopy, culture and sensitivity. The microscopy is usually performed on the day the lab receive the sample and will give an initial idea of the organism which is being treated. Gram staining identifies a thick layer of peptidoglycan in the cell wall of gram positive bacteria. First the cells are stained with crystal violet which stains them purple. Then they are washed with a solvent which leaves only the gram positive cells stained. The image below shows microscopy and gram staining indicating the presence of gram positive cocci on a sample from an infected tibial nail.

The organism was subsequently found to be Staph aureus. Once the organism has been identified its antibiotic sensitivities are determined to ascertain the best antibiotic for treatment. The image below shows two plates with different cultures of E. coli on each. The white paper discs are impregnated with the same antibiotics. The strain on the left is sensitive to all the antibiotics but the strain on the right is resistant to four and partially resistant to the fifth (the disc in the middle).

When treating infection it is key to know what organism you are dealing with and what antibiotics it is sensitive to in order to target treatment appropriately.

Deep Vein Thrombosis and Pulmonary Embolus: Symptomatic DVT and PE occur in around 1% of patients who have been surgically managed. For a full discussion of the conditions see the last chapter on ‘Fracture Complications’.

Stroke: There is a higher incidence of stroke in the early post-operative period than for the same patient when they are at their baseline risk. The risk is higher for older patients with cardiovascular disease than for younger patients. Identified risk factors include; previous heart attack, history of stroke, acute renal failure, dialysis and hypertension. The risk remains elevated for around 6 weeks after which it returns to the patients baseline risk.

Acute Renal Failure: Around 1% of all patients undergoing surgery will go into acute renal failure (ARF) postoperatively. There are a number of identified risk factors including advancing age, emergency surgery, liver disease, high body mass index, peripheral vascular disease and high risk surgery.

It is good practice to take bloods to check for renal function day 1 postoperatively and in high risk patients to catheterise at time of surgery so fluid input and output can be closely monitored.

Late
A number of complications may occur over the weeks to months following surgery.

Late Infection: As mentioned above delayed infection is defined as occurring between 2 and 10 weeks and late infection beyond 10 weeks. These infections can be more difficult to identify than early infections as their presentation is often subclinical with only mild signs and symptoms. Infection prevents healing and so the diagnosis should always be considered in cases of delayed or non-union.

With delayed infections the microbiology is often more complex. It is common to have multiple organisms involved (polymicrobial infection) with anaerobic bacteria such as Clostridium, Bacteroides and Peptostreptococcus being more frequent. Patients with a deep late infection present a real challenge to treat. It is important to have a confirmed organism and prolonged treatment with appropriate antibiotics. These patients may develop discharging sinuses. The following x-ray shows the case of a patient who had a distal ulna fixed with a plate which later on became chronically infected. In these films the plate has been removed and the necrotic bone debrided leaving a large gap in the ulna.

The beads on a wire that can be seen are impregnated with gentamicin to give a high local concentration of antibiotics.
Malunion: Malunion often occurs when a fracture is treated conservatively. However, it can also occur with operative intervention despite one of the main indications for surgery being to restore the fracture to an anatomical position.

There can be a number of reasons for this including surgeon error, particularly in causing a rotational deformity when performed intramedullary nailing. However, often fractures are significantly comminuted making an anatomical reduction virtually impossible.

The x-ray below shows a patient 2 years following a tibial plateau fracture which was fixed by open reduction and internal fixation with bone grafting. The lateral tibial plateau has collapsed despite the fixation leaving a significant valgus deformity at the knee.

Failure of Metalwork: All implants will fail eventually. In the trauma setting any implant is designed to last a certain number of ‘cycles’ before it fails. An example would be a tibial locking plate which should last around one million steps (each step being a loading event or cycle) before failing. The best way of thinking of a load bearing fixation therefore, is a construct to temporarily hold the fracture fragments in place while healing occurs. In cases of delayed union it is a race against time for the fracture to heal before the fixation fails.

The x-ray below shows a patient with an intertrochanteric proximal femur fracture which was fixed using a dynamic hip screw. The fracture has taken longer to unite than the cycles tolerated by the plate screws which have therefore failed.

Delayed and Non-Union: These are complications of both conservative and operative management. See the previous chapter on Fracture Complications.

When fixation fails it is almost always necessary to revise the fixation. In many cases it is also important to address the reasons for failure such as the presence of a non-union.