7

CLOSED FRACTURES

SCENARIO
CLOSED FRACTURE MANAGEMENT
POP IMMOBILIZATION
POP AFTER-CARE AND FOLLOW UP
REMOVING CASTS
TRACTION
PAEDIATRIC CONSIDERATIONS
TRANSFERS
MANAGEMENT OF CLOSED FRACTURES WITH INTERNAL FIXATION
SUGGESTED RESOURCES
REFERENCES

SCENARIO

It is 5 days post earthquake.

A 25-year-old man with a clinical diagnosis of a closed fracture of the mid-shaft of the left femur is brought to the medical facility.

An elderly woman with a swollen, unstable knee presents. She fell during the earthquake and has been unable to bear weight since her fall.

A 6-year-old girl presents after a fall from a damaged building the night prior. Her left elbow is grossly swollen, deformed, and no radial pulse is palpable.

TYPE 1

- Treat non-displaced clinical fractures with immobilization (back slab, splinting) but NOT circumferential casts.
- Provide analgesia and mobility aids such as crutches or walking frames for the elderly.
- Refer patients to higher levels of care with: limb deformities, neurovascular injury, major trauma (tibial/femoral fractures) or any injury that cannot be managed locally.
- If available, radiography may prevent unnecessary transfers.

TYPE 2

- Plain radiography required
- Treat with immobilization (splints/plaster), traction with pins and external fixation
- Early physical therapy to improve functional outcomes and prevent complications

TYPE 3

- No open reduction and internal fixation (ORIF) in temporary (tent) structures.
- Treat complex fractures that may benefit from internal fixation (periarticular or intraarticular), only if the team is integrated into the local infrastructure.
- Provide higher levels of medical and intensive care.

KEY POINT

The goals of treatment of closed fractures should include:

- **Avoid infection – first do no harm (such as through unsafe internal fixation).**
- **Optimize functional outcomes and minimize pain.**
- **Promote fracture union with acceptable length, rotation and alignment.**
- **In the upper limb, mobility is a priority over stability.**
- **In the lower limb, stability is a priority over mobility.**

CLOSED FRACTURE MANAGEMENT

If limb alignment is normal but a fracture is suspected or confirmed on radiology, a splint or cast should be applied to maintain the position and reduce pain.

NON-DISPLACED FRACTURES

- Application of casts and splints for fractures with acceptable position in the wrist, forearm and humerus may be applied without sedation.
- Application of casts for non-displaced fractures of the tibia is difficult and should be performed in a designated room where sedation can be provided if necessary.

All patients who require closed reduction of fractures and application of some form of immobilization should be managed in a designated area where safe anaesthesia or sedation can be provided.

DISPLACED FRACTURES REQUIRING REDUCTION

- In the immediate post injury period, back slabs rather than full circumferential casts are preferred.
- A bi-valved plaster cast of this type is easier for family to remove if necessary, but has a higher incidence of loss of fracture reduction.
- On most occasions this bivalve approach is the safer option if follow up is of concern.
- Follow up with all patients with limbs immobilized in full casts is essential.
- If this is not possible, select those patients most likely to have complications during the healing process:
  - Patients with fractures that required reduction
  - All patients with circular casts in order to rule out issues with cast pressure
  - Patients with fractures involving the elbow
  - Patients with fractures treated very close to the time of injury, as these can have an increased risk of problematic swelling.
  - Patients who underwent closed reduction while a significant amount of swelling and oedema were still present.

SPECIALIST SURGICAL TEAMS

- **If possible, all closed fractures should be initially treated in a closed fashion** to minimize complications, particularly infection, despite the longer treatment times associated with this approach.
- Articular and periarticular fractures which could benefit from delayed internal fixation should only be performed in facilities with the expertise, sterility and equipment to do this safely.
- Surgical techniques must be adapted to the local environment. Exceeding the local technical capability in fracture management creates problems for patients and staff alike when complications arise. **Any patient that has a fracture immobilized must have a follow up plan for review**.
- **Internal fixation uses up limited resources and carries a high risk of infection in disasters and in conflict**.
- **ORIF should only be performed at appropriate facilities with a safe water supply, sterile of equipment, specialist surgical teams, appropriate nursing support, and physical therapy following surgery**.
- Non-operative fracture management and avoiding internal fixation methods in the initial three weeks post disaster is not a reflection of the technical capability of the surgeon but of related resources such as:
  - contaminated water supplies
  - co-location of "clean" patients in wards with patients who have wound infections.

TYPE 1	EMT type 1 Facilities should have the equipment and expertise available to apply and manage a range of lower and upper limb immobilization techniques including splints and Plaster of Paris back slabs or casts.

APPLYING CASTS

CASTING MATERIALS

- **Plaster of Paris (POP) is the casting and splinting material of choice**.
- It can be removed by soaking and cutting the wet plaster.
- Medical teams who carry fiberglass as a fracture management solution should only use this material for splints and **never for full casts** in a disaster or in a conflict zone.
- Power failures, plaster saw breakage, and transfer of the patient to a facility without a plaster saw all place the patient at risk of having a cast that cannot be removed without serious risk to the casted limb.

PATIENT INFORMATION

» Patients who have splints or casts applied must be provided with a plain language statement, in their first language, regarding care while in the splint or cast. Emphasis should be placed on returning for medical care if pain is not controlled by the analgesics provided.

» Patients should be encouraged to mobilize even with one extremity splinted or casted.

» Write the POP calendar on the cast – including date of application of the cast, date of removal and X-ray.

DIFFERENT EXPECTATIONS

Write on tape secured to the cast the suspected diagnosis, name of provider, place, date, and a line drawn where the fracture is. This transcends language barriers and helps patient and family understand the diagnosis.

Figure 1. Plaster of Paris cast with patient info recorded on it. *(ICRC)*

POP IMMOBILIZATION

FABRICATION PROCEDURE OF POP CASTS AND SLABS

PREPARATION OF THE NECESSARY MATERIALS

» Prepare a good number of plaster bandages rather than just a few rolls, as the POP should be made all at once to assure the continuity of its structure.

POSITION OF THE PATIENT

» Adjust position with cushions and pillows if required.

» More than one person may be required to support the fractured limb.

» The medical professional should be in a suitable position to work without obstruction or difficulty.

PROTECTION OF SENSITIVE AREAS

» Clean and dry the skin as well as possible to avoid odour and discomfort inside the cast.

» Apply the stockinet over the entire area to be covered with POP, plus an extra length for folding back at both extremities.

APPLY ADDITIONAL PADDING (COTTON WOOL OR SOFT BAND) OVER SENSITIVE AREAS

» Areas that should never be compressed and must be well padded:

- Fracture site
- Bony prominences
- Nerves
- Vessels
- Wounds

GENERAL PRINCIPLES

- Never put plaster directly on unprotected skin.
- The edges of the POP should be covered and not chafe or puncture the skin.
- Molding should be done with the palms of the hands and not the fingertips.
- Application should be continuous to allow the cast to dry as a single, solid piece.
- Check and document the anatomical and functional position of the limb.
- For unstable patients immobilization with a POP back slab or skeletal traction is faster and easier than placing an external fixator.

DURATION OF IMMOBILIZATION

- If properly diagnosed and treated with immobilization, fractures of different bones require varying periods of immobilization to achieve union.

BONE	MOST COMMON IMMOBILIZATION PROTOCOLS WITH NO COMPLICATIONS		AVERAGE HEALING PERIOD WITH NO COMPLICATIONS	
	ADULT	CHILD < 10 YEARS	ADULT	CHILD < 10 YEARS
Metacarpal	4-6 weeks	2-3 weeks	6 weeks	4-6 weeks
Scaphoid	8-12 weeks	8-10 weeks	15-20 weeks	12 weeks
Carpal	4-6 weeks	2-3 weeks	6 weeks	4-6 weeks
Ulna	4-6 weeks	3-4 weeks	6-8 weeks	4-6 weeks
Radius	4-6 weeks	3-4 weeks	6-8 weeks	4-6 weeks
Humerus	4-6 weeks	3-4 weeks	6-8 weeks	4-6 weeks
Clavicie	4 weeks	2-3 weeks	4 weeks	2-3 weeks
Scapula	4 weeks	2-3 weeks	4 weeks	2-3 weeks
Ribs	4-6 weeks	2-4 weeks	4 weeks	2-3 weeks
Vertebral bones	6-8 weeks	4-6 weeks	12 weeks	6-8 weeks
Pelvic bones	6-8 weeks	4-6 weeks	6-8 weeks	4-6 weeks
Femur	6-8 weeks	4-6 weeks	12 weeks	6-8 weeks
Tibia	6-8 weeks	4-6 weeks	12 weeks	6-8 weeks
Talus	6-8 weeks	4-6 weeks	12 weeks	6-8 weeks
Calcaneus	6-8 weeks	4-6 weeks	12 weeks	6-8 weeks
Phalanges	4-6 weeks	2-3 weeks	6 weeks	4-6 weeks

Figure 2. Length of Immobilization times. *(ICRC)*

KEY POINT

- When applying POP, the drying time depends on the quantity of water left in the plaster.
- If there is too much water in the plaster, the POP becomes fragile after drying.
- Increasing the water temperature shortens the drying time. For long POP, cold water should be used to allow the different layers to dry as one solid cast.
- The higher the water temperature, the higher the temperature generated inside the cast:
- If the water temperature is 24°C, the POP temperature increases to 38°C. If the water temperature is 38°C, the POP temperature increases to 57°C.
- With a water temperature over 50°C, the heat produced inside the POP could burn the skin.

APPLYING BACK SLABS

- Position the patient appropriately, obtain materials, and prep the skin.
- Stockinet is applied to the limb to cover all joints surrounding fracture.
- Padding is applied over the stockinet to pad high risk pressure points.
- The first wetted plaster slab is applied along the length of the posterior aspect of the injured limb.
- A second slab is applied in the same fashion as the first using a figure-of-eight or X-crossing of the two slabs to give the lightweight posterior splint its strength.
- Any excess plaster is trimmed for patient comfort and to prevent any skin irritation.
- Gauze or elastic bandage is gently but firmly applied to keep the slabs in position.
- The back slab is held until the plaster has set with the appropriate joint position to facilitate fracture healing.

Figure 3. Forearm slab with fingers splinted in the safe position. *(ICRC)*

APPLYING CIRCULAR CASTS

- The skin should be thoroughly washed and dried before application.
- Stockinet is applied and the necessary amount of padding for protection of boney prominences is applied.
- The plaster bandages should be applied by rolling without tension. Each bandage covers one-half of the previous bandage without wrapping circumferentially.
- The palm of the hand is used, not the fingers, to mold the wet bandages to avoid pressure sores through the cast.
- The limb is held in the appropriate joint positioning until the cast is set. (Figure 5)
- When dry, the calendar time, fracture location, and other documentation is written on the cast.

Figure 4. Molding a tibial cast by indenting thumbs into both sides of the patellar tendon. *(ICRC)*

Figure 5. Allowing the plaster to set on a tibial cast. *(ICRC)*

POP AFTER-CARE AND FOLLOW UP

ADVICE AND INSTRUCTION FOR PATIENTS

Give the following advice to the patient and his or her family.

- Respect drying time before ambulation.
- POP should not be covered with cloth, varnish, or a blanket until it is dry.
- The POP must not come in contact with water or any other liquid.
- Raise or elevate the leg with POP on a pillow to decrease swelling.
- Perform isometric contraction under the POP to protect against muscle atrophy and phlebitis.
- Mobilize free joints.
- Never walk on the cast without a rocker or tip.

CAST VITAL SIGNS

- Pain
- Odour
- Cleanliness
- Strength
- Colour, heat, sensation and mobility of extremities
- General fever and heart rate

DANGER SIGNS IN CASTED FRACTURES

- Increasing pain
- Motor or sensory changes
- Increasing swelling
- Seepage through or around the cast

FOLLOW UP AND SUPERVISION

- Ideally have one follow up after 24 hours
- Provide basic physical therapy exercises if needed
- Tell the patient (and family) to return if there are any concerns
- All POP not tolerated by the patient should be removed
- Ensure patients have plans that allow for clinical review and cast removal
- Ensure mobility aids are provided if needed

POSSIBLE COMPLICATIONS

- Skin (pain, burns, sores due to pressure)
- Bones (secondary displacement, osteomyelitis)
- Joints (stiffness, osteoporosis)
- Muscles atrophy (amyotrophy)
- Neurovascular complications (complex regional pain syndrome, local compressions, compartment syndrome, thromboembolism).

Figure 6. Skin reaction to POP. *(ICRC)*

REMOVING CASTS

IMMEDIATE REMOVAL OF THE POP

- If swelling, diffuse pain or lack of sensation occurs, immediately split the POP along its length.
- Should local pain occur, open a window and check the skin. Close the window with an elastic bandage or POP if there is no wound. The incident should be recorded in writing on the cast.

REMOVING CAST TECHNIQUES

- The cast may be removed by an electric cutting device or plaster shears.
- For children, or if electricity is not available, plaster shears are necessary.
- Prior to removal, gather all materials needed. These include scissors, removal tools (Figure 7), materials to wash the limb after, and supportive material.
- Position and drape the patient. For upper extremity casts the patient can be in the sitting or supine position. For the lower extremity the patient should be in the supine position.
- Determine cutting lines, and do not cut over boney prominences.
- When using plaster shears, ensure correct blade alignment with each cut, and after 4-6 cuts clear the blades, utilize the benders, and continue. Never cut around corners, remove the blade and cut from the opposite direction.
- When using an electric cutter, ensure the patient is comfortable and understands the blade will not cut their skin.
- After the cast is removed, assess the skin for any damage from removal and assess the form of the limb following immobilization.
- Wash and dry the area, and apply oil or lotion to assist in restoration of normal skin nutrition.
- The patient needs to be educated about care of the skin and of the injured limb as the muscle tone returns.
- A referral for rehabilitation is strongly advised.

PITFALL

If a window is cut to assess the skin under a cast, or for treatment of a small (type 1) open fracture, the plaster should be reapplied and fixed in place with elastic bandage to prevent the formation of "window edema".

Figure 7. Tools needed for removal and manipulation of POP. From top to bottom, oscillating saw, cast spreader, plaster shears, cast breaker. *(ICRC)*

TRACTION

TYPE 2

Surgical teams providing care in disaster response and in conflict zones **must be familiar with the principles of managing patients with fractures in traction**, which may be used as a temporary method to manage a fracture or as a definitive technique (See ICRC manual on POP and Traction for additional information).

SKIN TRACTION

- Skin traction can be used temporarily in adults with femur fractures (for no more than 48–72 hours).
- It can serve as a method to allow for placement of traction for transfer to a higher level of care.
- Skin traction can serve as a definitive method of treatment for many femoral fractures in the paediatric group.

SKELETAL TRACTION

- Skeletal traction can be used as definitive management for adults with open long bone fractures, although external fixation provides better stabilization and optimizes management of the soft tissue injury (see chapter on open fractures).
- Skeletal traction for children with hip fractures is effective and commonly used.
- Although definitive treatment with traction is not as effective in adults, it may be the only locally available treatment for adults who sustain fractures of the proximal femur, and is more effective than skin traction.

PLACEMENT OF TRACTION PINS

- Traction pins should have a centrally threaded section, as this will prevent slipping in the bone.
- This can be inserted under local anesthesia with a hand drill (for safe pin insertion see the section on open fractures).
- Traction should not be applied across an unstable joint.

KEY POINT

- When placing a Denham pin for skeletal traction in a deployment scenario, place a piece of tape on the pin and write "threaded." This is important as you cannot guarantee that you will be the one to remove the pin.
- Always check the stability of the knee joint prior to placing a traction pin for a femoral shaft fracture.

TECHNICAL ASPECTS

- Traction pins should not pass through a synovial joint space or an open physeal plate.
- Beware the proximal extent of the knee joint and the proximal tibial physis in children.
- Check stability of the knee prior to inserting a traction pin for a femoral shaft fracture.
- If the knee is unstable, insert the pin in the distal femoral metaphysis.
- During insertion, start from the safe side—where the vessels and nerves at risk can be localized and avoided by careful selection of the insertion point.
- Distal femoral traction pins should be inserted from medial to lateral to avoid the adductor canal and femoral artery.
- Proximal tibial pins should be inserted from lateral to medial to avoid the common peroneal nerve as it passes around the neck of the fibula.
- Calcaneal pins should be inserted medial to lateral to avoid the posterior tibial neurovascular bundle.
- A Thomas splint or variant can be used for temporary stabilization, or for definitive care for a patient with a femoral shaft fracture.
  - These are commonly used for temporary treatment, either until femoral nailing can be safely performed, or to transport a patient to another surgical centre.
- If using a Thomas splint as a treatment option (more common in children), the ring must fit the patient, and attention must be paid to correctly padding and adjusting the traction equipment to prevent pressure areas in the groin.

Figure 8. Thomas splint. *(ICRC)*

Figure 9. Traction pin placed in the femoral metaphysis and an empty vial used as a pin guard. *(ICRC)*

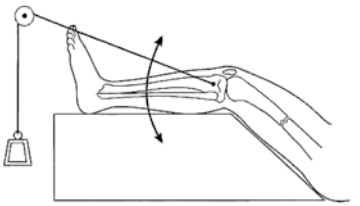

Figure 10. The larger force applied in skeletal traction is transmitted along the axis of the limb via a pin, pulley and a weight. *(ICRC)*

- Adults with femoral shaft fractures being managed in skeletal traction are often on a Böhler-Braun frame.
- This allows elevation of the lower limb, and knee flexion during traction. The frame must fit the patient and be suitably lined.
- In the absence of a Böhler-Braun frame, a split Hamilton Russell or a Thomas splint can be used for traction.

Figure 11. Construction of a traction frame in the field. *(J. von Schreeb)*

Figure 12. Alternative method to a Böhler-Braun frame for a proximal femur fracture. *(ICRC)*

Figure 13. Preparation of a Bohler-Braun Frame. *(ICRC)*

KEY POINT

- Patients in traction often develop an equinus deformity of the foot.
- This can be prevented with active and passive physiotherapy using bands and/or foot slings.
- Pressure sores of the heel and sacrum should be prevented, and DVT prophylaxis, if available, is indicated.

PAEDIATRIC CONSIDERATIONS

TRACTION AS DEFINITIVE CARE

- Children who have femoral shaft fractures are commonly treated in traction with union occurring in approximately the patient's age in years plus one week.
- Patients less than 8 should be treated with early Spica casting under sedation 1-3 days after fracture.
- Fixed traction using adhesive skin or skeletal traction in a Thomas splint is possible. Hamilton Russell Traction is possible as well and does not require a Thomas splint.
- Some surgeons view the Thomas splint as primarily useful for transport as the device can lead to pressure sores in the groin.
- Children under the age of 2 years with a femoral shaft fracture can be managed in Gallows traction.
- Children under the age of 6 months can be managed in a "Soft Spica" built with padding and bandages or by using a Pavlik harness if available.
- Weights required are minimal (1-2 kg) and should be over a pulley on an overhead bar, not tied off to the bar.

SKELETAL TRACTION

- Skeletal traction for children with hip fractures is effective and commonly used.
- Skeletal traction is the best choice for:
  - Initial immobilization of most femoral and some tibial and humeral fractures
  - Definitive immobilization of fractures of the femur
  - Definitive immobilization of particularly difficult fractures of the tibia near the knee and of the humerus near the elbow
  - Traction pins in children should not be placed near the tibial tuberosity as they may cause an anterior growth arrest and subsequent recurvatum deformity. They should be placed in the distal femur 1 cm proximal to the growth plate.

Figure 14. Gallows traction from a beam. *(ICRC)*

Figure 15. Patient in skeletal traction. *(ICRC)*

DISADVANTAGES OF SKELETAL TRACTION AND CONSIDERATIONS

- The principal disadvantage of skeletal traction is prolonged bed rest, along with increased demands on both nursing and physiotherapy care.

TRANSFERS

» An injured patient may have the opportunity for evacuation from the first hospital to a higher level of care.

» The patient needs to be consulted about a transfer and the transfer should be discussed with their family or support system.

SKIN TRACTION AND TRANSFERS

» Transport of a patient with a long bone fracture can be facilitated by using skin traction for a limited amount of time during the transport. Skin traction for transport should be adhesive in children and non-adhesive in the adult.

» Femoral shaft fractures in adults can be managed during a short distance transfer by continuing traction with a weight on a traction pin, but this should be avoided if possible.

» An alternative is the application of a Donway, Hare or Thomas splint. ***These splints cannot be used in the presence of ipsilateral pelvic fracture***.

» Another option is bandaging the fractured limb to the intact limb with slings or strips of fabric.

AIR TRANSPORT

» Consider a prophylactic fasciotomy of the calf prior to transfer due to pressure changes.

TRANSFERS IN CASTS

» Any patient in a full cast should have the cast split to skin for transfer.
  - This is done due to swelling and to minimize the risk of a tight cast/compartment syndrome during the transfer.

» Elevate the patient's hand or foot as appropriate to prevent distal limb swelling.

» Avoid hanging an arm in fabric on a pole beside the bed.
  - The edge of that fabric will cause an ulnar nerve neuropathy if it is allowed to compress the posterio-medial aspect of the elbow.
  - Simply elevate the hand on the abdomen, or prop it to be well above the elbow at rest.

MANAGEMENT OF CLOSED FRACTURES WITH INTERNAL FIXATION

H
TYPE 3

BEWARE THE RISKS OF INTERNAL FIXATION

LIMITED INDICATIONS IN DISASTER AND EMERGENCY SITUATIONS

- Only indicated if the situation has stabilized and a type 3 team is integrated into a local facility with prior history of performing internal fixation.
- Incidence of 50-80% of infection has occurred when internal fixation was used as a primary means of treatment.
- Consider transferring the patient to a more advanced facility if internal fixation is necessary.
- Evaluation of patient's normal environment, safety, risk of complications, and available resources must be considered before closed fracture internal fixation is performed.
- The principal methods of Plaster-Of-Paris, skeletal traction, and external fixation are viable options for many fractures and should be the first choice in disaster and conflicts.

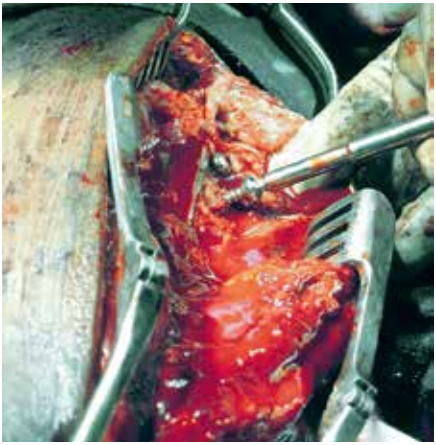

Figure 16. Pus pours from a wound treated with internal fixation. The plates and screws must now be removed. *(ICRC)*

SUGGESTED RESOURCES

1. Gosselin RA. War injuries, trauma, and disaster relief. *Techniques in Orthopaedics* 2005; **20**(2): 97-108.
2. Ngota DO, Friedel F. Plaster of Paris and Limb Traction: ICRC Physiotherapy Reference Manual. ICRC; 2009. p.101.

REFERENCES

1. Giannou C, Baldan M. War surgery: Working with limited resources in armed conflict and other situations of violence, Volume 2. Geneva: International Committee of the Red Cross; 2013.
2. Giannou C, Baldan M. War surgery: Working with limited resources in armed conflict and other situations of violence, Volume 1. Geneva: International Committee of the Red Cross; 2009.
3. Norton I, Von Schreeb J, Aitken P, Herard P, Lajolo C. Classification and minimum standards for foreign medical teams in sudden onset disasters. *Geneva: World Health Organization*; 2013.
4. Herard P, Boillot F. Amputation in emergency situations: indications, techniques and Médecins Sans Frontières France's experience in Haiti. *International Orthopaedics* 2012: 1-3.
5. Dufour D, Jensen SK, Owen-Smith M, Salmela J, Stening GF, Zetterström B. Surgery for victims of war. 1998.
6. Coupland RM. War wounds of limbs: surgical management. 1993.
7. Hayward-Karlsson J, Jeffery S, Kerr A, Schmidt H. Hospitals for the War Wounded: a practical guide for setting up and running a surgical hospital in an area of armed conflict. Geneva: International Committee of the Red Cross; 2005.
8. ICRC Guidelines for Teaching Nursing Care. Internal Document: International Committee of the Red Cross ICRC.

EMT Website: https://extranet.who.int/emt/page/home
AO/ICRC/WHO Training Resources: http://www.aofoundation.org/icrc