14.1 Overview of cast, splint, orthosis, and bandage techniques

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1 Introduction

In this third and final section, the techniques for preparing and applying casts, splints, orthoses, and support bandages are presented. It outlines the individual steps for 55 casting and immobilization procedures, covering the upper extremity, the lower extremity, and the spine. But just as with any invasive procedure, preparation and planning is mandatory before beginning to apply a noninvasive immobilization bandage. It is therefore recommended that prior to the procedure the caregiver obtains the relevant materials and has a full understanding of the following:

- The sequence for examination and treatment
- Resources and staffing needs
- The various types of immobilization
- The various types of materials
- Pain relief
- Fracture reduction
- Patient and limb positioning
- Applying and handling cast materials
- Bandaging techniques
- Cast splitting and cast removal
- Patient information and consent
- Controls and reviews
- Duration of immobilization.

The process of applying a cast, splint, or orthosis is initiated by the physician's decision that some form of immobilization is indicated, as a part of nonoperative or perioperative care. If immobilization is necessary, the required resources must be prepared. These may include assistance and appropriate facility, but appropriate supplies and equipment are always required. Since the various cast materials have different properties, the professional user must select the material that will best fit the type of fracture or lesion, the body region, or the age of the patient. The medical indications for immobilization have been spelled out in section 2 Guidelines.

Skillful application of the cast by the trauma or orthopedic resident or surgeon is essential for good results [1]. The physician confirming that immobilization is indicated should of course also be able to personally apply the cast, splint, orthosis, or support bandage themselves.

> Only this experience and understanding will enable the surgeon to assess casts applied by residents, cast technicians, or other caregivers. And only with this knowledge and experience will he/she be able to obtain the comprehensive informed consent and provide an informed discharge for the patient (see chapter 3 Principles of casting).

This chapter therefore provides the reader with an essential overview and technique tips for the effective and safe application of immobilization bandages.

2 Sequence of examination and treatment

In the case of nonoperative fracture care, the sequence of examination and treatment is as follows:
- Examination and diagnosis
- Fracture reduction
- Application of casting materials
- Assessment of reduction and immobilization
- Documentation.

2.1 Examination

In the previous section Guidelines, the process for examination and diagnosis is outlined for each of the extremities. Typically, the first step in any treatment is the medical history, including mechanism of injury, followed by a complete medical examination and relevant diagnostic tools.

When examining the injured extremity and body region, look for the following signs:
- Localized tenderness, swelling, deformity, or instability
- Unwillingness or inability to move or use the part normally
- Visible bone injury in an open wound
- Abnormal mobility at suspected fracture site
- Bony crepitus
- Fracture evident by x-ray.

This is followed by examination of the fracture region and distal extremity for:
- Traumatic skin lesion
- Hematoma
- Soft-tissue injury
- Vascular injury
- Nerve lesion.

2.2 Fracture reduction

The sequence of fracture reduction is nearly the same in all extremities, and should follow this sequence:
- Effective elimination of pain, with analgesia or anesthesia
  - Local
  - Regional
  - General
- Traction (extension) in longitudinal axial direction
- "Hooking-together" of the fragments, when the fracture pattern permits
- Alignment along the anatomical axis (rotation and angulation).

2.3 Cast procedure

The order and steps for applying the cast or splint are as follows:
- Lining layer over the skin, using tube bandage (stockinette)
- Padding
- Application of plaster of Paris or synthetic cast material
- Molding
- Splitting of the cast (in primary fracture care this is mandatory)
- Anchoring, with gauze or elastic bandage.

Take care to protect the patient's clothing against contact with plaster or synthetic cast material.

2.4 Documentation

These vital steps should be followed (see the topics Pretreatment medical information and informed consent, and Posttreatment patient information and cast check in chapter 3 Principles of casting):
- All results of the medical examination should be documented in writing
- All reduced fractures will be documented with x-ray review
- If a patient is unable to sign or give informed consent due to his/her injury, the information is documented by the physician.

> Documentation of the neurovascular status and x-ray review at the end of the cast/splint procedure is mandatory before the patient is allowed to leave the emergency department.

Each of the elements in the sequence for casting is further detailed in this chapter.

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3 Cast room preparation

For the application of plaster of Paris (POP) and synthetic immobilization bandages, the specially equipped room called a cast room is recommended (**Fig 14.1-1**) (see chapter 5 Logistics and resources in the cast room). While other nonoperative and bandaging activities can also take place in this room, it is specially designed for efficient cast application, including safety measures for patient and staff.

Prior to an immobilization procedure, ensure that all necessary materials, instruments, and equipment are readily available. Check monitoring equipment, energy, lighting, and water supply, and prepare image viewing equipment, if needed. Prepare the cast cart (trolley) and move it into place within easy reach. Similarly, prepare the cast table, cushions to support extremities, and other furniture so that the patient can be positioned appropriately before beginning the procedure. Remember that the materials have a limited working and setting time, so it is important not to interrupt the procedure.

The cast room must have an appropriate plaster sink and trap. When using plaster of Paris, plaster is lost into the water. Without separating this plaster from the wastewater, the outlet pipes will soon clog with hardening plaster sludge. A bucket or plaster basin can be used for dipping and wetting plaster closer to the patient, but these should always be emptied into an appropriately drained plaster sink.
Appropriate waste disposal containers should be readily available for both contaminated and nonmedical waste.

Normally a cast technician is the person applying the casts but operating room personnel or nursing staff may also be trained to apply casts and bandages. Every trauma or orthopedic surgeon should also be trained and able to apply casts and bandages. Fracture reduction, however, is always the task of the surgeon.

Fig 14.1-1 Cast room with equipment.

4 Types of immobilization

When considering what type of immobilization is required, the physician must assess the stage and severity of the injury, the potential for instability, the risk of complications, and the patient's functional requirements (see also chapter 3 Principles of casting) [2].

A cast is applied in a circumferential manner around the extremity. Split casts are often used in primary fracture care after reduction of complex fractures, but nonsplit casts are rarely indicated in definitive fracture care. A cast is the first choice in cases involving noncompliant patients because casts are more difficult for patients to remove by themselves. In special indications, primary definitive fracture care with semirigid synthetic cast materials could be considered. Boyd et al summarized that "casts provide more effective immobilization, but require more skill and time to apply and have a higher risk of complications if not applied properly" [2].

A splint does not circumferentially surround the extremity and therefore allows soft-tissue expansion during the posttraumatic inflammatory phase. Splints are often used in initial fracture care, as well as for sprains, tendon injuries, soft-tissue injuries, nerve injuries, and postoperatively. Splints make it easier to examine or redress the wound, because they are easier to remove than a fully circular (closed) or split plaster cast.

Orthoses, removable casts, and support bandages allow much easier access to the limb, but provide less stability. Their use is particularly indicated when functional therapy is considered appropriate.

4.1 Primary fracture care

The initial (primary) treatment of a fractured bone is reduction (if necessary), retention, and immobilization of the extremity. In primary fracture care, a splint is often used after reduction of the fracture because of the likelihood of soft-tissue swelling. Another immobilization method is the application of a POP cast that is mandatorily split to allow widening of the cast, again in expectation of soft-tissue swelling. Normally, this initial split cast or splint is then replaced by a final definitive cast after 2-3 weeks.

4.2 Primary definitive fracture care

In special indications, a cast is applied only once at admission in hospital, and no replacement is needed (hence it is called the definitive cast). For these indications, such as nondisplaced fractures, or pediatric greenstick fractures, the patient is treated with a split synthetic cast (eg, semirigid or using the combicast technique). After the swelling has decreased (normally after one week) the split cast is further reduced in diameter by cutting away a strip of cast material. The cast is then closed using another roll of semirigid cast material or by fixing it with an elastic bandage or velcro strips. This process also permits tightening of a cast that has become loose once swelling resolves.

5 Types of materials

As outlined in chapter 6 Properties of cast materials, casts, splints, and orthoses all follow the same modular construction:

- Lining material ie, tube bandage (stockinette)
- Padding
- Casting material.

Note that you should always read the instructions of use from the cast and padding material carefully before working with the material.

5.1 Tube bandage (stockinette)

Adapt the tube bandage diameter to the extremity or body region (**Table 14.1-1**). Do not tighten or stretch the tubular bandage too much as this can lead to high skin pressure and can result in compartment syndrome if not cut open at the end of the application. Once the first layer is applied, keep the joint and limb in the desired position. Avoid wrinkles, as they can lead to pressure sores beneath the cast or splint.

Site of cast	Diameter of tube bandage[1]
Finger	Approximately 2–2.5 cm
Upper extremity	Approximately 5–7.5 cm
Lower extremity	Approximately 7.5–10 cm

[1] Depending on the brand of the tube bandage.

Table 14.1-1 Recommended diameter of tube bandage in relation to body region.

5.2 Cast padding and the protection of bony prominences

Cast padding acts as a protection layer between the cast material, skin, and soft tissue (see also chapter 6 Properties of cast materials). The recommended width of rolled cast padding in relation to the body region is outlined in **Table 14.1-2**.

Site of cast	Recommended padding width
Hand	Approximately 5 cm
Upper extremity	Approximately 5–7.5 cm
Foot	Approximately 5 cm
Lower extremity	Approximately 10–15 cm

Table 14.1-2 Recommended width for cast padding rolls in relation to body region.

The padding should usually extend beyond the intended edge of the cast or splint by 1–2 fingers breadth. Cast padding is normally applied using the "half-overlapping technique" (see topic 10 Bandaging techniques in this chapter).

Padding is normally only applied after the desired joint position, usually the neutral (or "functional") position, has been achieved (see topic 8 Patient positioning in this chapter). Do not apply padding around joints, for example, the elbow joint, before the final position is reached. If this is not done carefully, poorly fitted padding can compress the concave region, and cause pressure that might cause swelling from venous compression, skin injury, nerve palsy, or ischemia.

If fingers or toes are included in a cast or splint, the interdigital space should be protected against maceration with additional tube bandages or padding (**Fig 14.1-2**). More padding layers can also be used if soft-tissue swelling, to a large extent, is to be expected.

Fig 14.1-2 Extra protection of the interdigital space between the fingers or toes is sometimes required.

A layer of water-resistant crepe paper bandage can be used over the padding before wet plaster or synthetic cast materials are applied. This can be used to "snug-up" and secure the padding for smooth, gentle compression. Underwrap is necessary to allow an even compression of the padding layers and to separate the dry padding from the wet POP. This layer also keeps water and dissolved plaster from wetting the padding layers, resulting in hardening of the padding and the potential for pressure sores.

At times, extra padding, typically as a focal patch instead of circumferentially, has to be applied at the "bony prominences" and vessels. A bony prominence is a part of a bone that sticks out or protrudes, such as a knobby knee or shoulder blade, and they are often not well covered by soft tissue or are positioned immediately under the skin surface. Bony prominences are areas with a high risk of developing pressure sores or other damage. Additionally, nerves running directly along the bone near the prominences are also in danger of suffering injury, such as nerve palsy.

In the upper limb, the prominences include the inner epicondyle of the humerus, the tip of the elbow, and the styloid process at the wrist. In the lower limb, areas requiring extra protection include the heel, malleoli, the patella, the head of the fibula, and the greater trochanter. Prominences of the torso include the sacrum/coccyx, the anterior superior iliac spines or iliac crest, and the ischial tuberosity of the spinal process. Particularly with synthetic casts, additional pieces of foam or felt padding to cover these sensitive places are recommended. **Fig 14.1-3** indicates the most sensitive locations, and these are further highlighted in each of the casting technique demonstrations in chapters 15 to 18.

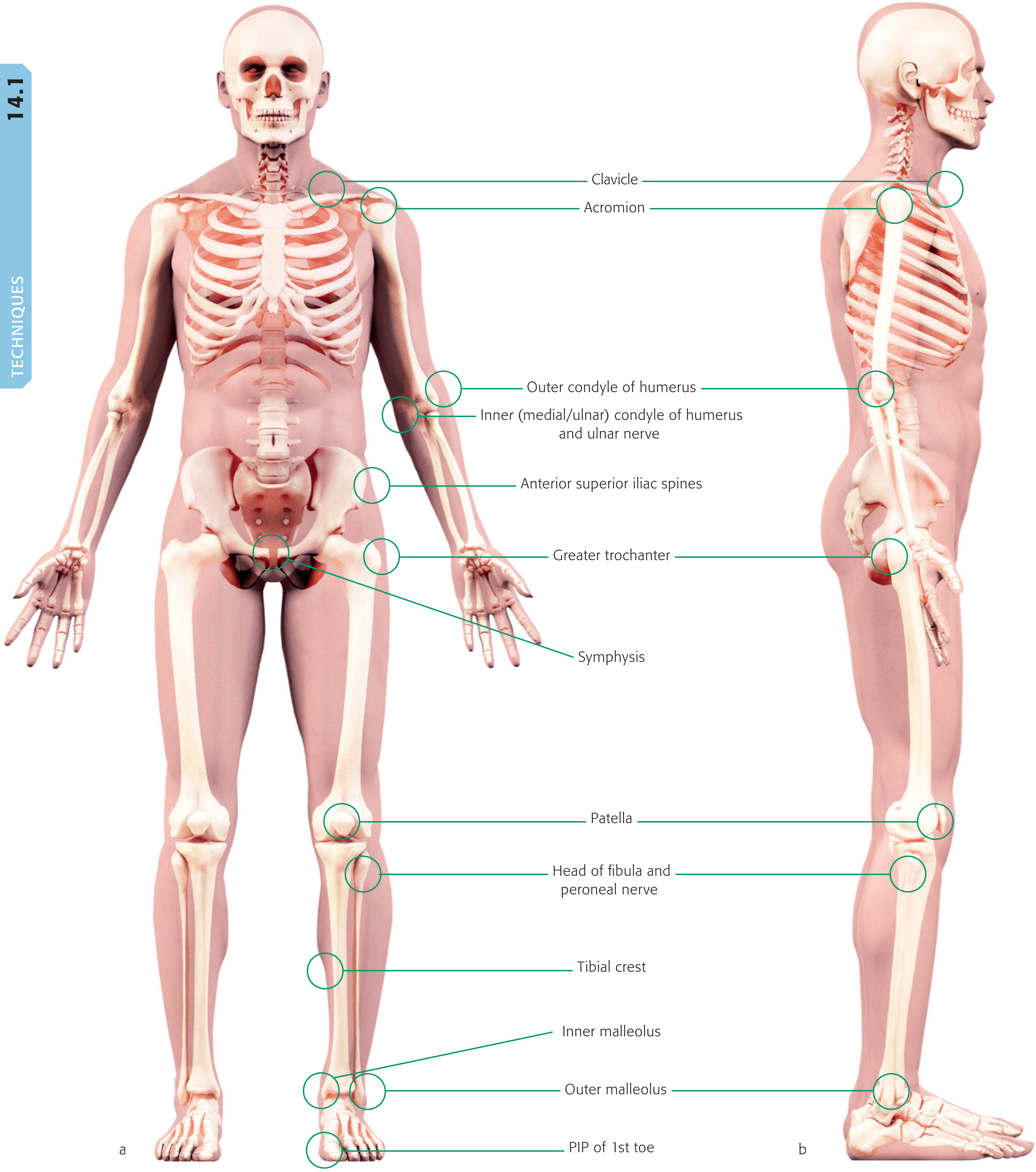
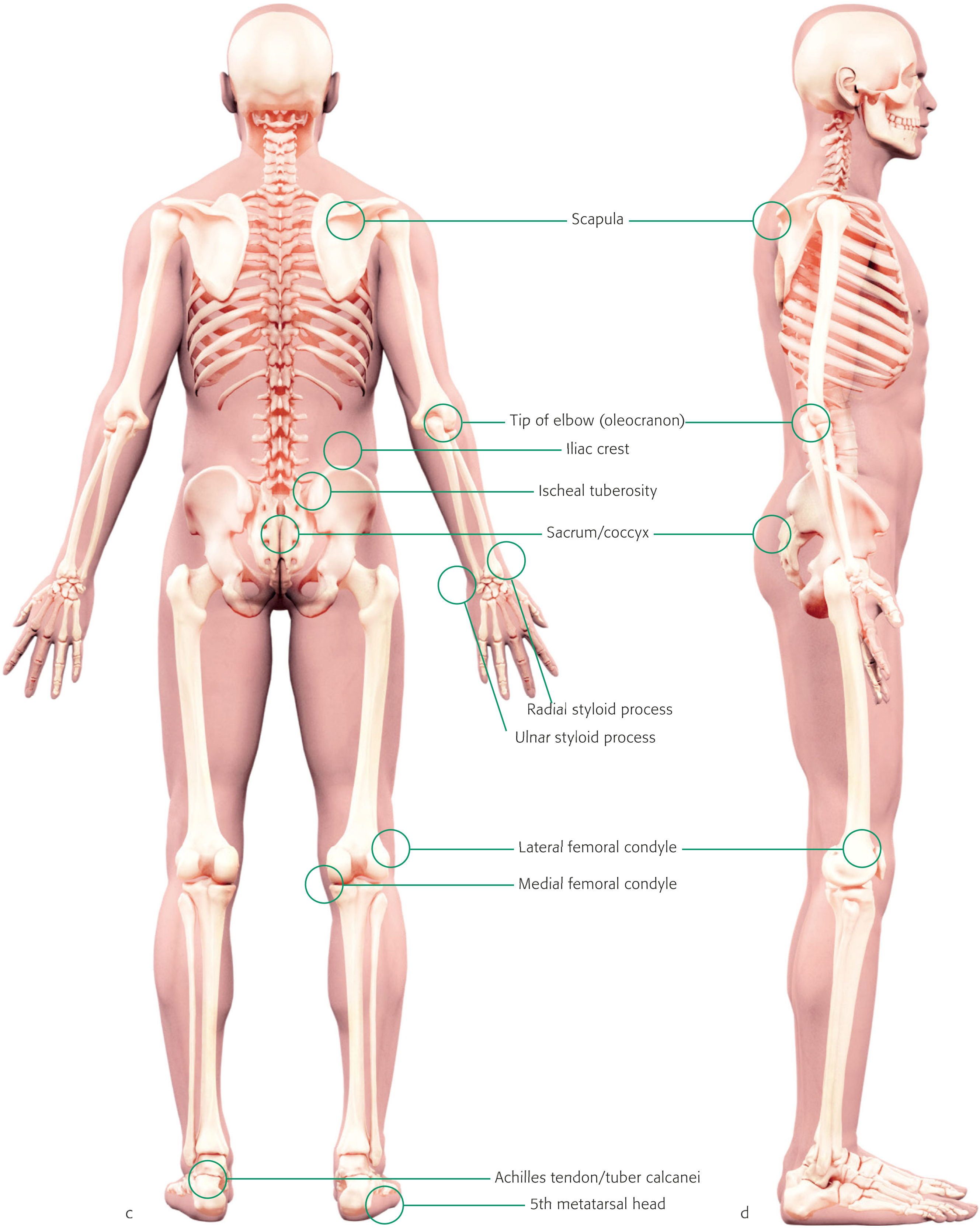


Fig 14.1-3a–d Bony prominences, nerves, and vessels needing extra padding.


Scapula
Tip of elbow (oleocranon)
Iliac crest
Ischeal tuberosity
Sacrum/coccyx
Radial styloid process
Ulnar styloid process
Lateral femoral condyle
Medial femoral condyle
Achilles tendon/tuber calcanei
5th metatarsal head
c
d

5.3 Cast material

5.3.1 Plaster of Paris

The main advantage of plaster of Paris is its pliability and moldability (see also chapter 6 Properties of cast materials). **Table 14.1-3** provides a list of the appropriate dimensions for POP cast material in relation to the respective area of application.

Site of cast	Recommended width of plaster of Paris cast rolls
Hand	6–8 cm
Upper extremity	8–10 cm
Foot	6–8 cm
Lower extremity	10–15 cm

Table 14.1-3 Width recommendations for plaster of Paris cast material in relation to body region.

5.3.2 Synthetic

The advantages of synthetic cast material are its stability, water resistance, low weight, and shorter setting and hardening time (see also chapter 6 Properties of cast materials) in comparison to POP. **Table 14.1-4** provides a list of the appropriate dimensions for synthetic cast material in relation to the respective area of application.

Site of cast	Recommended width of synthetic cast rolls
Hand	2.5–5 cm
Upper extremity	5–7.5 cm
Foot	5–7.5 cm
Lower extremity	7.5–10 cm

Table 14.1-4 Width recommendations for synthetic cast material in relation to body region.

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6 Pain relief

Acute fractures are normally quite painful. For fracture reduction, and sometimes even for cast application without fracture manipulation, some form of analgesia and/or anesthesia is needed. Fracture reduction, or even just splint application, are procedures that can temporarily increase pain. For patient comfort, and muscle relaxation to facilitate fracture manipulation, an anesthetic is recommended typically in addition to analgesic medications.

While an anesthetic may not be required, a strong analgesic can still make the procedure more tolerable, and improves the patient's ability to relax and cooperate. Consider analgesia alone if the fracture is stable, when manipulation is not necessary, or if a recent injury's pain has significantly resolved. Use some form of anesthesia for more severe pain, and if relaxation is necessary for the reduction. In any case, it is essential to assess the patient's need for pain relief and provide it adequately. This may require a change in plans if discomfort proves more than anticipated. While a given procedure may be satisfactorily tolerated by an adult with analgesia plus local or regional anesthesia, a child is usually more comfortable with a general anesthetic.

It is essential for the surgeon to be aware of the available medications and their pharmacologic aspects, as well as his/her institution's pain management policies and the necessary safety precautions. Patient allergies must be identified. Awareness of maximal allowable doses of any local anesthetic is important. Particularly if given rapidly, the possibility of causing a seizure must be considered when using a so-called hematoma block (see below), since an injection into a bone's intramedullary space is essentially an intravenous injection. Antidotes for reversal of narcotics and benzodiazepines should be available. Whenever intravenous sedation is used, an emergency cart is required. This must contain devices for suction, positive pressure breathing, and airway establishment. All members of the treatment team must be aware of how to request an emergency resuscitation team ("code call").

6.1 Anesthetics

Anesthetics are classified according to route of administration as:

- Local anesthesia, injected into the involved area
- Regional anesthesia
  - Neuraxial: spinal or epidural, or
  - Peripheral: via plexus or single nerve blocks
  - Another form of regional anesthesia, available in some institutions, is an intravenous regional or Bier block, used with an arterial tourniquet
- General anesthesia, with inhalation and or intravenous medications.

In many hospitals, surgeons will administer local and sometimes regional anesthetics, while anesthesiologists or nurse anesthetists manage more complex regional as well as general anesthetics. In some situations, other techniques of anesthesia/analgesia are used during fracture treatment, such as a mixture of nitrous oxide and oxygen which is administered to the patient with a self-controlled inhalation device. So-called "conscious sedation" is another technique used during procedures, and is often applicable for nonoperative fracture care. This involves intravenous administration of sedative and analgesic drugs, at a level that depresses consciousness but allows the patient to maintain their airway, independently and continuously. It requires a trained nurse or physician, and comprehensive continuous monitoring by an assigned member of the treating team with no other responsibilities. There should be a pulse oximeter, electrocardiographic monitor, and facilities for measuring and recording blood pressure, pulse, and level of consciousness, as well as a complete emergency cart with all necessary resuscitation equipment and supplies. Yet another technique involves the use of ketamine, a dissociative anesthetic with less respiratory and cardiac depression, but frequent dysphoric effects in adults. Its major use is for children.

6.1.1 Local anesthesia

The hematoma block is often a good alternative to more complex anesthesia, if the fracture is fresh and the hematoma is still liquid. Premedication with systemic analgesics is helpful. Sterile technique is required. The fracture is localized by palpation or with x-ray under the C-arm. After subcutaneous application of a small deposit of local anesthetic, followed by an appropriate reaction time, the needle is inserted into the gap between the main fragments (**Fig 14.1-4**).

After bone contact with the needle, aspiration of blood confirms that the needle is correctly located within the hematoma (**Fig 14.1-5**). The aspiration of fat droplets is additional evidence of correct positioning of the needle (**Fig 14.1-6**). Inject 5–10 ml of anesthetic (for example, 0.5% or 1% lidocaine without epinephrine) stepwise after aspiration of as much hematoma as possible. This may be easier with a larger bore needle, after the initial injection with a smaller one. Hematoma removal may decrease the pressure in the fracture gap.

During the creation of a hematoma block, the patient can become anxious, in which case muscle spasms are common. Sufficient time should be allowed for the patient to adapt to the situation and for the drug to act. The surgeon should inform the patient of all steps of treatment; he or she should calm the patient and create a professional atmosphere for treatment. With pain relief, the muscles will be more relaxed and fracture reduction can be performed more easily and effectively.

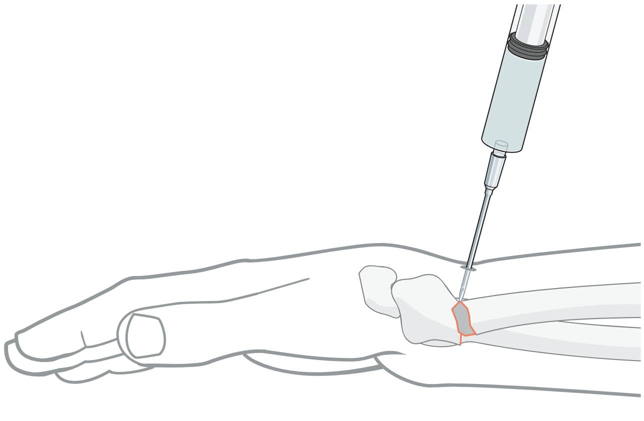

Fig 14.1-4 A needle with local anesthetic is inserted into the gap between the main fracture fragments.

Fig 14.1-5 After subcutaneous injection of a small deposit of local anesthesia, the needle is guided into the fracture hematoma. The aspiration of blood into the syringe is proof of correct positioning of the needle into the fracture gap.

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6.1.2 Regional anesthesia

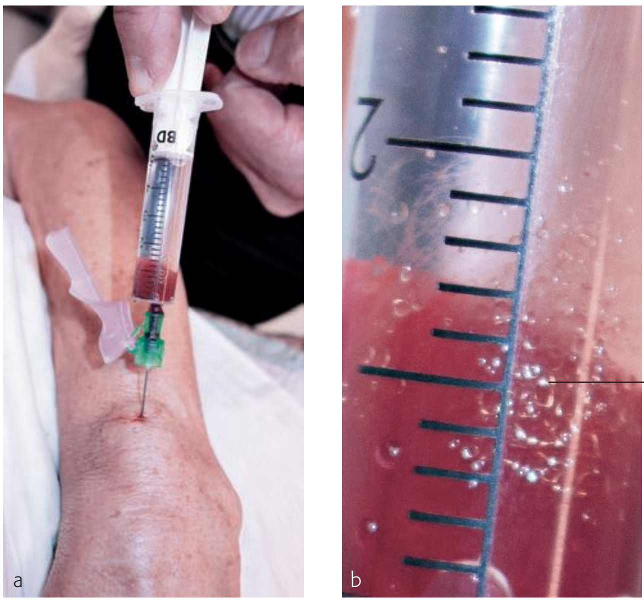
Peripheral regional anesthesia is achieved by injection of an appropriate volume of local anesthetic adjacent to the nerves supplying the anatomic region for which anesthesia is desired. If a structural sheath envelopes the nerves (eg, brachial plexus) the injection should fill and distend this structure. A successful regional anesthetic should eliminate sensation and motor function in the distribution of the blocked nerves, through its inhibition of nerve membrane depolarization. Normally, serious complications from regional anesthesia are exceedingly rare.

There are a number of nerve blocks commonly used in clinical practice:

- Upper extremity: interscalene block, axillary (brachial plexus) block, medial, ulnar, and digital blocks
- Lower extremity: femoral, sciatic, saphenous, sural and ankle blocks
- Digital nerve blocks are frequently used in the emergency department for finger injuries and distal infections (felons and paronychiae).

6.1.3 General anesthesia

General anesthetics offer advantages for children, especially pain-free induction, reliable anesthesia, good muscle relaxation, and amnesia for the procedure. They should be considered whenever fracture reduction is being planned for a young child [3]. A general anesthetic is certainly an option for any significant fracture manipulation in an adult as well. Sometimes the combination of a regional anesthetic with a lower level of general anesthesia nicely balances the benefits of both techniques. Collaboration with an anesthesiologist is often helpful in choosing the most appropriate means of pain control, and is highly recommended when patients have complicating medical issues. The surgeon should discuss with the anesthesiologist the planned procedure, its steps (such as the need to assess x-rays before awakening the patient), the need for muscle relaxation, and other relevant details.



Note the many fat droplets aspirated from the medullary space.

Fig 14.1-6a–b Hematoma with fat droplets indicates correct needle placement.

6.2 Analgesia

Analgesia for fracture manipulation can be provided using oral premedication with a well-absorbed narcotic or nonsteroidal antiinflammatory agent. Alternatively, a parenteral analgesic can be given, via intramuscular or intravenous routes. Parenteral analgesics are often needed initially. Intravenous medications can be given with a patient- controlled device, or titrated with repeated small doses to achieve relief without excessive sedation or respiratory depression. Intramuscular administration is slower to take effect, and harder to control, but lasts longer.

Typically, it is the procedure itself that is painful, with relief after the cast has been applied and is hard enough to be an effective splint. Sufficient medication to permit a fracture reduction can result in over-sedation after the procedure is finished. Whenever significant analgesic doses are used, they should be appropriate for the patient's age, weight, and metabolism.

Strong analgesics are typically needed for the pain of a fresh fracture, at least for the first few days after injury [3]. Adequate fracture splinting aids significantly with pain control. Muscle spasms aggravate fracture pain. Muscle relaxants (for example, benzodiazepines) are sometimes added to analgesics, but they do not themselves relieve pain, and, in combination with narcotics, can produce excessive sedation.

Significant fracture pain often persists for a week or two, especially with nonoperative treatment. Thus, every patient should receive an analgesic prescription for use in the post-fracture and post-reduction periods. In addition, patients should be instructed to consult the surgeon immediately if the pain does not ease with time and/or rest, and especially if it increases in spite of analgesics. A compartment syndrome could be the cause of severe, increasing pain.

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7 Reducing the fracture

The anatomical realignment of fractures is called reduction. In diaphyseal fractures, restoration of axis, bone length, and anatomical rotation are the goals. While this might be sufficient for metaphyseal fractures, displaced articular fractures cannot be anatomically reduced successfully without surgical reduction and fixation. In most anatomic regions, rotation and angular alignment of diaphyseal fractures can be achieved with manipulation, and often maintained with a cast. Successful maintenance of length can be more difficult, unless the ends of two major fracture fragments can be hooked onto one another so that, stabilized by external immobilization, they do not redisplace and shorten. Fractures that are comminuted, spiral, or significantly oblique cannot be hooked together in a way that produces length stability. If they are significantly shortened, even if temporarily restored to appropriate length, they can be expected to return to the degree of shortening evident on initial unreduced x-rays.

While some shortening of the humerus is well tolerated, forearm diaphyseal fractures must be fixed anatomically, and only slight shortening of the tibia or femur can be accepted without compromise of gait.

Closed reduction of a displaced fracture, in an adult, typically requires initial distraction, to permit correction of the deformity, and/or to allow hooking-on and restoration of length stability. To distract the fracture site, gravity can be used to great advantage (**Fig 14.1-7** and **Fig 14.1-8**) (see chapters 9.2 Fractures, dislocations, and subluxations of the lower extremity; and 15.15 Short arm cast using plaster of Paris with traction and reduction).

The amount of force needed to realign the fragments depends on displacement, relaxation, and the location of the fracture, but especially upon the viscoelasticity of the fracture site. Sustained, sufficient, but relatively gentle force can gradually stretch the soft tissues surrounding a fresh fracture so that overlapping is eliminated, and a gap develops between the fracture ends (see also topic 7 Reduction of bone fractures in chapter 3 Principles of casting).

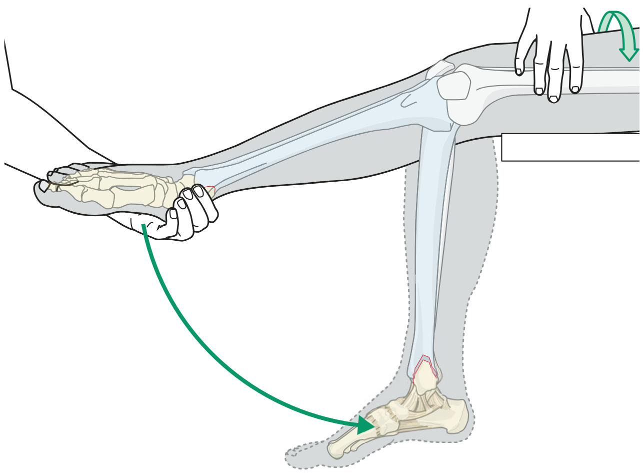

Fig 14.1-7 The effect of using gravity in order to achieve fracture reduction.

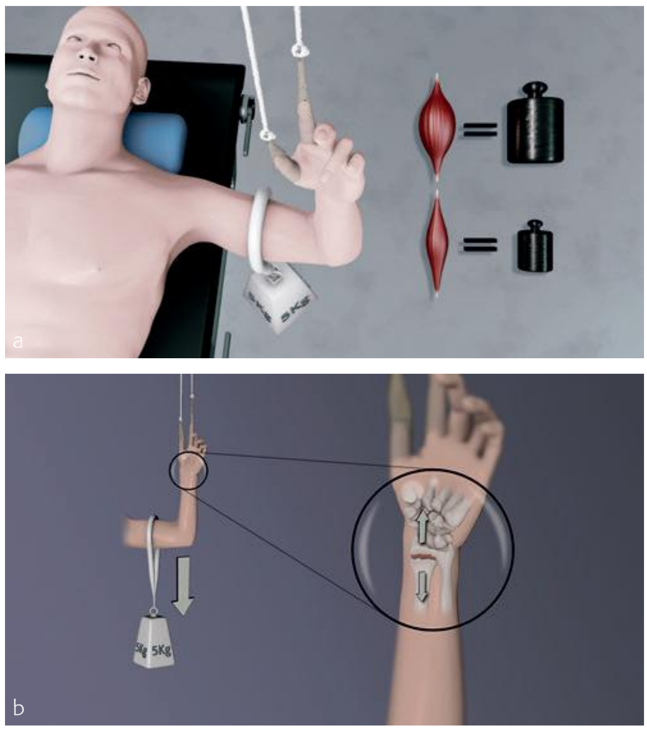

Fig 14.1-8a–b Gravity and fracture reduction.

a The amount of weight to be used in traction depends on the patient's muscle volume and strength.

b The relevant weight is used to disimpact the fracture.

If the fragments are impacted (truly crushed into each other, as typically occurs in corticocancellous metaphyseal bone), the surgeon will try to disimpact the fracture. Since x-rays are two dimensional, it is important to remember that apparent "impaction" may only represent overlapping fragments. To correct true impaction, the fragments must be mobilized so they can be moved independently. One way to do this is to apply forces in the direction of those that caused the fracture ("reproduce the injury"), and then correct the fracture deformity. For example, with a typical, dorsally displaced and angulated distal radius fracture, one may begin by increasing dorsal angulation, increasing deformity, and then, with distracting force, correct the dorsal displacement and restore palmar angulation. To help us understand this, Charnley described the "gear-wheel" mechanism, pointing out that disengagement of the improperly "meshed gears" was necessary before deformity could be corrected (**Fig 14.1-9**) (and see chapter 15.15 Short arm cast using plaster of Paris with traction and reduction) [4].

Fig 14.1-9 "Gear-wheel" mechanism illustration of the radius, according to Charnley [4]. Note that first impaction and then displacement must be corrected before reduction is possible.

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7.1 X-ray review during reduction

An x-ray is mandatory to assess and confirm a successful fracture reduction. Although x-rays are potentially dangerous, for both patient and medical personnel, this is the only way to verify the anatomical position of the fractured limb. Normally, a C-arm imaging apparatus is used in the emergency department or cast room. Surgeons and staff should wear protective clothing during x-ray exposure: thyroid shield, gown, and, if possible, lead goggles, and lead gloves. Increasing the distance from an x-ray source is the best way of limiting x-ray exposure for the surgeon and staff, especially considering the inverse square law. Duration of x-ray exposure must also be considered. Manipulation with the fluoroscope running continuously results in greater radiation exposure than if brief single-shot images were obtained instead. These are almost always the most appropriate choice of image acquisition [5] (**Fig 14.1-10**).

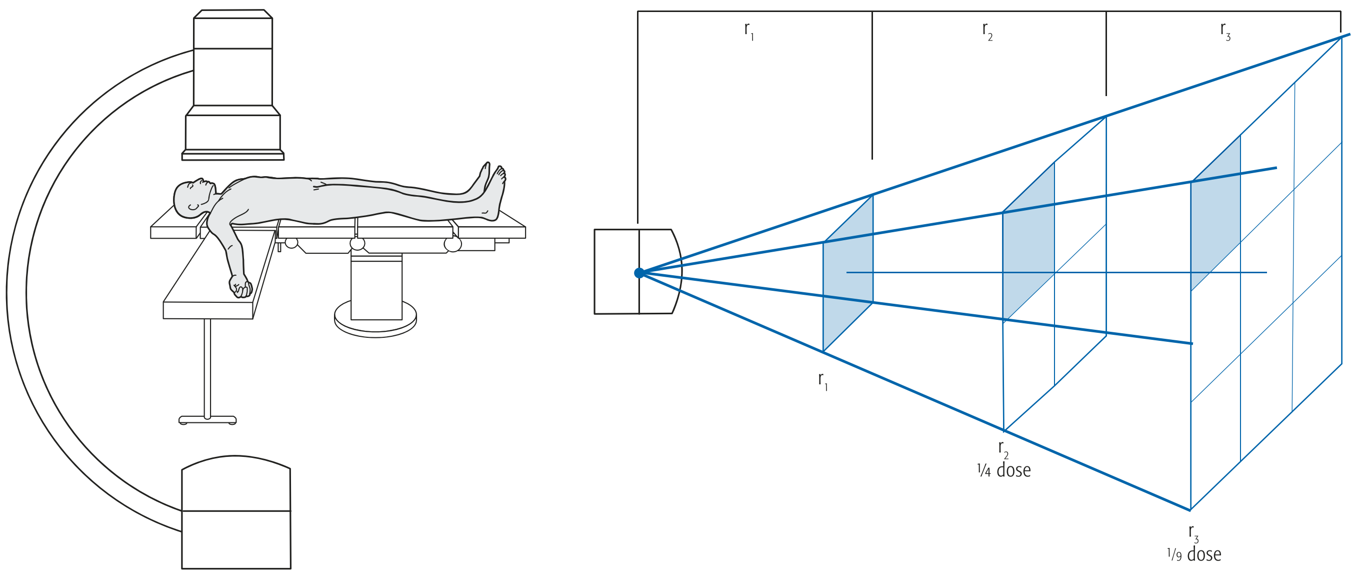

Fig 14.1-10 The inverse square law. The dose is reduced by the power of two of the distance to the x-ray source.

Fracture reduction performed directly over the tube is the worst position of the C-arm with the highest radiation exposure to the surgeon and staff [5]. However, positioning the x-ray tube above the patient is dangerous as most of the scattered radiation is reflected off the patient's body towards the team. Exposure to radiation, especially scattered radiation, can be reduced by positioning the image intensifier over the top, ie, having a short distance between the image intensifier and above the patient, and a long distance between the patient and the x-ray tube (**Fig 14.1-11**). By posi-

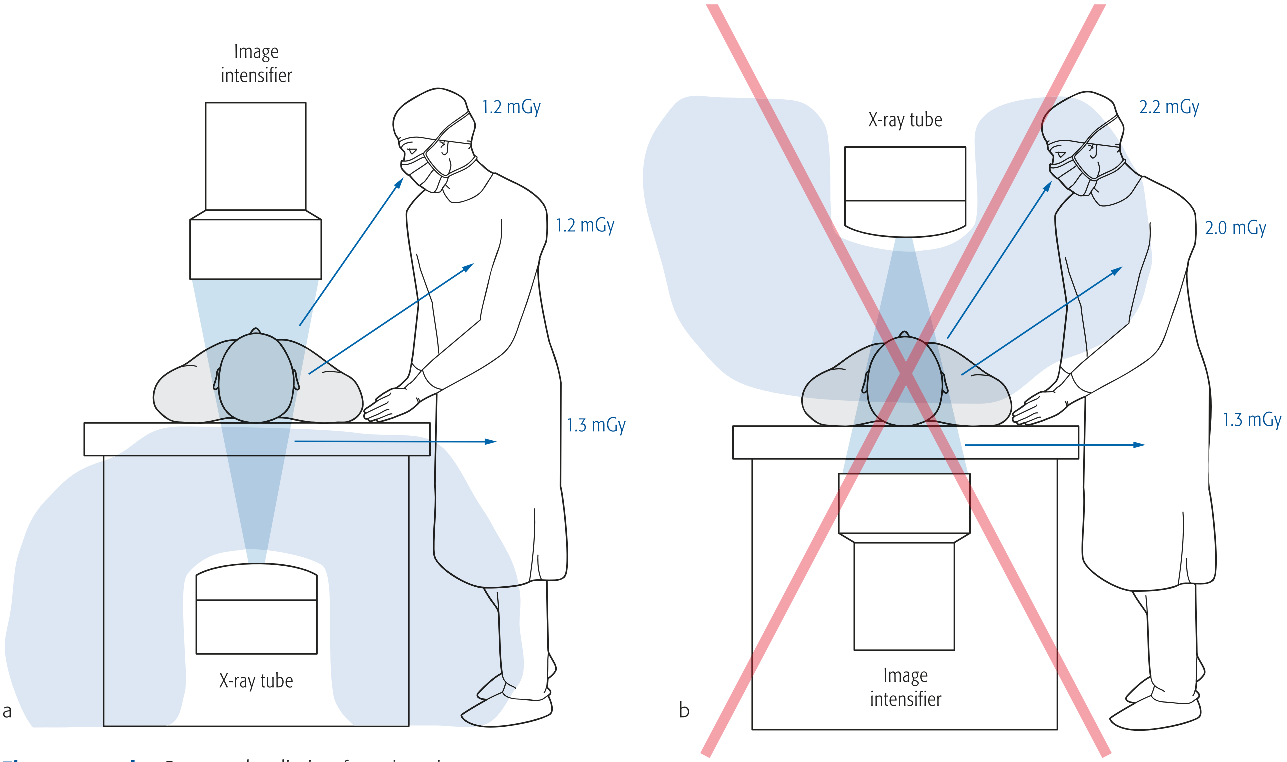

Fig 14.1-11a–b Scattered radiation from imaging.

a By positioning the C-arm in the recommended position below the operating table, the scattered radiation that comes from the x-ray tube will mostly stay under the table (indicated by the blue radiation cloud). A Gray is the physical quantity of radiation, with 1 Gray (Gy) being the deposit of a joule of radiation energy in a kg of matter or tissue. With the x-ray tube placed under the table, between 1.2 and 1.3 mGy are scattered towards the surgeon's eyes, sternum, and pelvic region.

b Positioning the x-ray tube above the operating table and patient reflects the radiation off the patient's body towards the team. It also increases high-dose radiation rates to the eyes. With the x-ray tube in this position, the amount of radiation that is scattered towards the eyes and sternum regions nearly doubles (ie, 2.0 to 2.2 mGy) compared to **Fig 14.1-11a**.

tioning the x-ray tube below the operating table there is the further advantage of reducing high-dose radiation rates to the eye lenses and thyroid gland by a factor of three or more [5–7].

In lateral projection, the surgeon should be on the image intensifier (receiver) side because scattered radiation exposure, from the beam hitting the patient, can be as much as ten times less than if on the other side [6] (**Fig 14.1-12)**.

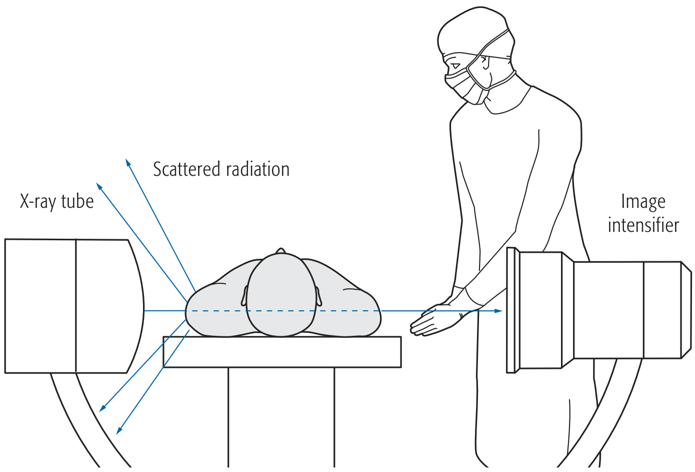

Fig 14.1-12 The exposure to scattered radiation is approximately ten times less on the amplifier side than the x-ray tube side.

8 Patient positioning

Joint angulation and positioning of the affected limb are important considerations when beginning the immobilization procedure. Depending on the affected limb, the patient should be sitting or lying comfortably, with the affected limb resting on the table. Specific information on patient positioning is outlined in each of the demonstrations in chapters 15 Upper extremities; 16 Lower extremities; 17 Spine; and 18 Support bandages.

8.1 Joint position

In the functional position of a joint, the antagonistic muscle groups are balanced, with less deforming tension across the fracture. Additionally, should joint stiffness develop, the recommended functional position is the one that least interferes with the important activities of daily life. Therefore, immobilization of the joint in the functional position benefits functional recovery.

8.2 Shoulder position

When beginning immobilization for the shoulder, the shoulder position should be 80° flexion, 40° abduction, 20° external rotation, and 20° elevation of the forearm (**Fig 14.1-13**).

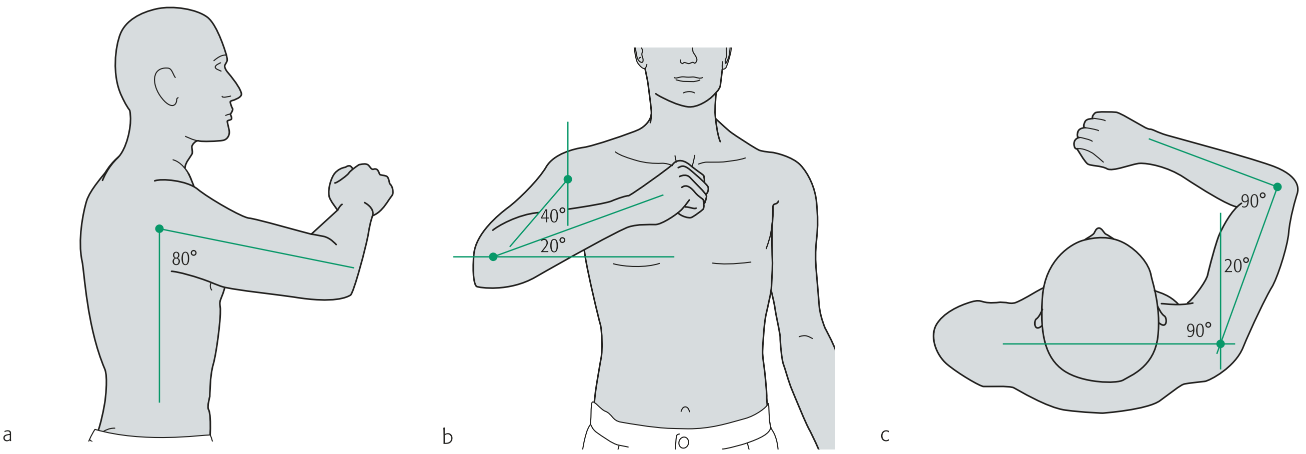

Fig 14.1-13a–c Optimal shoulder position for cast immobilization.
a Shoulder in frontal plane, with 80° flexion.
b Shoulder in sagittal plane, with 40° abduction and 20° forearm elevation.
c Shoulder in transverse plane, with 20° external rotation of the arm and 90° flexion of the elbow.

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8.3 Elbow position

The functional position of the elbow is in 90° flexion (see **Fig 14.1-14**).

8.4 Position of proximal and distal radioulnar joints

The functional position of these joints is 10° pronation (see **Fig 14.1-15**).

8.5 Wrist position

Functional position of the wrist is 20–30° dorsal flexion with full fist closure possible (**Fig 14.1-16**).

8.6 Position of fingers and hand

8.6.1 Thumb position

With the thumb, there should be slight flexion of 15–20° in the metacarpophalangeal joint and 10° in the interphalangeal joint. It should be opposed to the fingers, rather than in the same plane with them (**Fig 14.1-17**).

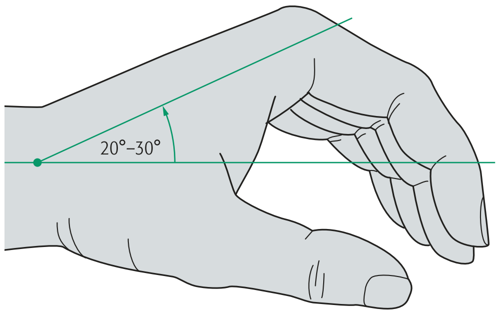


Fig 14.1-16 Functional position of the wrist.

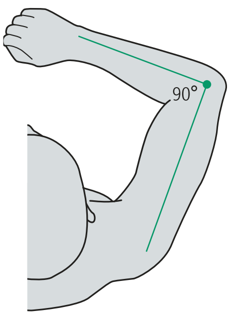


Fig 14.1-14 Elbow in 90° flexion.

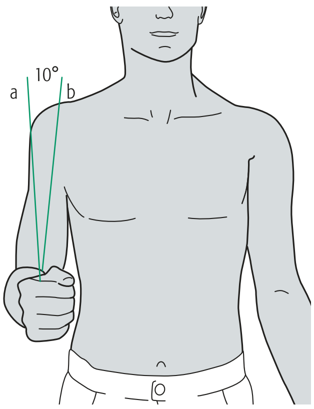


Fig 14.1-15 Functional position of the radioulnar joints.

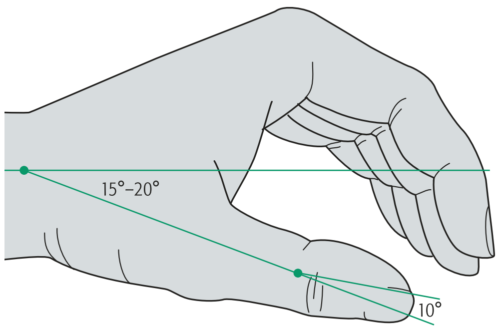


Fig 14.1-17 Functional position of the thumb.

8.6.2 Position of fingers II–V

The functional position of the metacarpophalangeal (MCP) joints is 45–50° flexion with the interphalangeal (IP) joints in 20 to 30° flexion. The fingers are positioned as if they are holding a bottle (**Fig 14.1-18).**

8.6.3 Intrinsic-plus position

The intrinsic-plus position allows better preservation of finger function, particularly regarding metacarpophalangeal flexion range, than the previously described functional position. In the intrinsic-plus position, the MCP joints are in 70–90° flexion with the IP joints in extension. This places the collateral ligaments of the MCP joints under tension so they do not contract while immobilized. The proximal interphalangeal and distal interphalangeal joints, immobilized in full extension, have less risk of developing flexion contractures (**Fig 14.1-19**). Rotational alignment of metacarpal of proximal phalangeal fractures is correct if all injured fingers point to the scaphoid in flexion (**Fig 14.1-20**).

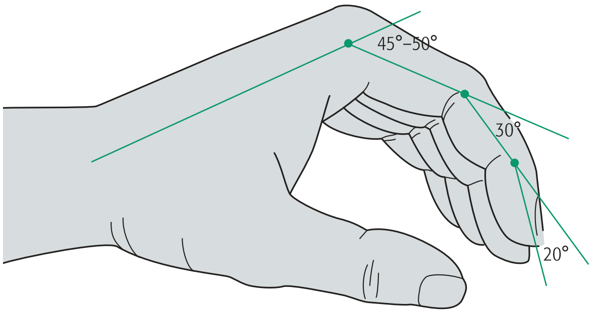
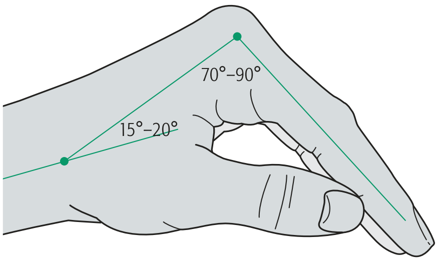


Fig 14.1-18 Functional position of the fingers.



a

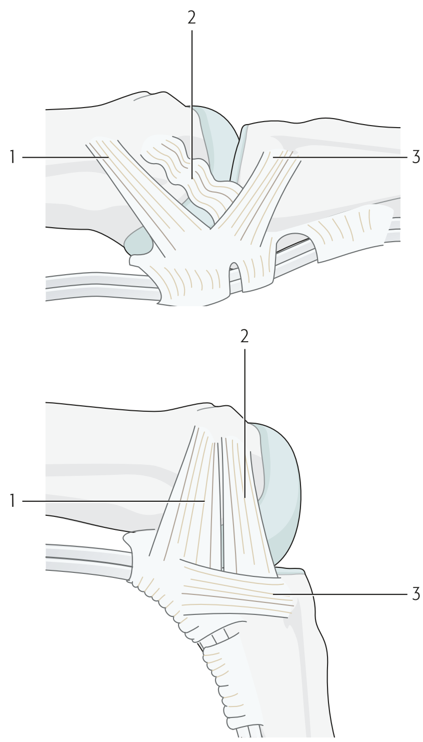


Fig 14.1-19a–c Intrinsic-plus position of fingers for cast immobilization.

a Correct position of fingers and hand for cast immobilization.

b In extension of the proximal interphalangeal (PIP) joints, the collateral ligaments are without tension and would shorten during immobilization in this position.

c In flexion of the PIP joints, the ligaments are under tension and will not shorten during immobilization in this position.

1 Accessory collateral ligament.
2 Collateral ligament.
3 Phalango-glenoidale ligament

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8.6.4 Thumb carpometacarpal

For the thumb carpometacarpal (trapeziometacarpal or saddle joint), the functional position is with the thumb opposed, as when you are holding a bottle.

8.7 Hip position

The functional position of the hip joint is 15° flexion, with neutral abduction and approximately 30° of external rotation (**Fig 14.1-21**).

8.8 Knee position

The functional position of the knee in a cast is 10–20° flexion. In a weight bearing cast, knee flexion should be closer to 10° in order to achieve better walking function.

8.9 Ankle position

For the ankle, a functional position corresponding to 90° flexion is advised. Keep in mind that when relaxed, the foot falls into the “drop foot” position (supination and plantar flexion). It is important to preserve a plantigrade foot position, with the plantar surface parallel to the ground when the tibia is upright.

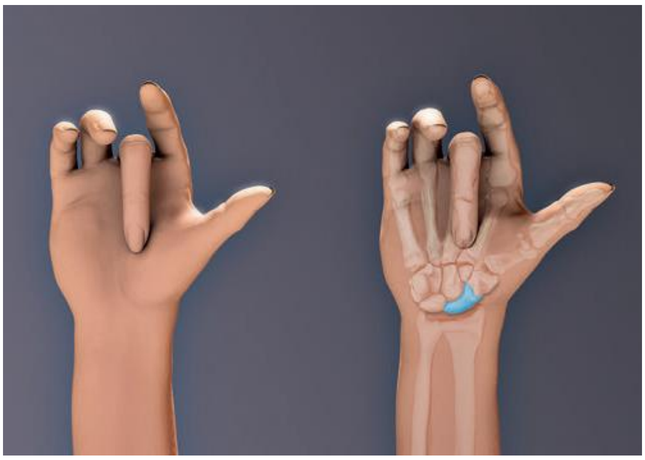

Fig 14.1-20 Correct rotation. In flexion, all fingers point to the scaphoid.

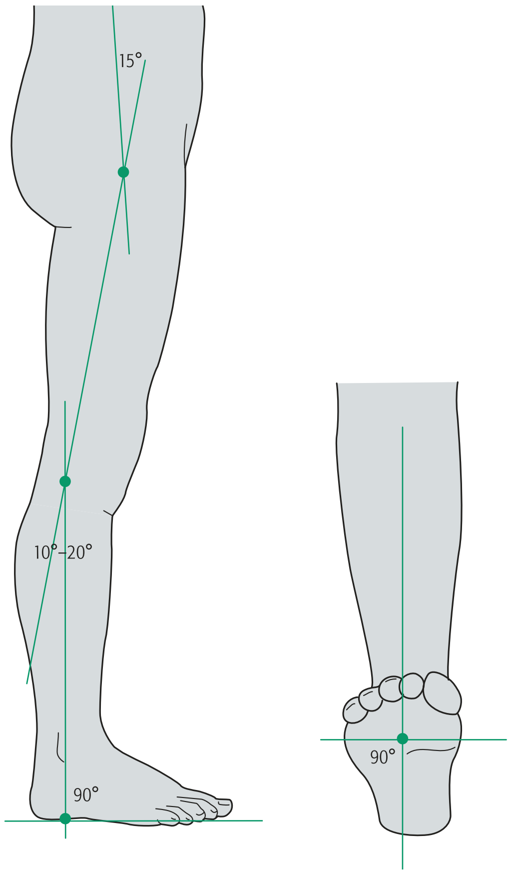

Fig 14.1-21 Functional position of hip, knee, and lower leg for cast immobilization.

8.10 Foot joints

In standing position, all joints of the foot are in the functional position.

8.11 Dynamic splinting after Kleinert

In "dynamic splinting" (see chapters 15.21 Kleinert dynamic splint using plaster of Paris; and 15.22 Kleinert dynamic splint using synthetic, combicast technique) the position of the joints are changed in comparison to the functional position. This special splint avoids flexor tension while allowing motion as the digit is actively extended against elastic resistance. With relaxation of extensors, the elastic passively restores finger flexion.

8.11.1 Thumb

In cases of tendon flexion injuries of the thumb, dynamic Kleinert splinting is carried out in a 30° wrist position and 30° position of the basic joint and thumb end joint (**Fig 14.1-22**).

8.11.2 Fingers II–V

In cases of tendon flexion injuries of the fingers, dynamic Kleinert splinting is carried out in a 30–40° wrist position and 50–70° finger flexion (**Fig 14.1-23**).

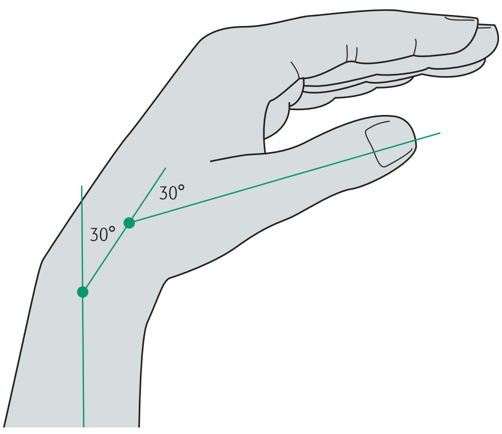

Fig 14.1-22 Position of thumb and wrist for dynamic Kleinert splinting in cases of tendon flexion injury of the thumb.

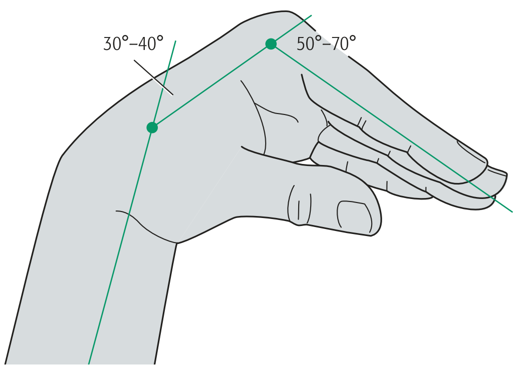

Fig 14.1-23 Position of the fingers and wrist for dynamic Kleinert splinting after flexor tendon repairs.

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9 Applying and handling cast material

There are pronounced differences among POP, rigid synthetic, and semirigid synthetic cast materials (see chapter 6 Properties of cast materials). These differences affect both the application process and the end result.

9.1 Applying plaster of Paris

Before beginning the casting procedure, prepare a container of water at room temperature (at or around 20° C). The correct water temperature is important to avoid allow sufficient time for cast application, and to excessive heat and due to the normal exothermic reaction of the setting cast (see chapter 6 Properties of cast materials). A higher temperature of the dipping water will accelerate setting, and shorten molding working time. Increased heat within the cast might result in burn injuries. Furthermore, in hot water, plaster will detach from the textile layer or dissolve into the water, a process that will result in reduced stability (**Fig 14.1-24**). It must also be remembered that that cast thickness also contributes to heating of a setting cast. Thus the more cast layers that are used, the higher the temperature during setting.

Water in the cast basin or sink should be clean and changed routinely several times during the day.

9.1.1 Plaster of Paris roll

Rolled plaster bandages will become wet rapidly if submerged into water in the correct way. The best way is to hold the POP roll between thumb and fingers during the dipping process (**Fig 14.1-25**), with the axis of the roll more or less vertical in the water. The POP bandage roll lies in the palm of the hand, the thumb rests on the roll without much pressure, while the free end of the bandage is supported by the long fingers. This way "the eyes can look into the bandage" as it is unrolled onto the patient's limb (**Fig 14.1-26).** Dipping the plaster roll without leaving the first layer free causes the cast layers to stick together, and interferes with identifying the free end (**Fig 14.1-27**).

Fig 14.1-25 Holding the POP roll correctly during the dipping process allows you to quickly identify the free end of the roll, and begin applying the cast.

Fig 14.1-24 Cast basin with residues of plaster material.

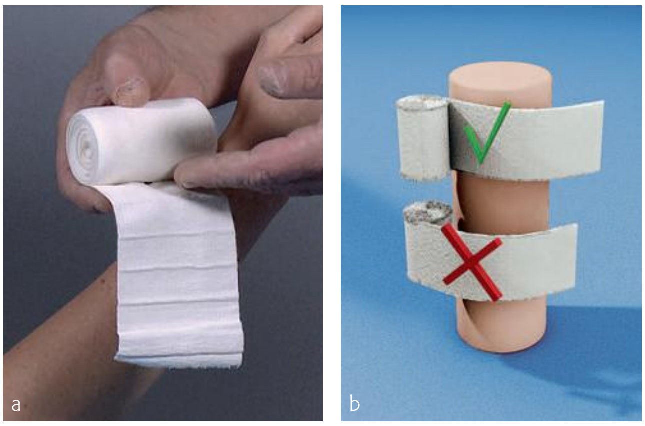

Fig 14.1-26a–b The caregiver must be able to look into the space between the roll and the end being wrapped around the patient.

When dipping plaster rolls, the depth of the water should be at least 20–30 cm. When rolls are dipped as described above, air bubbles will escape through the core of the roll, allowing the water to saturate all layers of plaster uniformly. After a few seconds, when the bubbling ceases, the plaster is adequately wet (**Fig 14.1-28**). A gentle squeeze eliminates excess water (**Fig 14.1-29**). Then, the free end is applied to the patient's limb and the roll material is wrapped onto the limb while the roll itself remains in contact with the cast padding. Plaster of Paris rolls are applied using the half-overlapping technique (see topic 10 Bandaging techniques) so that at least half of each preceding wrap is covered by the following turn. When rolling plaster over an angled region, for example the ankle joint, plaster overlaps halfway over the heel while much greater overlapping is accepted anteriorly.

Fig 14.1-27 Plaster roll that was dipped incorrectly, without keeping the end free.

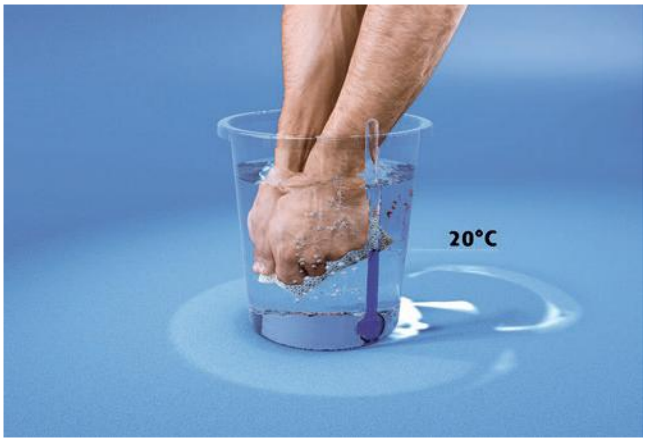

Fig 14.1-28 If dipped correctly into 20–30 cm water depth, air bubbles escape from the POP roll.

Fig 14.1-29 Slight squeezing of the wet POP roll.

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9.1.2 Plaster of Paris splints (longuettes)

Plaster of Paris splints (longuettes) are folded and dipped into water at an angle of 45° in order to let the air bubbles escape (**Fig 14.1-30**). A water column of 20–30 cm produces enough pressure to expel air bubbles from between the layers. The immersion time is approximately 3 seconds or until bubbling ceases. The excess water is then squeezed out as it is with plaster rolls (**Fig 14.1-31**). Hold each end separately, so that they can readily be separated to preserve correct alignment of the splint layers.

The layers of the splint (longuette) are now stuck together by manual longitudinal compression "massage" on a flat, easily cleanable surface of a counter or the cast cart (**Fig 14.1-32**).

Dry spots or dry POP layers reduce the quality and strength of the cast. Insufficiently soaked plaster will result in delaminated, uncompounded plaster, resulting in so-called puff pastry plaster (**Fig 14.1-33**).

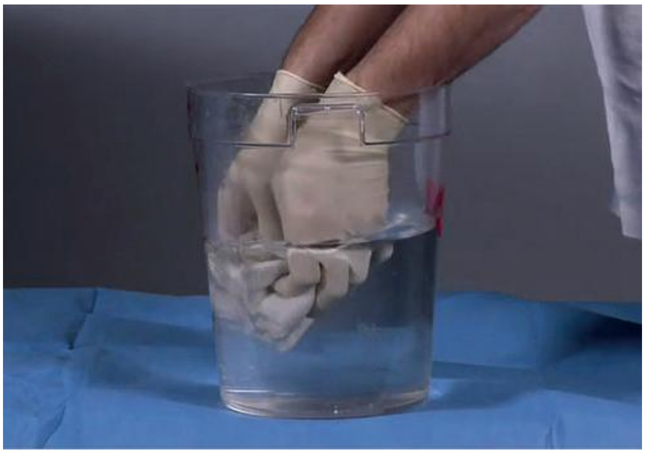

Fig 14.1-30 Dipping the dry folded POP splint (longuette) into water.

Fig 14.1-32 Splint (longuette) is stretched and smoothed out, molding the layers together and releasing the air bubbles trapped inside the material.

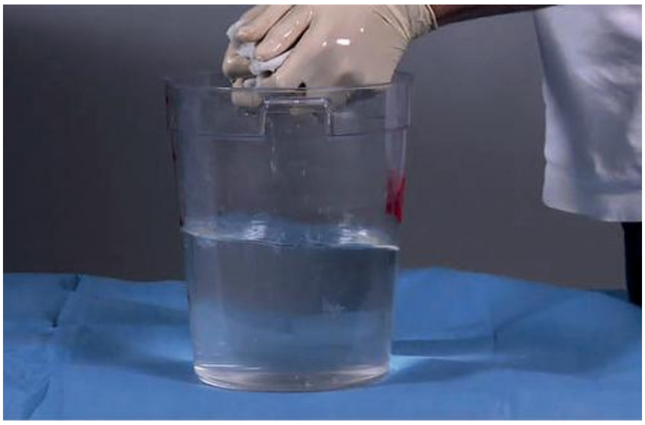

Fig 14.1-31 Slight squeezing of the wet POP splint (longuette).

Fig 14.1-33 Puff pastry plaster.

After having smoothed the plaster splints (longuettes), they are applied where desired, and the smoothing process is repeated manually on the extremity, rubbing them into previously applied plaster, or onto the padding if an end-product splint rather than a circumferential cast is intended. This smoothing process should result in wrinkleless POP cast material, positioned as chosen on the extremity, which remains in the desired functional position without wrinkles or weak spots in the plaster, and without irregularities in the padding. While the plaster is still soft, it is molded to the extremity, with smooth broad appropriately located pressure surfaces to maintain fracture reduction and limb alignment.

During the application and molding of POP, avoid creating finger-tip pressure points (indentations) by using only the heel and flat surface of the hand ("flat hand technique") (**Fig 14.1-34**).

9.2 Applying synthetic

Synthetic cast material is normally (according to its accompanying instructions) dipped into cold water at room temperature of around 20 degrees. However, synthetic material can actually be applied either wet, or using a dry application technique.

9.2.1 Wet application

With the standard wet application, dip the synthetic material into water with an immersion time of approximately 3 seconds and a water depth of 20–30 cm. Submerging the material in water begins the polymerization process (**Fig 14.1-35)**.

Fig 14.1-34 Flat hand technique. Correct manner of applying and molding the plaster by only using the heel of the palm, not the fingers.

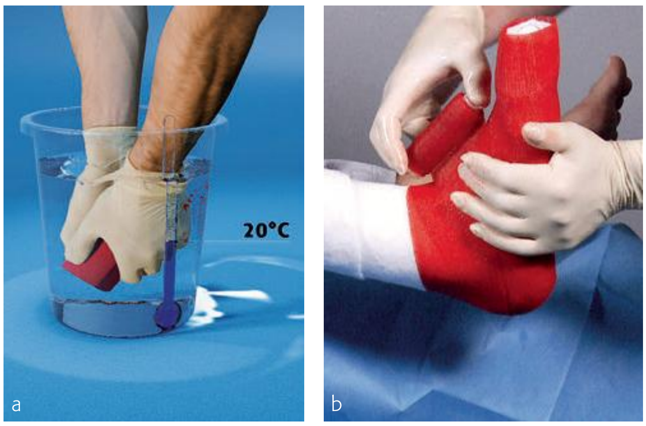

Fig 14.1-35a-b Dipping synthetic material in water starts the polymerization process.

9.2.2 Dry application

Synthetic material can also be applied dry, without previous dipping into water. This increases the working time, before the cast can no longer accept molding. This application technique is recommended for inexperienced users or in complex cases where more time is needed, as well as on occasions when an assistant is not available. After dry application of synthetic cast material, polymerization can be accelerated by wrapping the cast temporarily with a wet elastic cloth bandage (**Fig 14.1-36**). Like POP, synthetic cast rolls are applied using the half-overlapping technique.

9.3 Number of cast material layers

The thickness (number of cast material layers) required depends on the following:

- The casting material used (POP or synthetic)
- The patient's weight
- Body region (lower or upper extremity and anticipated loading)
- Expected patient compliance.

More layers will provide greater strength but will also increase the weight and cost of the cast or splint. **Table 14.1-5a** and **Table 14.1-5b** provide a list of the required number of cast material layers (thickness) in relation to body region.

Body region	Number of layers for plaster of Paris cast material	Number of layers for synthetic cast material
Upper extremity	8–10 layers	4–6 layers
Lower extremity	8–10 layers	6–8 layers

Table 14.1-5a Number of cast material layers within a cast in relation to body region.

Body region	Number of layers for plaster of Paris cast material	Number of layers for synthetic cast material
Upper extremity	8–10 layers	6–8 layers
Lower extremity	12–16 layers	9–12 layers

Table 14.1-5b Number of cast material layers within a splint in relation to body region.

Fig 14.1-36a-c Dry application of synthetic.

a Synthetic cast material being applied using a dry application.

b–c After applying the synthetic material, an elastic bandage can be dipped in water, then wrapped around the material to accelerate the setting.

9.4 Trimming and molding of cast edges

The length of a cast or splint should be enough for optimal support, without impinging on the flexed surface of an adjacent nonimmobilized joint. The adequate length of splints and casts has to be determined in order to avoid insufficient immobilization on one side and unnecessary restriction of joint motion on the other side (**Fig 14.1-37**). By folding back the padding and tube bandage, smooth edges will result, which will protect both soft tissues and bones from pressure and sharp edges (**Fig 14.1-38**).

9.5 Working and setting time

An overview of working and setting times for POP and synthetic cast materials is provided in **Table 14.1-6**. When using dry synthetic material, the setting time can be shortened by wrapping a wet bandage around the dry cast or splint in order to speed up the polymerization rate.

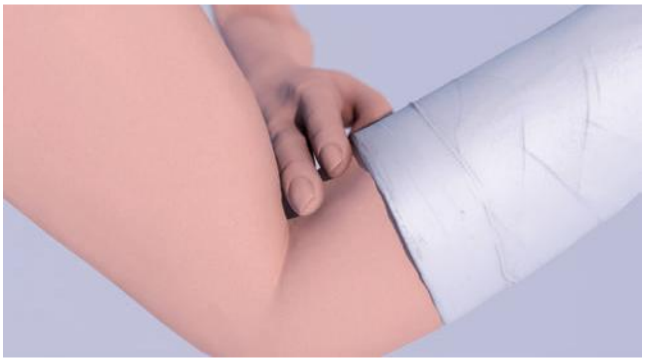

Fig 14.1-37 When applying a cast, joint motion should be possible without any restriction. During flexion, a gap of two fingers breadth (approximately 2-3 cm) should exist between the proximal cast and the proximal limb segment, as shown here for the elbow. On the extensor side, the cast can approach the joint line, but still should be checked for impingement with the joint in full extension.

Fig 14.1-38 Folding the padding and the tube bandage back over the edge of the cast results in smooth padded edges and protects the soft tissue during motion.

Type of cast material / application	Working time	Setting time	Weight bearing permissible after
Plaster of Paris	3–5 minutes[1]	10–12 minutes[2]	24–48 hours[3] (if allowed)
Synthetic cast material:			
Wet application	2–4 minutes	6-8 minutes	30 minutes
Dry application	5–7 minutes	8-10 minutes	30 minutes

Legend

[1] Depending on water temperature and cast material (brand).

[2] For the initial period of hardening.

[3] Complete period of time for setting and possibility of weight bearing depends on the thickness of the cast or splint.

Table 14.1-6 Overview of working and setting times for POP and synthetic cast materials.

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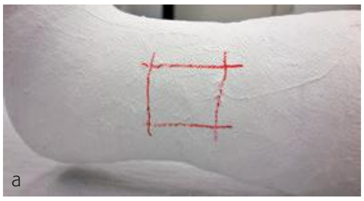
9.6 Cast fenestration (windowing)

Sometimes it is indicated to cut a “window” into the cast to permit wound examination and care while the cast is maintained on the limb (**Fig 14.1-39**). After marking the window, and cutting the hardened cast with a saw, the cast window and padding are removed, and the tube bandage is cut to allow access to the wound. The tube bandage can be turned back over the window edges to secure the remaining padding. After treatment and dressing of the wound, the cast segment that was removed is repadded, and replaced into the window, to cover the wound and apply uniform gentle pressure to minimize swelling of soft tissues into the window (window edema). The window cover is secured with elastic or adhesive bandage, with the goal of restoring uniform pressure over the windowed area. Plastic foam padding, with adhesive backing, if available, is ideal for this purpose.

If a cast window is desired, it must be positioned perfectly over the wound, and large enough to permit dressing removal and reapplication. Planning ahead will include an appropriately sized and applied dressing, and often a bump or mound of rolled cast padding over the dressing so it is easily located before the window is cut. Too large a window weakens a cast, especially if wound drainage is significant. Strength and patient compliance can be augmented by overwrapping the window with cast material (plaster or synthetic). To avoid its adherence to the underlying cast, a layer of cast padding can be applied first. This permits removal of the overwrap with a cast saw, without adding undesirable additional cast thickness, or weakening the cast by trying to find the covered window.



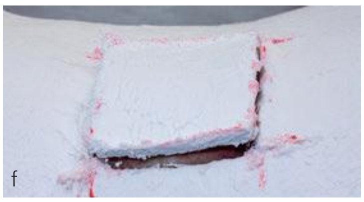
Planning of the fenestration and marking with a felt tip marker or wax crayon.

Cutting of the cast window with the oscillating cast saw.

Using a cast knife to lever out the cast window.

View of the soft tissue after removing padding and undercast material. The wound can now be examined and the treatment can take place.

Swelling of the soft tissue results in a window edema. The photograph shows blanched areas of skin suggesting impaired perfusion.



This image shows the window edema preventing the reinsertion of the cast window to the same level (niveau) of the adjacent cast material.

Fig 14.1-39a–f Cast fenestration to view soft tissues during casting.

10 Bandaging techniques

The most common bandage wrapping techniques include the following:

- Half-overlapping technique
- Criss-cross technique
- Stretch-relax technique
- Figure-of-eight wrapping technique.

10.1 Half-overlapping technique

Elastic bandages and casting materials are often applied using the half-overlapping technique, where the bandage is overlapped by about half of its width on each wrap. When applying the half-overlapping technique (see **Fig 14.1-40**) the soft tissues are compressed in order to decrease swelling and edema.

10.2 Criss-cross technique

The criss-cross technique is used on a tapered extremity, where there is an increasing or decreasing diameter as you progress proximally or distally along a limb. Begin by anchoring the bandage, then wrap around the extremity at a slight angle away from the joint or injury. Head back towards the joint moving above the previous level of wrapping, then again wrap down away from the joint at a slight angle before moving up again. Slowly, you make your way up the limb, from smaller to larger diameter (**Fig 14.1-41**). This technique is ideal for providing compression when there are variations in the circumference of the extremity, and is therefore effective for longer (see chapter 18.4 Wrist bandage).

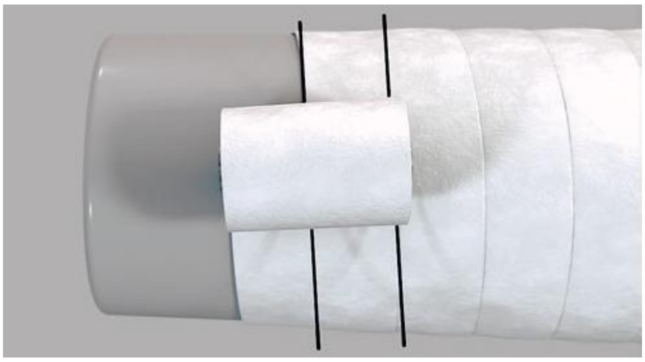


Fig 14.1-40 The half-overlapping technique.

Fig 14.1-41 Criss-cross bandage technique used for tapered extremities.

10.3 Stretch-relax technique

The stretch-relax technique is used for synthetic cast material. Firstly, by pulling the material from the roll, the tension is released. Then, without the tension, the bandage is applied onto the extremity or underlying layers of synthetic cast material (**Fig 14.1-42**). Using too much tension while applying the synthetic material would result in the cast being too tight.

10.4 Figure-of-eight technique

The figure-of-eight technique is used to wrap a joint at an angle, and is principally used for the elbow, knee, or ankle joint. Once anchored (circular wrap) below the joint, the bandage is applied diagonally and anchors to the limb above the joint, before returning to its origin. This step is repeated, making a figure of eight shape. This technique provides support while still allowing movement in the joint.

The most frequent indication for an elastic bandages is the bandage of the ankle joint, and at this location, the figure-of-eight technique is recommended. The complete ankle wrapping technique is described in detail in chapter 18.6 Ankle and foot bandage (**Fig 14.1-43**).

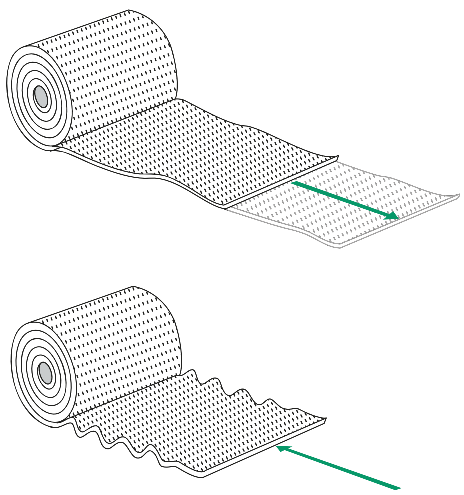


Fig 14.1-42 Stretch-relax technique for synthetic cast materials.

14.1-43 The figure-of-eight technique provides support but avoids excessive material at the joint.

11 Cast splitting techniques and cast removal

Böhler was the first to emphasize the need for splitting casts completely in primary fracture care [8]. In primary care, POP and synthetic casts are always split completely to ensure that swelling can be accommodated. The location of the split should be planned before the cast is cut. If possible, avoid splitting over bony prominences. A good manner is to first mark the line with a felt or grease pen (on POP casts only) or a permanent marker (**Fig 14.1-44**).

Fig 14.1-44 Before splitting the cast, mark the splitting line with a marker/pen.

Fig 14.1-45a-b Cast saw being used to split a leg cast.

In semirigid synthetic casts, the cast is split with scissors. In most rigid synthetic or POP casts, the use of a cast saw is recommended (**Fig 14.1-45**). However, the padding and underlying lining material (ie, tube bandage) are then completely cut using scissors (**Fig 14.1-46**).

11.1 Oscillating cast saw

When using the oscillating cast saw for either cast splitting or for permanent removal at the end of treatment, it is important to explain to the patient how the cast saw works as the blade and saw design can terrify some patients, and the loud noises can be frightening for children. A good sawing technique and ear protectors for the patient can greatly reduce patient anxiety. Cast saw blades, especially if dull, can become hot, and burns as well as lacerations are possible. If the patient complains of pain, sawing should be stopped immediately, and the underlying skin assessed, along with the blade temperature. Very careful resumption of sawing may, of course, be required to expose the possibly injured area.

Fig 14.1-46 Cutting the padding and underlying lining material with scissors.

An oscillating saw blade does not rotate like a circular saw but instead vibrates rapidly with very little rotation. The vibrations or oscillations are still enough to allow the blade to cut the rigid cast/plaster material. When the saw gets through the cast, the technician will feel less pressure due to the soft underlying cast padding. At that moment, the saw should be lifted, manually rotated slightly, and reapplied further along the cast (**Fig 14.1-47**). With this technique, there is less risk of burns or skin damage, but the risks are not entirely eliminated, particularly if the skin is dystrophic, as with some elderly patients, or those receiving high doses of adreno-cortical steroids. It is, however, highly recommended to demonstrate the saw harmlessly touching the skin of the operator (**Fig 14.1-48)**.

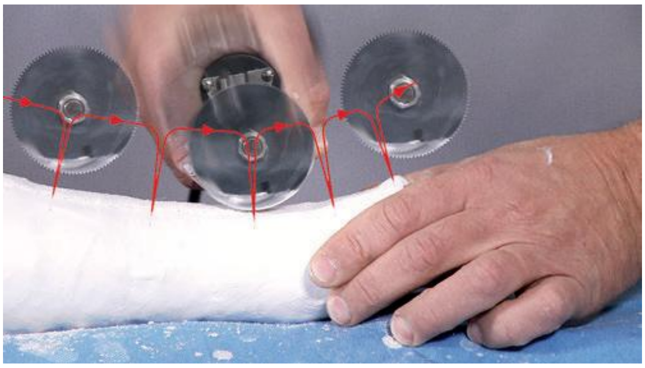


Fig 14.1-47 Lifting the saw blade, rotating the blade slightly by hand, then reapplying the saw further along the cast greatly reduces heat generation.

Fig 14.1-48 The saw blade oscillates and does not rotate, so the risk of skin injury is reduced.

To split or remove the cast, follow these steps:

1 Training: The use of a cast saw is only permitted for trained personal.
2 Heat: Use a sharp saw blade as a blunt blade will get hot much faster.
3 Rotate the blade: Due to the vibrations that occur within the rigid material, the blade will get hot and can cause burning stripes. This effect is reduced/avoided if a sharp saw blade is used and when the saw blade in manually turned slightly by the saw operator, after each step of cutting. With this procedure, another part of the blade is used for cutting resulting in less heat at that part of the blade.
4 Gentle application: Apply the saw blade with a little pressure on the cast. Use the opposite hand or the fingers of the ipsilateral hand for depth regulation.
5 Bony prominences: Ensure the cutting line is not over bony prominences (eg, malleolus or styloid process of radius or ulna).
6 Padding: The padding and tube bandage are cut with blunt-tipped bandage scissors.
7 Bivalving: Sometimes it is necessary to cut the cast at two sides (bivalve it) in order to make removal/opening easier and less harmful to the patient. Careful placement of the two cuts is necessary to ensure easy removal and preservation of the cast if its reapplication is intended.

If considerable swelling is expected during primary fracture care, a strip is cut out of the cast (**Fig 14.1-49**). After complete splitting of the underlying layers of padding and tube bandage, the gap is filled with padding in order to avoid gap edema (similar to window edema). The cast is then wrapped with elastic bandage.

Fig 14.1-49a–e Removing a strip of cast.

a–b Splitting and removal of cast material, padding, and tube bandaging.
c–d The resulting gap is refilled with padding.
e The cast is then wrapped with an elastic bandage.

When cutting semirigid casts, squeeze the cast by pressing on both sides to bulge the cast away from the patient, as shown. This provides space to insert scissors and helps avoid injury to the patient's skin and soft tissues (**Fig 14.1-50**).

11.2 Refixing the cast

After splitting of the cast, the cast is closed (fixed) with an elastic bandage (**Fig 14.1-51**).

In special situations, it is advisable not to split the cast completely all at once but to split and fix the cast in stages (step-by-step) in order to avoid affecting the fracture reduction. This involves cutting a part of the cast, then wrapping that section with bandage, then cutting a little more of the cast, followed by a little more bandaging, etc. **Fig 14.1-52** shows the step-by-step splitting and fixing technique.

Fig 14.1-50a–b Pressing on both sides of the cast with the hand creates a small bulge for inserting the scissors.

Fig 14.1-51a–b Applying the elastic fixation bandage around the split cast.

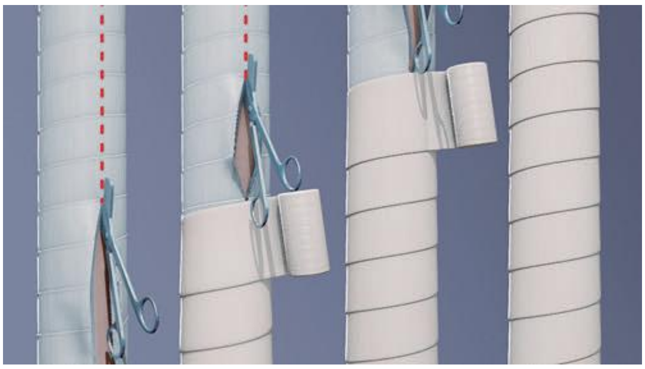


Fig 14.1-52 The step-by-step splitting and fixing technique helps to prevent loss of reduction.

12 Patient information

The surgeon should inform the patient about the diagnosis and treatment options, as well as provide sufficient, specific information about any planned intervention (see topic 6 in chapter 3 Principles of casting). Before leaving the emergency department, the patient should receive information on how to deal with potential problems or complications related to the injury and its treatment, including the cast or bandage (see topic 11 in chapter 3 Principles of casting). A well-accepted method is to give the patient not only verbal but also written information (Appendix 1) before he or she leaves the treatment center. This should include instructions for when and how to call for help should any problems arise.

Patients should be scheduled to return the following day for cast review and re-assessment.

13 Review and assessment

The day after application of the cast, a medical review is mandatory. It is very important that the following items are checked:

- Circulation with
  - Pulse assessment
  - Capillary refill assessment
- Sensation
- Motor function
- Swelling
- Level of pain.

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14 Duration of immobilization

The duration of immobilization varies depending on the type of fracture or injury, patient's age, if surgery was involved, joint stability, and patient compliance. More specific information on duration of immobilization is provided in the chapters of section 2 Guidelines.

15 Summary

- Physicians responsible for selecting and managing nonoperative fracture care should also be able to apply any cast, splint, orthosis, or support bandage themselves
- In primary fracture care, a splint is often initially used after reduction of the fracture because of the likelihood of soft-tissue swelling; the splint can later be replaced with a cast
- Primary definitive fracture care occurs when, in special circumstances, the initial cast or splint does not need to be replaced
- Before applying any form of immobilization bandage, the caregiver should have a thorough understanding of the properties, recommended sizes, working and setting times, and wrapping and cutting techniques for the various types of paddings and casting materials
- Before conducting an immobilization procedure, the caregiver should be fully prepared with the relevant materials, casting and monitoring equipment, instrumentation, and ideally, a specific cast room
- Apart from the actual bandaging techniques, the surgeon is also responsible for other important elements including pain relief, fracture reduction, patient information and consent, and reviews and assessment post-immobilization
- Only when the surgeon has the full understanding of performing nonoperative immobilization can he or she confidently assess the casts applied by residents, cast technicians, or other caregivers.

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