1 Introduction

The overall care plan for a trauma patient should cover the preoperative management, the surgical procedures, and postoperative care (Table 4.7-1). All too often, it is following surgical intervention that vigilance is relaxed and complications may occur. These, at best, deprive the patient of the full benefit of the procedure and, at worst, may seriously reduce a patient’s quality of life.

Postoperative management is not limited to the time spent in hospital but must be continued at home and later at work and at leisure. To achieve this, three postoperative phases are recognized:

• In the first phase, immediately after surgery, emphasis is on pain control, mobilization, prevention, and early recognition of complications.
• In the second phase, after hospitalization, attention is centered upon integration into the social environment and mobilization.
• The final phase concludes treatment and returns the patient to his/her preoperative capabilities including work, education, and leisure activities.

2 First phase—immediate postoperative phase

2.1 Postoperative pain management

The International Association for the Study of Pain (IASP) defines pain as “an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage” [1]. In addition to being an unpleasant experience for the patient, poorly controlled pain may have deleterious physiological consequences for the patient leading to increased morbidity [2].

With adequate analgesia the orthopedic patient will be able to mobilize and perform physical therapy better and recover more quickly.

The simplest and most common methods used to quantify pain are scales that measure the intensity of the pain. Among the most commonly used is the Visual Analog Scale (VAS), which consists of a straight line with the words “no pain at all” on one end and “worst pain imaginable” on the other (Fig 4.7-1). Patients quantify the severity of their pain by placing a mark along the scale [3]. Measurement can be improved by using a standard 10 cm line and then quantifying the pain from 0 to 10 for later comparison. By quantifying pain on VAS, pain can be classified as mild (VAS 1–4), moderate (VAS 4–7), or severe (VAS 7–10). However, surgeons should be aware that pain scores can be affected by anxiety, with more anxious patients reporting higher pain scores [4] and a significant correlation between high anxiety and high reported pain. This emphasizes the close interaction of psychosocial factors and pain. The World Health Organization’s Analgesic Ladder can be adapted to suit the needs of the orthopedic patient (Table 4.7-2).

2.1.1 Analgesics

Acetaminophen has no antiinflammatory effect; it is an effective analgesic and antipyretic. Doses are 10–15 mg/kg orally every 4–6 hours. For adults, these may be doses of 500–1,000 mg (depending on availability) every 4–6 hours. Rectal suppositories may be given in doses of 15–20 mg/kg every 4 hours and it is now available for intravenous administration. The total daily dose of acetaminophen for adults from all sources must not exceed 4 g to prevent liver toxicity.

Fig 4.7-1 Numerical Visual Analog Scale.
### General topics

#### 4.7 Postoperative management: general considerations

<table>
<thead>
<tr>
<th>Fracture type and fixation</th>
<th>Postoperative positioning</th>
<th>Additional limb support</th>
<th>Exercise, weight bearing</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Humerus, proximal: “dynamic”, unstable splitting by K-wire</td>
<td>Orthopedic sling, Câchêrist's bandage, abduction frame, etc</td>
<td>Immobilization for 3 weeks</td>
<td>Pendulum exercises starting at once; active-assisted mobilization after week 2; Partial functional use: week 3–6; Full functional use: week 6–10</td>
<td>Note: associated injuries (eg, rotator cuff)</td>
</tr>
<tr>
<td>Humerus, proximal: “stable” fixation: PHILOS, PHN</td>
<td>Arm placed on a cushion, orthopedic sling</td>
<td>Orthopedic sling for 2 weeks</td>
<td>Active-assisted mobilization starting at once; Partial functional use: week 3–6; Full functional use: week 6–10</td>
<td>More details in Table 6.2.1-1 Shoulder rehabilitation protocol</td>
</tr>
<tr>
<td>Humerus, shaft: “stable” fixation: intramedullary nail, plate</td>
<td>Arm placed on a cushion, elevated position</td>
<td>Orthopedic sling for 1 week</td>
<td>Active-assisted mobilization starting at once; Partial functional use and limited rotation: week 4–6; Full functional use: week 6–10</td>
<td>Mobilization of the shoulder and elbow</td>
</tr>
<tr>
<td>Humerus, distal: stable ORIF</td>
<td>Arm placed on a cushion, elevated position</td>
<td>Upper arm splint or sling</td>
<td>Active-assisted mobilization starting at once; Partial functional use and limited rotation: week 4–6; Full functional use: week 6–10</td>
<td>Mobilization of the shoulder</td>
</tr>
<tr>
<td>Olecranon: tension band</td>
<td>Arm placed on a cushion, elevated position</td>
<td>None</td>
<td>Active-assisted mobilization starting at once; Partial functional use: week 6–10</td>
<td></td>
</tr>
<tr>
<td>Radial head: stable ORIF</td>
<td>Arm placed on a cushion, elevated position</td>
<td>Sling, exceptionally removable splint</td>
<td>Limited rotation: week 0–4; Partial functional use: week 4–6; Full functional use: week 6–12</td>
<td>Note: associated ligament injuries, mobilization of the shoulder</td>
</tr>
<tr>
<td>Forearm, shaft: stable plate fixation</td>
<td>Arm placed on a cushion, elevated position</td>
<td>None or light splint</td>
<td>Active-assisted mobilization starting at once; Partial functional use: week 4–6; Full functional use: week 6–10</td>
<td>Note: mobilization of hand, wrist, elbow, and shoulder, splint for associated neurological injuries</td>
</tr>
<tr>
<td>Radius, distal: “stable” fixation: plate</td>
<td>Elevated position</td>
<td>Positioning splint</td>
<td>Active-assisted mobilization starting at once; Partial functional use: week 4–6; Full functional use: week 6–10</td>
<td>Mobilization of adjacent joints (excluding shoulder)</td>
</tr>
<tr>
<td>Radius, distal: “unstable” fixation: K-wire</td>
<td>Elevated position</td>
<td>Palmar splint or cast</td>
<td>Mobilization of adjacent joints</td>
<td></td>
</tr>
<tr>
<td>Radius, distal: external fixation</td>
<td>Elevated position</td>
<td>Sling</td>
<td>Active exercises for mobile fingers</td>
<td>Release of distraction after 3–4 weeks, mobilization of the elbow and shoulder</td>
</tr>
<tr>
<td>Femur, neck: screw fixation or DHS</td>
<td>Leg extended in slight abduction (cushion between legs)</td>
<td>None</td>
<td>Young patients (&lt; 60 years of age): 30 kg week 0–4; 50 kg week 4–6, then full weight bearing; Older patients: full weight bearing</td>
<td>If stable: full weight bearing, consider compliance of the patient and bone quality</td>
</tr>
<tr>
<td>Femur: intertrochanteric/ pertrochanteric: DHS/PFNA</td>
<td>Leg extended in slight abduction (cushion between legs)</td>
<td>None</td>
<td>Young patients (&lt; 60 years of age): partial weight bearing (toe-touch): 15 kg week 0–4, 30 kg week 4–6, then full weight bearing when pain has dissipated; Elderly patients (&gt; 60 years of age): full weight bearing</td>
<td>With intramedullary implant, full weight bearing can start immediately</td>
</tr>
<tr>
<td>Femur: subtrochanteric: PFNA, AFN, DCS, angled blade plate</td>
<td>Leg extended</td>
<td>None</td>
<td>Partial weight bearing: 15 kg week 0–6, 30 kg week 4–10; Elderly patients (&gt; 60 years of age): full weight bearing</td>
<td></td>
</tr>
<tr>
<td>Femur, shaft: stable fixation with locked intramedullary nail</td>
<td>Leg extended</td>
<td>None</td>
<td>Partial weight bearing: 15 kg week 3–4; All femurs nailed are full weight bearing. If plated, full weight bearing with active hip and knee movements</td>
<td>Dynamization is rarely indicated</td>
</tr>
</tbody>
</table>

**Table 4.7-1** Guidelines for postoperative treatment of specific adult fractures according to AO principles. The aim of operative fracture treatment is functional restitution and early pain-free active mobilization. Surgery followed by immobilization is a poor combination. Abbreviations: AFN, antegrade femoral nail; DCS, damage-control surgery; DHS, dynamic hip screw; ORIF, open reduction and internal fixation; PFNA, proximal femoral nail antirotation; PHILOS, proximal humerus internal locked system; PHN, proximal humeral nail.
<table>
<thead>
<tr>
<th>Fracture type and fixation</th>
<th>Postoperative positioning</th>
<th>Additional limb support</th>
<th>Exercise, weight bearing</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Femur, shaft: stable plate fixation</td>
<td>90°–90° positioning or CPM Note: protect common fibular nerve</td>
<td>None</td>
<td>Partial weight bearing: 15 kg week 5–6, 30 kg week 6–8 Full weight bearing: after week 8 Knee should be exercised without restrictions</td>
<td>Consider compliance of the patient and fracture pattern/MIPO</td>
</tr>
<tr>
<td>Femur, distal: LISS/DCS angled blade plate</td>
<td>90°–90° positioning, (CPM) Note: protect the fibular nerve</td>
<td>Knee brace in case of associated ligamental lesions</td>
<td>Partial weight bearing: 15 kg week 0–6, 30 kg week 6–10 Full weight bearing: week 10–12 Knee should be moved without restrictions</td>
<td>“Stable” situation: full weight bearing from week 6–8</td>
</tr>
<tr>
<td>Tibia, proximal: LCP/L-plate LISS plate</td>
<td>Elevated position, (CPM) (Dorsal splint or knee brace in extension)</td>
<td>Partial weight bearing: 15 kg week 1–6, 30 kg week 6–10 Full weight bearing: week 10–14 After 2–3 weeks in full extension, splint should be removed and knee flexion is begun but extension must be emphasized</td>
<td>Avoid resting knee flexion to prevent loss of knee flexion</td>
<td></td>
</tr>
<tr>
<td>Patella: tension band</td>
<td>Elevated position, (CPM)</td>
<td>—</td>
<td>Isometric quadriceps exercises at once Partial weight bearing on fully extended leg: 30 kg week 0–6 Full weight bearing: week 6–8</td>
<td>Active-assisted flexion of the knee starting at once (to a maximum of 90°)</td>
</tr>
<tr>
<td>Tibia, shaft: intramedullary nailing</td>
<td>Elevated position</td>
<td>None</td>
<td>Partial weight bearing: 15 kg week 0–2, 30 kg week 2–4 Full weight bearing: when comfortable</td>
<td>Prevention of pes equinus</td>
</tr>
<tr>
<td>Tibia, shaft: plate fixation LC-DCP, LCP absolute stability</td>
<td>Elevated position</td>
<td>None</td>
<td>Partial weight bearing: 15 kg week 0–6, 30 kg week 6–10 Full weight bearing: week 10–12</td>
<td>Prevention of pes equinus, watch for clinical and radiological signs of instability</td>
</tr>
<tr>
<td>Tibia, shaft: plate fixation LC-DCP, LCP Relative stability</td>
<td>Elevated position</td>
<td>None</td>
<td>Partial weight bearing: 15 kg week 8–6 followed by progressive weight bearing as healing dictates</td>
<td>Prevention of pes equinus, watch for clinical and radiological signs of instability</td>
</tr>
<tr>
<td>Tibia, distal: pilon: different pilon plates</td>
<td>Elevated position, CPM</td>
<td>Postoperative U-splint to prevent pes equinus</td>
<td>Partial weight bearing (toe-touch): 15 kg week 0–6, 30 kg week 6–12 Full weight bearing: week 12–14</td>
<td>Active-assisted mobilization at once</td>
</tr>
<tr>
<td>Malleoli</td>
<td>Elevated position, (CPM)</td>
<td>Postoperative U-splint Associated ligamental injuries: cast for 6 weeks</td>
<td>Immediate full weight bearing as tolerated unless contraindication such as diastasis, diabetes, alcohol abuse, or neuropathy</td>
<td>In case of a position screw, dorsal extension and full weight bearing should be restricted until screw removal (week 12–16)</td>
</tr>
<tr>
<td>Calcaneus</td>
<td>Elevated position</td>
<td>Removable splint to prevent pes equinus</td>
<td>Nonweight bearing for 6 weeks then partial weight bearing 6–10 weeks Full weight bearing: after week 10–16</td>
<td>Active-assisted mobilization at once of the ankle, subtalar joint, and toes Diabetics with neuropathy should be splinted and have restricted weight bearing for 8–12 weeks</td>
</tr>
</tbody>
</table>

**Table 4.7-1 (cont)** Guidelines for postoperative treatment of specific adult fractures according to AO principles. The aim of operative fracture treatment is functional restitution and early pain-free active mobilization. Surgery followed by immobilization is a poor combination. Abbreviations: AFN, antegrade femoral nail; DCS, damage-control surgery; DHS, dynamic hip screw; ORIF, open reduction and internal fixation; PFNA, proximal femoral nail antirotation; PHILOS, proximal humerus internal locked system; PHN, proximal humeral nail.
Nonsteroidal antiinflammatory drugs (NSAIDs) given even as a single dose preoperatively can significantly decrease morphine requirements by up to 29% over 24 hours [5]. This translates into a lower incidence of opioid-induced adverse effects, such as pruritus, nausea and vomiting. Unlike opioids, which exert their effect predominantly on rest pain, NSAIDs have shown considerable efficacy in minimizing pain associated with movement, thereby facilitating postoperative physiotherapy and minimizing postoperative physiological impairment [6]. Reducing postoperative opioid requirements may also decrease the likelihood of sedation and opioid requirements may also decrease the likelihood of sedation and opioid-induced respiratory depression. In addition to single preoperative doses, NSAIDs may also be given at regular scheduled intervals as appropriate (Table 4.7-3).

Some of the more common adverse effects of NSAIDs include gastric bleeding and ulceration, bleeding from the operative site, nephrotoxicity, bronchospastic hypersensitivity reactions, and the suppression of heterotopic bone formation. Nonsteroidal antiinflammatory drugs should be used with care in geriatric patients and avoided in patients with impaired renal function.

Of special interest is the effect of NSAIDs on bone healing. Although there is evidence from animal studies that NSAIDs inhibit bone healing via their antiinflammatory effect [9], there is increasing evidence that their short-term use in humans does not affect fracture healing [10].

COX-2 inhibitors are well known for their analgesic efficacy. Their lower potential to induce gastrointestinal bleeding and minimal effect on platelet function make them seem an attractive choice in the elderly orthopedic patient. However, their propensity for harm in patients at risk for cardiovascular disease precludes their use in this population [11].

Because of concerns about cardiovascular problems, many COX-2 inhibitors have been withdrawn.

Neuromodulating drugs, such as amitriptyline, gabapentin, and pregabalin have been explored for their coanalgesic effect in the setting of postoperative pain. Turan et al [12] found that in the setting of spine surgery, a single oral dose of 1,200 mg gabapentin preoperatively decreased not only early postoperative pain scores but also resulted in a large reduction in morphine requirements and a significant reduction in opioid-related adverse effects postoperatively. Anti-convulsant drugs exert their diverse pharmacological effects on both ascending and descending pain pathways through a variety of mechanisms, including sodium and calcium channel blocking [13]. The dose of gabapentin for chronic pain ranges from 900–1,800 mg/day. These drugs may also have a place in the management of phantom pain following amputation and in the setting of elective amputation may be started a few days before surgery.

N-methyl-D-aspartate antagonists receptor antagonists, such as ketamine, magnesium and dextromethorphan, potentiate opioid analgesia through their modulation of pain pathways. Their use results in decreased morphine consumption and significantly decreased postoperative pain [14].

Opioid analgesics are a cornerstone of treatment for moderate to severe postoperative pain. Opioids exert their analgesic effects in the central nervous system at the µ-, κ-, and δ-receptors. All pure opioid analgesics cause a dose-dependent sedation and respiratory depression that is similar to equianalgesic doses. This phenomenon is exacerbated by the concomitant use of benzodiazepines, sedating antiemetics, and antihistamines.

<table>
<thead>
<tr>
<th>Drug</th>
<th>Adult dose</th>
<th>Pediatric dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ibuprofen</td>
<td>Oral: 200–400 mg every 4–6 h, max 3.2 g/d</td>
<td>Oral: 4–10 mg/kg every 6–8 h to max 40 mg/kg/d</td>
</tr>
<tr>
<td>Indomethacin</td>
<td>Oral, rectal: 25–50 mg/dose, 2–3 times daily, max 200 mg/d</td>
<td>Oral: 1–2 mg/kg/d in 2–4 separate doses, max 4 mg/kg/d</td>
</tr>
<tr>
<td>Acetylsalicylic acid (ASA)</td>
<td>Oral: 650–975 mg every 4–6 h, max 4 g/d</td>
<td>Oral: 10–15 mg/kg every 4–6 h, max 60–80 mg/d</td>
</tr>
<tr>
<td>Naproxen</td>
<td>Oral: 500 mg initial dose, then 250 mg every 6–8 h, max 1,250 mg/d</td>
<td>Oral: 5–7 mg/kg every 8–12 h, max 1,000 mg/d</td>
</tr>
<tr>
<td>Diclofenac</td>
<td>Oral: 50 mg, 3 times daily, max 200 mg/d</td>
<td>Oral: 2–3 mg/kg/d in 2–4 separate doses</td>
</tr>
<tr>
<td>Ketorolac</td>
<td>Intravenous: 10–30 mg every 6 h, max 120 mg/d</td>
<td>Intravenous: 0.5 mg/kg every 6 h</td>
</tr>
</tbody>
</table>

Table 4.7-2 World Health Organization Analgesic Ladder for pain in orthopedics. Abbreviations: NSAID, nonsteroidal antiinflammatory drug.

Table 4.7-3 Nonsteroidal antiinflammatory drugs dosing [7, 8].
Codeine is a weak opioid frequently used in conjunction with acetaminophen for the treatment of mild to moderate pain. Codeine is a prodrug that undergoes hepatic O-de-methylation to morphine, which is primarily responsible for its analgesic effect. Approximately 7–10% of Caucasians lack the enzyme cytochrome CYP2D6 that is necessary to convert codeine to morphine, and it is likely that this sizable segment of the population will not obtain pain relief from this drug. Conversely, in some populations up to 30% of patients have duplicate copies of the gene resulting in much higher and potentially dangerous serum morphine levels [15]. For this reason, codeine should not be used as a first-line analgesic unless the patient has a favorable history with this drug (Table 4.7-4).

Oxycodone and hydrocodone are oral opioid analgesics used in the treatment of moderate to severe pain. Unlike codeine, neither drug undergoes extensive metabolism prior to exerting their analgesic effect. Both oxycodone and hydrocodone are commonly used in conjunction with acetaminophen for the treatment of pain. Oxycodone, like morphine, is commonly used as a sustained-release preparation for around-the-clock dosing.

Morphine is the drug to which other opioids are compared. It penetrates the blood-brain barrier poorly, so that peak analgesic effects do not occur for 15–30 minutes after intravenous injection. It is hepatically conjugated and renally excreted as morphine-6-glucuronide. Because this metabolite can accumulate in renal failure and cause respiratory depression, morphine should be avoided in patients with renal insufficiency.

Meperidine is a synthetic opioid with 1/10 the potency of morphine. Its onset is significantly faster than morphine and it exerts a potent effect on the κ receptor, which makes it useful in low doses to treat shivering. Its major drawback, however, is its hepatic metabolism to normeperidine, which can induce seizures. For this reason, many institutions discourage its use and limit its dosage to 10 mg/kg daily. Normeperidine is renally excreted, making meperidine an unsuitable choice for patients with a history of either epileptic seizures or renal failure.

Hydromorphone is 6–7 times as potent as morphine and is indicated for moderate to severe pain. It has a slightly faster onset than morphine and like morphine undergoes glucuronidation in the liver. Unlike morphine and meperidine, however, it is relatively devoid of toxic metabolites that depend on renal excretion making it a more appropriate drug in patients with renal insufficiency.

Fentanyl is a synthetic opioid analgesic with approximately 100 times the potency of morphine. It is also indicated in the treatment of moderate to severe pain. The onset of action is less than 30 seconds with a peak effect of 2–3 minutes when given intravenously. It has a relatively short duration of action. Like hydromorphone, its lack of toxic metabolites makes it a suitable drug for patients with renal failure. However, its short duration of action makes it difficult to maintain a steady state of analgesia in patients using fentanyl as a patient-controlled analgesia (PCA).

Fear of causing addiction has traditionally been one of the major reasons that physicians avoid prescribing opioid analgesics and by 2015, overdoses attributed to opioid analgesics outnumbered deaths from trauma in the US [16].

The incidence of addiction when prescribing opioids appropriately for the treatment of pain is remarkably low, likely far lower than the incidence of untoward cardiopulmonary adverse effects when pain is not adequately treated. However, surgeons should also be aware of the natural recovery period following trauma and prolonged, outpatient prescription of opioids (more than 3–4 weeks) during the recovery period should be discouraged and is rarely required to treat pain from acute trauma.

Another common reason for under prescribing opioid analgesics is the fear of inducing respiratory depression. This risk can be minimized by using PCA to deliver opioids, instead of larger intramuscular or intravenous injections. When PCA is compared with intramuscular administration of opioids, PCA is found to provide better analgesia with fewer pulmonary and cognitive complications [17]. Smaller, more frequent PCA doses will result in more consistent blood levels with fewer and smaller peaks and troughs in drug levels. Other

<table>
<thead>
<tr>
<th>Drug</th>
<th>Equianalgesic parenteral adult dose, mg</th>
<th>Equianalgesic oral adult dose, mg</th>
<th>Duration of action, hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Codeine</td>
<td>120</td>
<td>200</td>
<td>3–4</td>
</tr>
<tr>
<td>Oxycodone</td>
<td>5–10</td>
<td>30</td>
<td>2–4</td>
</tr>
<tr>
<td>Hydrocodone</td>
<td></td>
<td>5–10</td>
<td>2–4</td>
</tr>
<tr>
<td>Morphine</td>
<td>10</td>
<td>30–60*</td>
<td>3–4</td>
</tr>
<tr>
<td>Meperidine</td>
<td>100</td>
<td>300</td>
<td>2–3</td>
</tr>
<tr>
<td>Hydromorphone</td>
<td></td>
<td>1.5</td>
<td>2–4</td>
</tr>
<tr>
<td>Fentanyl</td>
<td>0.1</td>
<td>–</td>
<td>0.5</td>
</tr>
</tbody>
</table>

* 60 mg morphine for acute dosing, 30 mg for chronic dosing due to accumulation of metabolites.

Table 4.7-4 Opioid analgesics [8].
4.7 Postoperative management: general considerations

keys to avoiding oversedation in these patients are to minimize the use of unnecessary sedating medications. Benzodiazepines or sedatives should not be used unnecessarily and, even then, only in smaller doses. Opioid consumption is greatest during the first 24 hours and patients require closer monitoring during this time. In many institutions, patients will routinely be administered oxygen by nasal prongs once therapy with PCA is started.

2.1.2 Nerve blocks

Without question, the most profound analgesia will be obtained via neural blockade, whether it is a neuraxial or peripherial technique. With long-acting local anesthetics, the analgesic effects of a nerve block can be expected to last between 18 and 24 hours (following a single injection), or for several days if a catheter technique is chosen.

There are many studies confirming the analgesic advantages of neural blockade over general anesthesia, especially in patients with significant cardiac and pulmonary morbidity [18]. For patients with significant cardiac or pulmonary disease, the challenge may not be the anesthetic but rather the debilitating adverse effects of postoperative opioid analgesics. These patients may derive the greatest benefit from regional anesthesia, be it a single injection or a catheter technique. Regional anesthesia, however, is not without its drawbacks, and compartment syndrome is a potential problem in the limbs [19] (see chapter 1.5). One of the earliest symptoms is pain that is disproportionate to the degree of injury accompanied by pain on passive motion or neurological signs, such as numbness and paresthesia. Neural blockade may delay the diagnosis by masking these symptoms and signs. If the use of regional anesthesia cannot be avoided in patients at risk of compartment syndrome, then the local anesthetic concentration of the postoperative infusion may be lowered and the patient must be monitored with extra vigilance for the development of this syndrome. The use of compartment pressure monitoring may also be considered. In elderly patients with hip fracture, femoral nerve block has been shown to give good analgesia and significantly reduce opiate use and associated pulmonary complications.

2.2 Dressings

To allow the surgical wounds to dry as quickly as possible, they are covered in the operating room with sterile, absorbent gauze that allows for air circulation or a composite hydrophilic wound dressing. If used, suction drainage remains in place for about 24 hours if there are routine amounts of exudation. For larger volumes of exudate, as in pelvic or hip fractures, 48 hours may be required. Articular fractures are a special case and should be drained for no more than 8–12 hours. Beyond these times, the risk of infection is increased. If the wounds have bled extensively, the first change of dressings takes place 24 hours after surgery; otherwise they can remain in place for 48 hours and hydrophilic dressings may be left for longer. Thereafter, the dressings are changed daily to prevent the formation of a moist environment. Such changes are carried out under strict hygienic conditions. Chlorhexidine solutions with alcohol are recommended for skin disinfection. As soon as bleeding or secretion ceases, the wound is left uncovered. Even with sutures in place, the patient can bathe or undergo hydrotherapy if the wound is temporarily protected by a watertight dressing (eg, OpSite film, Tegaderm). Open wounds should be covered with an occlusive dressing (possibly including antibiotic beads to produce an antibiotic pouch) and left undisturbed, to reduce the risk of nosocomial infection, until the patient returns to the operating room. Alternatively, a negative-pressure dressing can be used (see chapter 4.3).

A recent development is the use of negative-pressure wound dressings for the management of closed wounds. Early clinical experience is good and these new dressings are currently being evaluated with prospective randomized controlled trials.

2.3 Elevation and support of the injured limb

Many surgeons have their own preferred regimens but the guidelines shown in Table 4.7-1 are widely applicable.

Immediately after operation, the treated extremity is positioned at the level of the heart to minimize swelling while maintaining perfusion.

Following osteosynthesis of the upper extremity, the limb is placed on a cushion. Flexion of the elbow should not exceed 75°. After any procedure, pressure from malpositioning and deformity must be prevented. The medial epicondyle of the elbow (ulnar nerve) and the head of the fibula (common peroneal nerve) must be well padded. Removable plaster bandages or splints, if they are used, must not lead to malpositioning nor inhibit early postoperative mobilization and physical therapy. Splints on the forearm and hand are placed in the position of safety to prevent contracture of the muscles and joints of the hand (see chapter 6.3.4).

In fractures close to the hip, the affected extremity is placed in moderate abduction and held in that position between cushions or in a padded splint. In distal and midshaft femoral fractures, the lower leg is supported with the knee joint in 30° of flexion (Fig 4.7-2). In all patients with lower limb fractures, it is essential to prevent pes equinus deformity of the ankle and foot by using appropriate splints.
The reduction of swelling may be reinforced with cooling (icing). Foot pumps are also effective for reducing leg swelling. In patients with a tendency toward pes equinus position, a U-splint is adapted to fit the lower limb. Splints with hinges that allow limited mobility are helpful either in gradual mobilization after an articular fracture, or if there have been associated ligamentous lesions.

The combination of surgery followed by protracted immobilization is inappropriate due to the increased rate of associated complications.

External splints should only be used to prevent malpositioning or additional injury, as well as to ensure soft-tissue healing.

### 2.4 Swelling, mobilization, and thrombosis prophylaxis

Early mobilization is important to reduce the risk of thrombosis. Prophylaxis against thrombosis may be used as described in chapter 4.6. Articular fractures require early mobilization and a continuous passive motion machine can be applied as soon as the wound condition allows (Fig 4.7-2). This can be particularly helpful for patients who are unable to mobilize the joint actively. Patients who have had an operation on the upper extremity should get up on the day of their surgery. If the lower extremity has been operated upon, ambulation is minimized until soft-tissue swelling has disappeared and the wound shows no signs of inflammation (Videos 4.7-1–2). The weight-bearing status of the limb depends on the following:

- Personality of the injury
- Function of implants used
- Coexisting injuries
- Preoperative morbidity and frailty
- Patient compliance

Although guidelines are helpful, the final decision is with the operating surgeon who should be in the position of knowing how reliable the fixation is. Be careful not to allow early mobilization to interfere with wound healing.

**Video 4.7-1** Early mobilization from bed with physiotherapy is essential after fracture surgery.

**Video 4.7-2** After surgery, the leg should be elevated and active mobilization of joints encouraged.
2.5 Antibiotics
The use of antibiotic prophylaxis and the treatment of contaminated wounds is covered in chapter 4.5.

2.6 Activity and weight bearing
Postoperative physical therapy begins on postoperative day 1. In long-bone injuries, the neighboring joints start active and active-assisted movement (Video 4.7-3). Continuous passive motion may also be used. At first, weight bearing (up to 15–20 kg) should take place with the assistance of crutches and walkers and only under the guidance of trained personnel. Prolonged delay in weight bearing may cause osteopenia and joint stiffness. Training in walking up and down stairs (Video 4.7-4) with canes is particularly difficult for patients and should be carefully supervised. Hydrotherapy is an important means of providing weightless and pain-free mobilization for patients with fractures of the spine, shoulder, pelvis, and hip; it also helps to build up confidence.

2.7 Radiographic assessment
During surgery x-rays are taken in at least two planes. Many patients require formal postoperative x-rays, as the image intensifier provides images of a narrow field and inferior quality. These serve to document fracture reduction and fixation, record the orientation of implants, and provide a basis for the evaluation of how fracture healing is progressing.

2.8 Communication
Throughout this first phase, the patient and relatives should be informed regularly and fully about the clinical state, the rate of progress, and what is to be expected along the timetable to recovery. The expectations of the patient and the family should be ascertained and the involved persons should be appropriately educated toward an understanding of the actual situation. All relevant support services should be involved at an early stage.

The following points should be established between patient and staff:
- The wound is healing without complication and pain is controlled.
- Intraoperative x-rays have been taken.
- Instructions have been given for ambulation with crutches (including stairs), and for further mobilization (Video 4.7-5).
- Information has been provided about symptoms and signs of possible complications.
- Instructions have been given to care providers about postoperative treatment and follow-up.

In addition, patients also find it helpful to have estimates of the following as it helps them to organize their life:
- Date of hospital discharge
- Time to resume walking without crutches
- Time to resume driving
- Return to occupation or education

Elderly patients must be given instructions on activities, such as stair walking, before discharge from hospital.
CRPS I and CRPS II are neuropathic pain syndromes associated with sudomotor and vasomotor disturbances. The two pain syndromes have similar symptoms, the difference being that an identifiable nerve lesion is associated with CRPS II.

There is no specific test for the diagnosis of these conditions. The diagnosis depends on clinical findings and the exclusion of other conditions that could account for the clinical manifestation.

The Budapest IASP—approved diagnostic criteria for CRPS [21] requires adherence to all the following four points. There are two versions of diagnostic criteria. For clinical purposes, there is a positive diagnosis if (under category 3) more than two categories are fulfilled. For research purposes three or more categories must be fulfilled.

Budapest diagnostic criteria for CRPS [21]:
• Continuing pain that is disproportionate to any inciting event.
• Must report at least one symptom in three of the four following categories:
  – Sensory: reports of hyperesthesia and/or allodynia
  – Vasomotor: reports of temperature asymmetry and/or skin color changes and/or skin color asymmetry
  – Sudomotor/edema: reports of edema and/or sweating changes and/or sweating asymmetry
  – Motor/trophic: reports of decreased range of motion and/or motor dysfunction (weakness, tremor, dystonia) and/or trophic changes (hair, nail, skin)
• Must display at least one sign at the time of evaluation in two (clinical) or three or more (scientific) of the following categories:
  – Sensory: evidence of hyperalgesia (to pinprick) or allodynia (to light touch and/or deep somatic pressure and/or joint movement)
  – Vasomotor: evidence of temperature asymmetry and/or skin color changes and/or asymmetry
  – Sudomotor/edema: evidence of edema and/or sweating changes and/or sweating asymmetry
  – Motor/trophic: evidence of decreased range of motion and/or motor dysfunction (weakness, tremor, dystonia) and/or trophic changes (hair, nail, skin)
• There is no diagnosis that better explains the signs and symptoms.

3 Second phase of postoperative fracture treatment

3.1 Clinical care outside hospital
The surgeon must ensure competent follow-up after hospital discharge. The patient must be provided with sufficient information to be able to decide, and carry out, the next steps in their rehabilitation. The follow-up physician must be aware of irregularities in the healing process and prevent them from becoming serious complications. The first postoperative consultation usually takes place around 14 days after surgery, conveniently at the time of suture removal. Sedentary work can be resumed as early as 2 weeks after the operation, provided injury-related restrictions are followed. A prerequisite is that adequate arrangements for transportation can be made.

3.2 Complex regional pain syndrome
The IASP introduced a new taxonomy in 1994 to more accurately describe the pain syndromes of reflex sympathetic dystrophy (CRPS I) and causalgia (CRPS II). The reason for these changes in taxonomy was to avoid terms that implied a pathophysiology where none had yet been elucidated [20]. These criteria were revised by expert consensus in 2003, becoming what is known as the “Budapest Criteria” for CRPS. These newer diagnostic criteria offer the advantage of greatly enhanced diagnostic specificity [21].
Pain that seems disproportionate or out of the ordinary is the most consistent feature of CRPS. In one study [22], intense pain (more than 5/10) persisting 1 week after wrist fracture was highly predictive (46%) of developing CRPS versus 3.8% of patients who did not experience intense pain after a wrist fracture.

Although diagnostic tests can at times be helpful in the diagnosis of CRPS, it must be emphasized that the diagnosis of CRPS is entirely clinical. There must be objective clinical signs (not just the subjective report of pain), but the diagnosis does not depend on the presence or absence of a positive laboratory or radiological finding.

Plain x-rays may demonstrate cortical thinning and osteopenia secondary to increased osteoclast activity. These features have a periarticular predominance and are more pronounced than is expected from disuse alone. With progression of the disease, the osteopenia has a diffuse ground-glass appearance (Fig 4.7-3).

While the precise etiology of the changes involving the peripheral and central nervous systems has not been elucidated, our understanding of the role of the sympathetic nervous system in CRPS continues to evolve. The pathophysiology may differ between patients and even within a single patient over time [23]. Various mechanisms may include inflammation, oxidative stress, and/or perturbations of the sympathetic nervous system.

Most authors emphasize a multidisciplinary approach to the treatment of CRPS with analgesia, exercise, rehabilitation, and functional restoration being the mainstays [24].

The successful treatment of CRPS necessitates early diagnosis and early appropriate pain management to assist the patient in progressing and achieving the goals of exercise and physical therapy, together with psychological support.

If the patient fails to progress in a timely manner (ie, 2 weeks), then the incremental use of pain management strategies and psychological intervention are used to aid in their progression [20]. There must be an appropriate analgesia regimen, usually involving regular medication with increased doses at the time of physical therapy so that the patient will be able to tolerate such therapeutic modalities as desensitization, isometric exercises, resisted range of motion, and finally stress loading [20]. Passive range of motion exercises are contraindicated as they can have the detrimental effect of activating large α-β fiber types I and II mechanoreceptors. Even with appropriate analgesia and psychological therapy, it is common for patients to notice a temporary increase in pain and swelling at the start of physical therapy. They must be warned about this and reassured that it is normal.

It is recommended that patients experiencing significant symptoms of CRPS for more than 6–8 weeks undergo psychological assessment [20]. By developing coping skills via cognitive behavioral therapy and utilizing relaxation techniques, such as biofeedback, patients help to facilitate their pain management and eventually their physical therapy.

The primary goal in pain management of CRPS is to facilitate physical therapy because ultimately it is physical therapy that is responsible for improvement in the patient’s condition. Pain management in CRPS proceeds aggressively, step by step. Pharmacotherapy is initiated to target the patient’s symptoms. Bisphosphonates can reduce pain intensity and bone loss in patients with CRPS [25]. Neuropathic pain is a common feature of CRPS and tricyclic antidepressants, such as amitriptyline, are often initiated along with an anticonvulsant medication such as gabapentin or pregabalin. Antidepressants facilitate catecholamine neurotransmission within the central nervous system, which causes hyperpolarize dorsal horn neurons and an antinociceptive effect [26].
Other medications commonly include NSAIDs and oral opioids. Oral opioids may initially be given as shorter-acting compounds, for example, oxycodone combined with acetaminophen. These are particularly helpful if taken 30 minutes before physical therapy. If tolerance develops or the pain is not well managed with intermittent dosing, then sustained release opioid preparations are added. If the patient is no longer progressing in physical therapy with the aid of oral medication then he/she should receive more aggressive treatment, such as sympathetic or somatic nerve blocks [20]. Patients with sympathetically maintained pain should receive a sympathetic nerve block and if they respond well to a block then a course of 3–6 sympathetic blocks along with physical therapy may help achieve remission [20]. If the patient does not respond well to a sympathetic block then a somatic nerve block or a tunneled epidural catheter may be indicated to provide optimal analgesia for physical therapy.

If the patient is still unable to progress, consideration must be directed toward more invasive techniques. Neuromodulation in the form of spinal cord stimulation for CRPS I and II or peripheral nerve stimulation for CRPS II may be indicated if the patient only partially responds to sympathetic or somatic nerve blocks [20]. Intrathecal pumps may be used to deliver local anesthetics, opioids, or baclofen in patients who have failed neuromodulation [20] or have dystonia or long-standing disease.

CRPS remains a potentially devastating disease of unclear etiology. Early diagnosis is essential with immediate physical therapy and an appropriate analgesic regimen. This offers the highest chance of a good outcome. This treatment can be started by the orthopedic surgeon and with early intervention, many patients do not need to see a pain specialist.

If clinicians fail to consider the diagnosis early, an unfavorable outcome may result. Whether the patient presents with a mild or a fulminant picture of CRPS, remember that facilitating physical therapy is the primary goal of pain management and frequent reevaluation of the patient’s progress in therapy is crucial to minimize disease progression.

### 3.3 Clinical and x-ray monitoring

The frequency and timing of follow-up visits to a physician are largely a matter of local arrangement but certain features are always essential.

During periodic visits for monitoring, special attention should be given to specific questions regarding routine patient activities like showering, bathing, sitting, lifting, work, and sports. These can be highly relevant to the patient’s personal and professional life. The sooner problems in these areas are resolved, the sooner the patient may again be assimilated into his/her familiar environment. With good communication between patient and physician in this phase of fracture treatment, conditions are optimal for reassuming work, education and sports. Increased redness, swelling or local tenderness, arrest or reversal of progress, or decreased mobility associated with pain are clinical features to be considered as warning signs of possible complex regional pain syndrome, deep infection, or nonunion. Difficulty caused by activities that patients have previously been comfortable with (eg, weight bearing) is a valuable guide. Pain on weight bearing suggests that the fracture is still moving.

Radiographic monitoring at 4–6 week intervals must include full-length views in two planes; in special cases, additional views may be necessary. For fractures involving a joint surface, tangential views may be essential in the evaluation of articular congruity. In long-bone fractures, the neighboring joints should be included in the x-ray, which usually demands the use of a suitably long film. In the presence of hardware, fracture union can sometimes be difficult to assess on plain x-rays and computed tomographic scan can be helpful. Evaluation of postoperative x-rays must be performed based on the type of healing expected (primary or secondary). The surgeon must compare with previous x-rays and look at two key factors: the implant and the fracture. Evaluation of the implant should include position, displacement, bending, loosening or breakage. Osteolysis around screws is an important early sign of implant loosening. Evaluation of the fracture should include alignment, displacement of fragment, fracture line and bridging callus.

If primary bone healing is anticipated, the appearance of irritation callus or a widening of the fracture line may point to impending trouble and require modification of the management regimen.

With secondary bone healing, timely development of callus surrounding the fracture site and steadily maturing callus is encouraging.

Careful attention must be paid for secondary displacement, implant loosening, bone resorption, or failure and secondary displacement.
The surgeon should always be sure that union is progressing at a rate appropriate to the particular clinical situation, and be prepared to take action if this does not apply. Early bone grafting (week 6–12) in difficult fractures will prevent many nonunions.

Given positive clinical and radiographic findings, weight bearing may be gradually increased. When joints are involved, a simultaneous decision is made regarding the allowable freedom of motion.

### 3.4 Early removal of implants

Implants that may be removed to allow full mobilization (such as percutaneous K-wires, diastasis screws, hook plate on the clavicle, or external fixators) can be partially or completely removed after 12 weeks. This may allow full range of motion or weight bearing, for example, following the removal of a diastasis screw from a type C malleolar fracture.

### 4 Third phase—conclusion of the postoperative fracture treatment

Fracture treatment is complete when the patient regains full capacity for normal activities of daily living, work, and sports (if appropriate). This phase can take many months and visits to see the surgeon but is important for the continued well-being of the patient with continued encouragement and reassurance for a satisfactory outcome.

### 5 Implant removal

Implant removal for many patients represents the true completion of fracture treatment. At an early stage after surgery, the patient should be given a clear outline of the surgeon’s opinion on the removal of implants. While giving due concern to the patient’s own wishes, the expense, utility, and risks of implant removal must be considered and communicated. Before implant removal, further x-rays must be taken to:

- Confirm fracture healing is complete especially with primary bone healing.
- Evaluate the type, condition, and location of implants.
- Ensure correct and good quality implant removal equipment is available.

There are several indications for implant removal. Early removal may be necessary for implants, such as position screws. Late implant removal is more common in young patients, and over bony prominences under the skin, such as the olecranon, patella, and malleoli. In the upper extremity, implant removal is generally neither necessary nor recommended. The main indication for removal of hardware is implant–related soft-tissue irritation or pain. Allergic-type hypersensitivity reactions can occur but they are very rare with stainless steel implants and practically unknown with implants made of pure titanium (see chapter 1.3). External fixators and K-wires are always completely removed due to the danger of secondary displacement or migration, and pin-track infection.

When additional surgery is indicated (eg, arthrolysis, tenolysis, neurolysis, scar revision), the implants may be removed at the same time if fracture healing is complete.

Implants are usually left in place in elderly patients to prevent refracture through the previously fixed area. The risks and benefits of removal must be carefully estimated in patients with poor general health, immune deficiencies (eg, HIV, hepatitis, tuberculosis), or local circulatory disturbances (eg, diabetes mellitus, peripheral arterial disease). Implants in areas with a higher risk of iatrogenic nerve or vessel damage (eg, forearm, humerus, pelvis) are left in place.

When implant removal is indicated, timing is determined by the location of the fracture and the character of the implants used. The implants are usually left in place for at least 1–2 years (especially on tension surfaces, such as the patella or greater trochanter), during which the progress of fracture healing is monitored. X-rays must show complete fracture healing [27]. Patients must always be warned of the small risk of infection, refracture, and local nerve damage. Titanium implants can be difficult to remove because of bone ingrowth and a careful preoperative plan and full inventory of instruments will prevent intraoperative failure of hardware removal. Following removal and appropriate soft-tissue healing, full function and weight bearing may be resumed within a few days.

After removal of large plates, contact sports and heavy physical work should be postponed for at least 2–4 months. Thereafter, and possibly after another x-ray, fracture healing may be considered complete.
6 References


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