Principles of Cast Application

Mahmmud Alqawasmi (PGY-5)

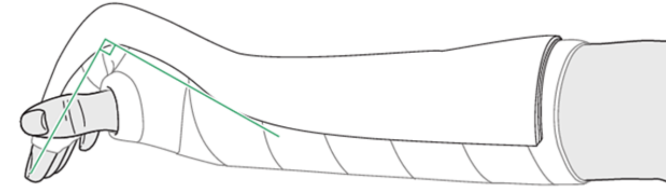
Introduction

- **Definition**
  - A cast is a supportive structure that surrounds an injured body part to protect, immobilize, and promote healing of fractures and soft tissues.

Splints and casts: indications and methods - PubMed. (n.d.).
https://pubmed.ncbi.nlm.nih.gov/19725490/

Splints vs. Casts

- **Splints → noncircumferential** immobilizers that accommodate swelling.
  - Ideal for acute musculoskeletal conditions in which swelling is anticipated



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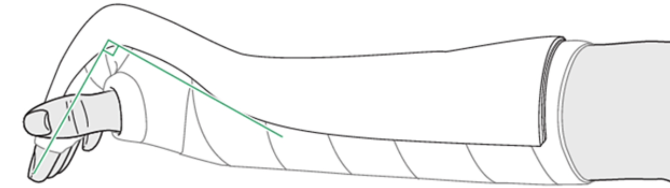
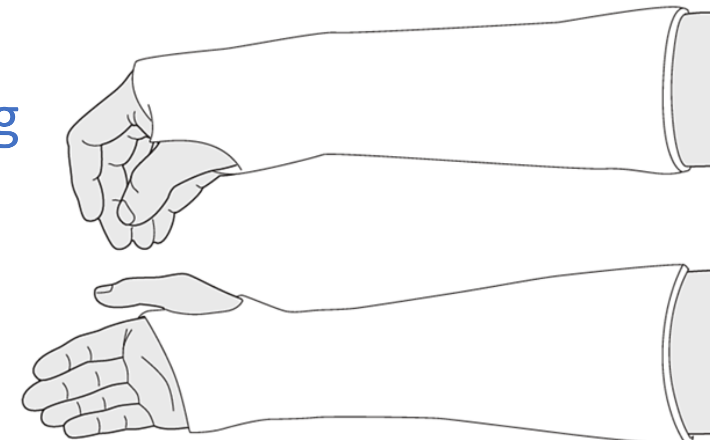


- **Casts → circumferential** immobilizers.
  - Casts provide superior immobilization but are less forgiving
  - Have higher complication rates
  - Generally reserved for complex and/or definitive fracture management.



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History

American Academy of Orthopaedic Surgeons

Exhibit Selection

Plaster: Our Orthopaedic Heritage

AAOS Exhibit Selection

Marlene DeMaio, MD (CAPT MC, USN), Kathleen McHale, MD (COL MC, USA [ret]), Martha Lenhart, MD, PhD (COL MC, USA), Joshua Garland, MD (LCDR MC, USN), Christopher McIlvaine, and Michael Rhode, BA

Investigation performed at the Naval Medical Center, Portsmouth, Virginia

History

- The earliest known splinting of extremities involves **sticks and bandages** of palm fiber with linen found **in prehistoric remains and in mummies**

- **The Romans**, world-renowned for their development of concrete and art plaster frescoes, **did not apply plaster to medical bandages**

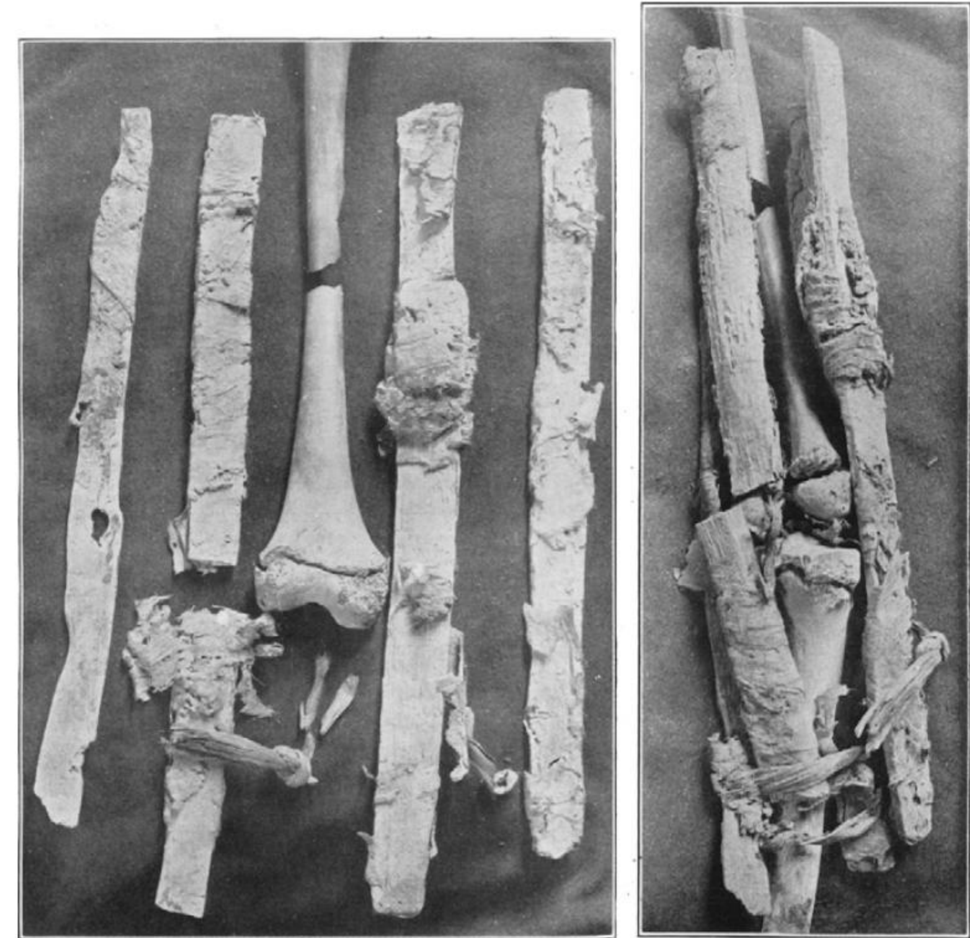


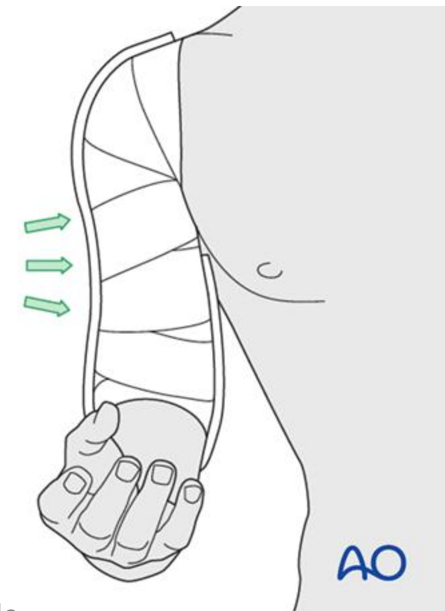
Fig. 1
An ancient splint from an Egyptian mummy with a fractured femur, documented in the Edwin Smith Papyrus (Reproduced from: Br Med J. 1908 Mar 28;1[2465]:732-62, copyright 1908, with permission from BMJ Publishing Group Ltd.)

DeMaio, M., McHale, K., Lenhart, M., Garland, J., McIlvaine, C., & Rhode, M. (2012). Plaster: our orthopaedic heritage: AAOS exhibit selection. The Journal of Bone and Joint Surgery. American Volume, 94(20), e152(1).

History

- **The first record** of the use of plaster for stiffening bandages was by the **Arabian surgeon (Ebn-Sina)** in the **ninth century.**
  - He described linen bandages with calcium oxide (lime from sea shells) and albumen (from egg whites)

- **Albucasis** (Abul al-Qasim Khalaf ibn al-Abbas Al-Zahrawi)
  - In the eleventh century, he developed the **"coaptation" splint**



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History

- The widespread use of Plaster of Paris casts **during World War I and World War II** further advanced the techniques and popularity of this method for treating fractures.
  - The need for quick and effective treatment of bone injuries on the battlefield highlighted the importance of Plaster of Paris in orthopedic care.

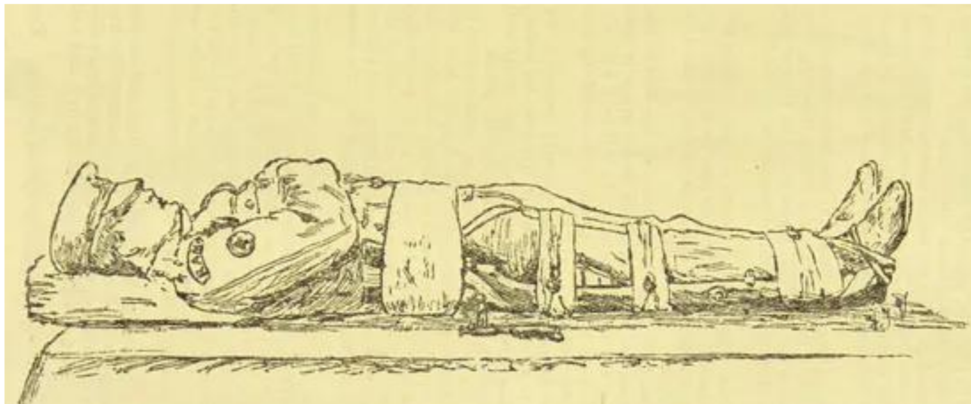

Fig. 2
A man in a body cast, circa World War I (National Museum of Health and Medicine, Reeve Collection 10015).

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History

- **By the mid-20th century**,
  - **Synthetic alternatives** to Plaster of Paris, such as fiberglass, began to be developed.
  - These new materials offered advantages such as **lighter weight**, **increased durability**, and **water resistance**.
  - However, Plaster of Paris **remained a widely used and cost-effective option** for many applications.

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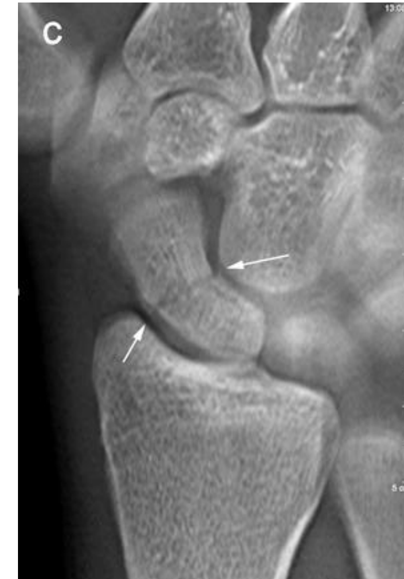
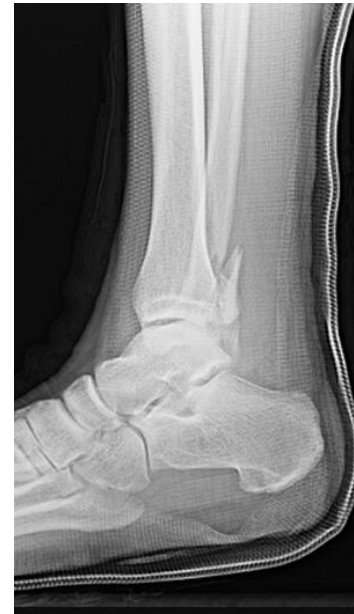
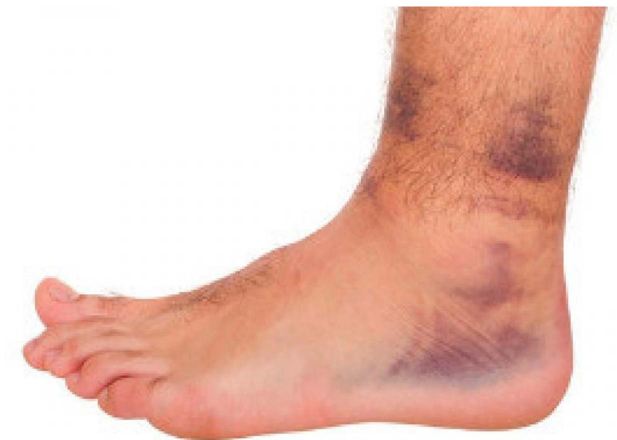
Cast Indications

1. **Temporary stabilization of acute fractures**, **sprains**, or **strains**
2. **Definitive management** of specific **stable** fracture patterns
3. **Immobilization of a suspected occult fracture**, such as a scaphoid fracture
4. **Severe soft tissue injuries** requiring immobilization and protection from further injury







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Revolution in orthopedic immobilization materials: A comprehensive review. Heliyon, 9(3), e13640.

Cast Indications

5. **Treatment of joint instability**, including dislocation
6. **Deformities correction**, e.g: clubfoot and ponseti technique
7. **Pain control**
8. **Post Tendon and joint ligamentous repair**

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Cast Materials

- ***Plaster of Paris***
  - **The most popularly used casting and splinting material to this date**
  - 85% Calcium Sulphate
  - Rapid exothermic reaction
  - For proper crystal interlocking, **immobility** of the plaster cast is essential.
    - This is called "**The Critical Point**", where immobility of the plaster is imperious for it to set properly and become rigid for ultimate strength gain

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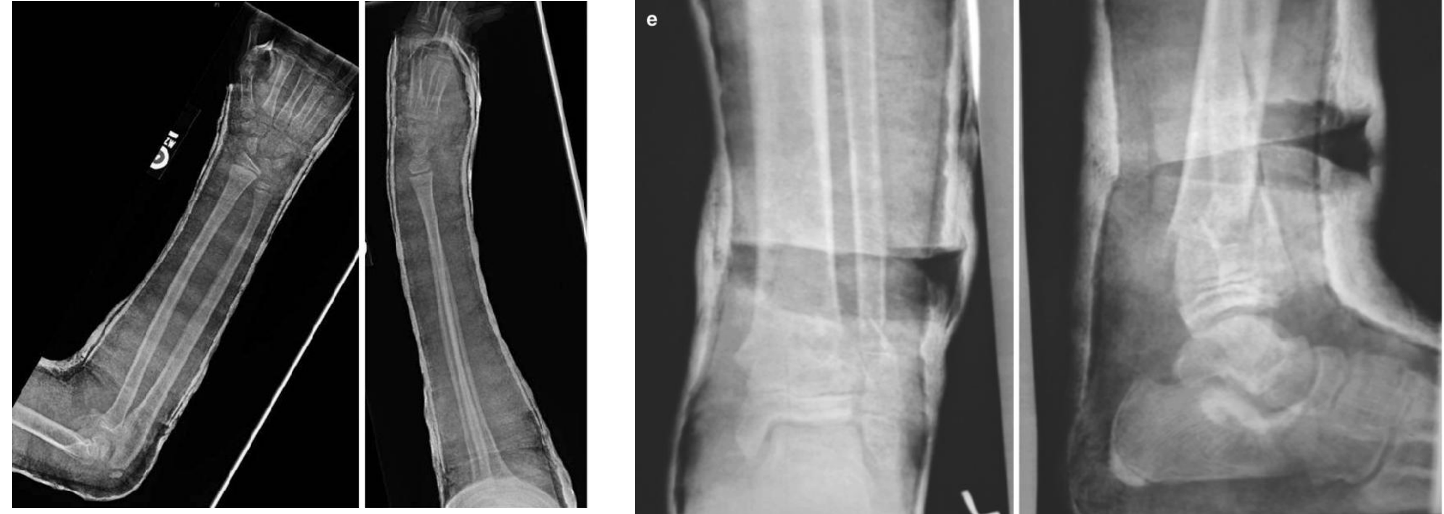
Cast Materials

- ***Plaster of paris***
  - **Advantages**
    - Good availability
    - Low cost
    - Better molding
  - **Disadvantages**
    - Plaster is brittle
    - Has poor mechanical properties
      - The low fatigue strength of plaster results in increased cast breakage during weight bearing and movement
    - The high mineral content and crystallization of plaster, attenuates and scatters x-rays, difficult to carry out proper x-ray diagnosis



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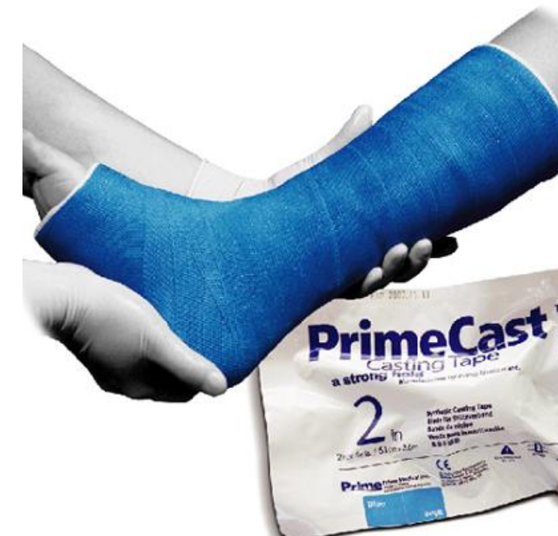
Cast Materials

- ***Fiberglass casts***
  - Also known as Glass-reinforced plastic (GRP)
  - Is a composite material made from **fine fibers of glass** and a **resin matrix**

  - The combination of these materials results in a product that is **lightweight**, **strong**, and **versatile**, making it suitable for a wide range of applications.

  - Fiberglass tape is dipped in water at 20–25 ◦C to activate the resin and applied in the same manner as plaster casts.



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Cast Materials

- ***Fiberglass casts***
  - **Advantages**
    - Lightweight (i.e. 1/3 the weight of plaster casts)
    - More durable
    - Quicker setting times and strength (2–3 times stronger than plaster)
    - Porous material hence it reduces the risk of skin related issues making it suitable for long term immobilization
    - Higher radiolucency than plaster
  - **Disadvantages**
    - Inferior molding properties than plaster.
    - Less forgiving
    - Technicians require gloves during application and molding of fiberglass casts due to adherence of the water activated resin to the skin and clothes

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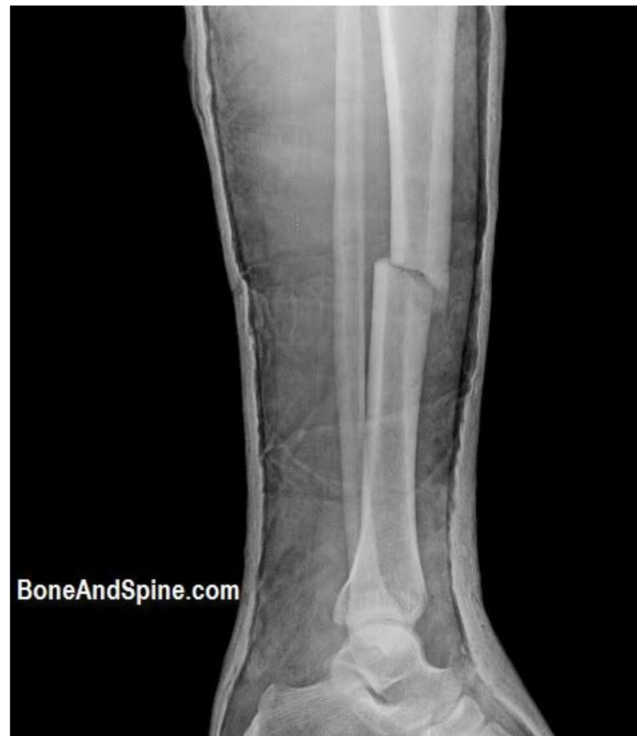
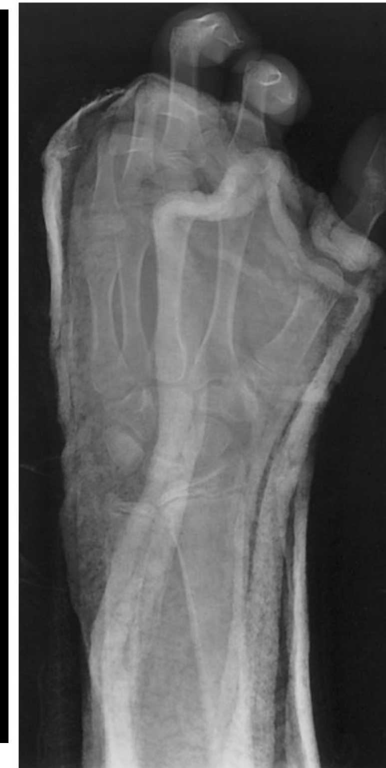
Cast Application Principles

- **The ideal cast** has a long list of **factors** that need to be considered to ensure a high quality of patient care.

- **A good cast should**
  - immobilize the extremity,
  - remain comfortable,
  - not cause complications.

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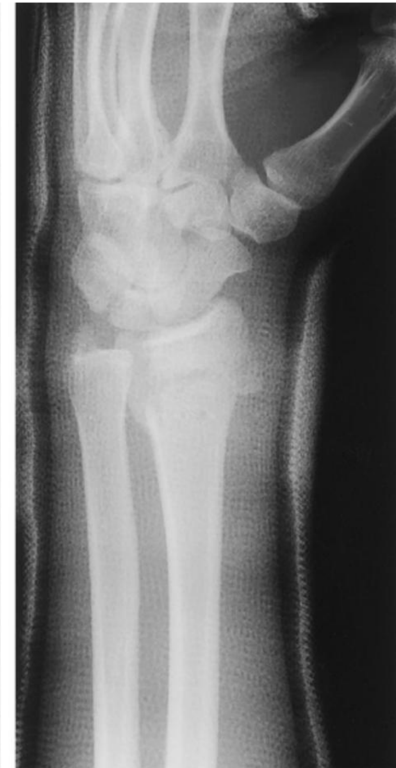

b.

Nguyen, S., Schlechter, J., & McDowell, M. (2016).
Casting: Pearls and pitfalls learned while caring for children's fractures. World Journal of Orthopedics, 7(9), 539.

Cast Application Principles

- The plaster should be **one solid line with no onion-skinning appearance**
- A badly made cast will have **uneven plaster thickness**, **show "onion skinning,"** and **appear fuzzy**

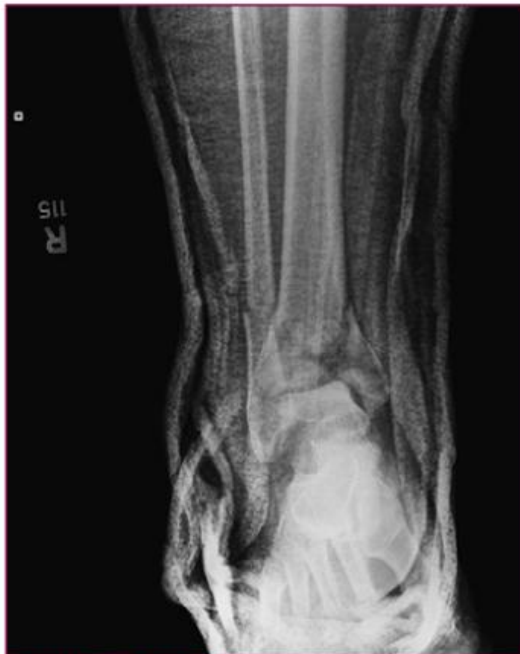


FIGURE 12-88

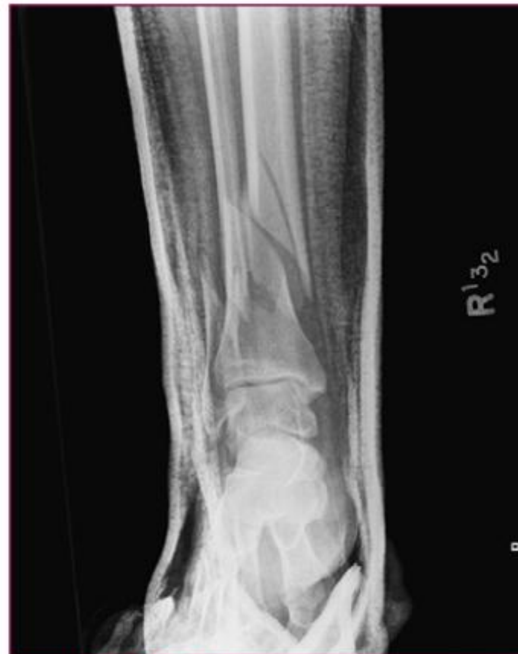


FIGURE 12-89

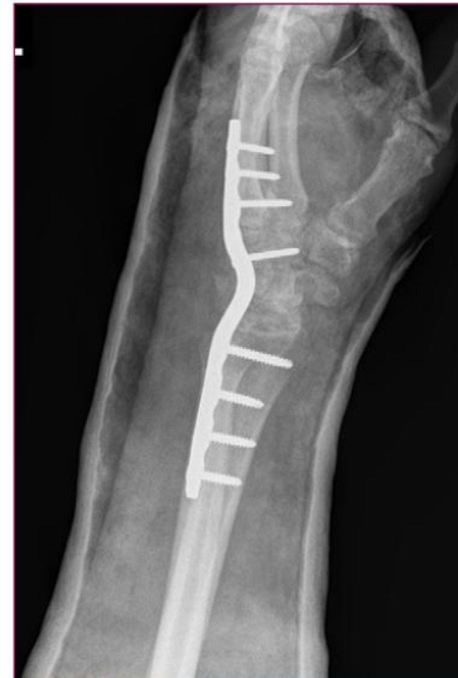


FIGURE 12-65

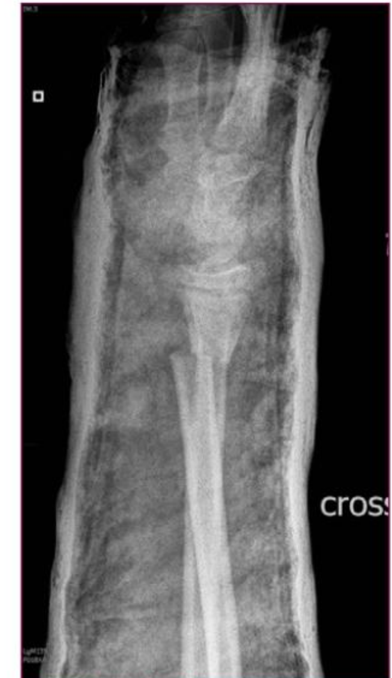


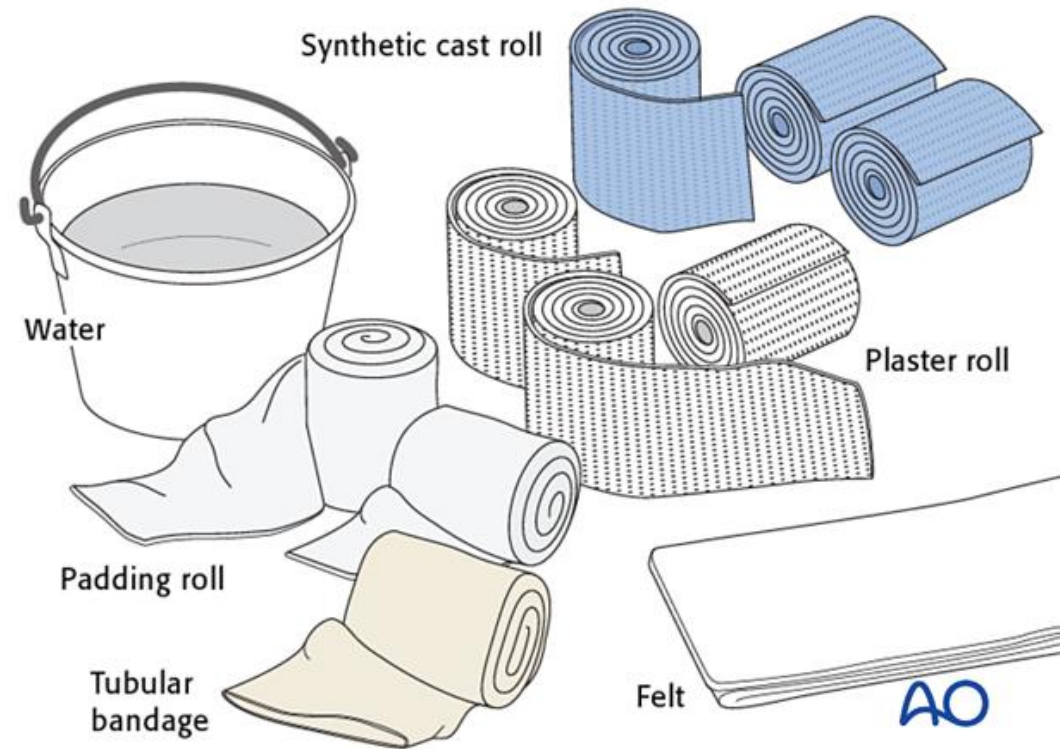
FIGURE 12-66

Cast Application Principles

- **Steps:**
  1. Lining layer over skin (stockinette)
  2. Cotton padding
  3. Application of POP or dyna cast
  4. Molding
  5. Splitting if needed
  6. Elastic bandage

Cast Application Principles

- **Equipment**
  - Sheet or towel to protect the patient's clothing
  - Stockinette or fabric underpadding
  - Undercast padding, typically cotton
  - Plaster or padded fiberglass
    - Wider material is appropriate for upper arm or lower extremity splints
    - Narrower material is appropriate for forearm splints
  - Water bucket filled with cool water. (20 cel deg)
  - Elastic bandage
  - Sling for upper extremity injuries



Casts, Splints, and Support Bandages: Nonoperative Treatment and Perioperative Protection
Klaus Dresing, Peter G Trafton

Cast Application Principles

- **Cast Padding**
  - Roll distal to proximal
  - **50% overlap**
  - Minimum of 3 layers thickness
  - **Extra padding** at bony prominences
  - Avoid wrinkles in stockinette

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.

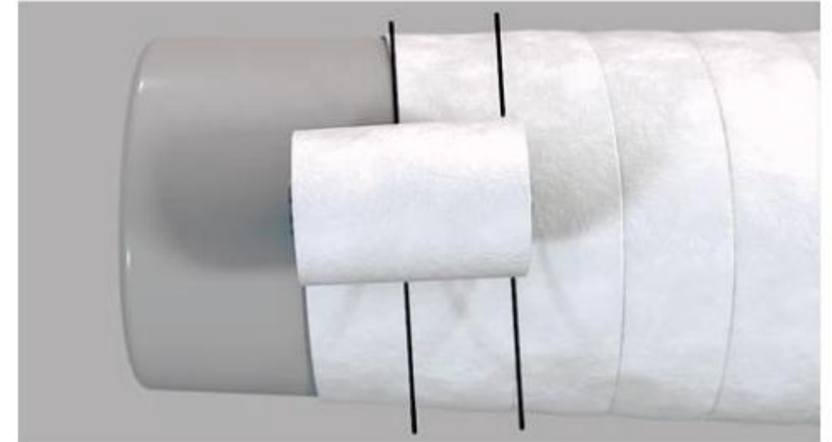
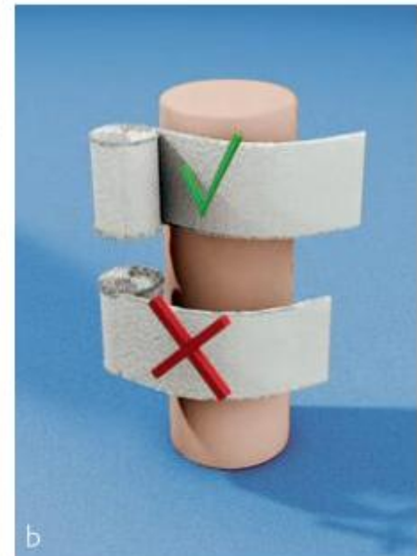


Fig 14.1-40 The half-overlapping technique.



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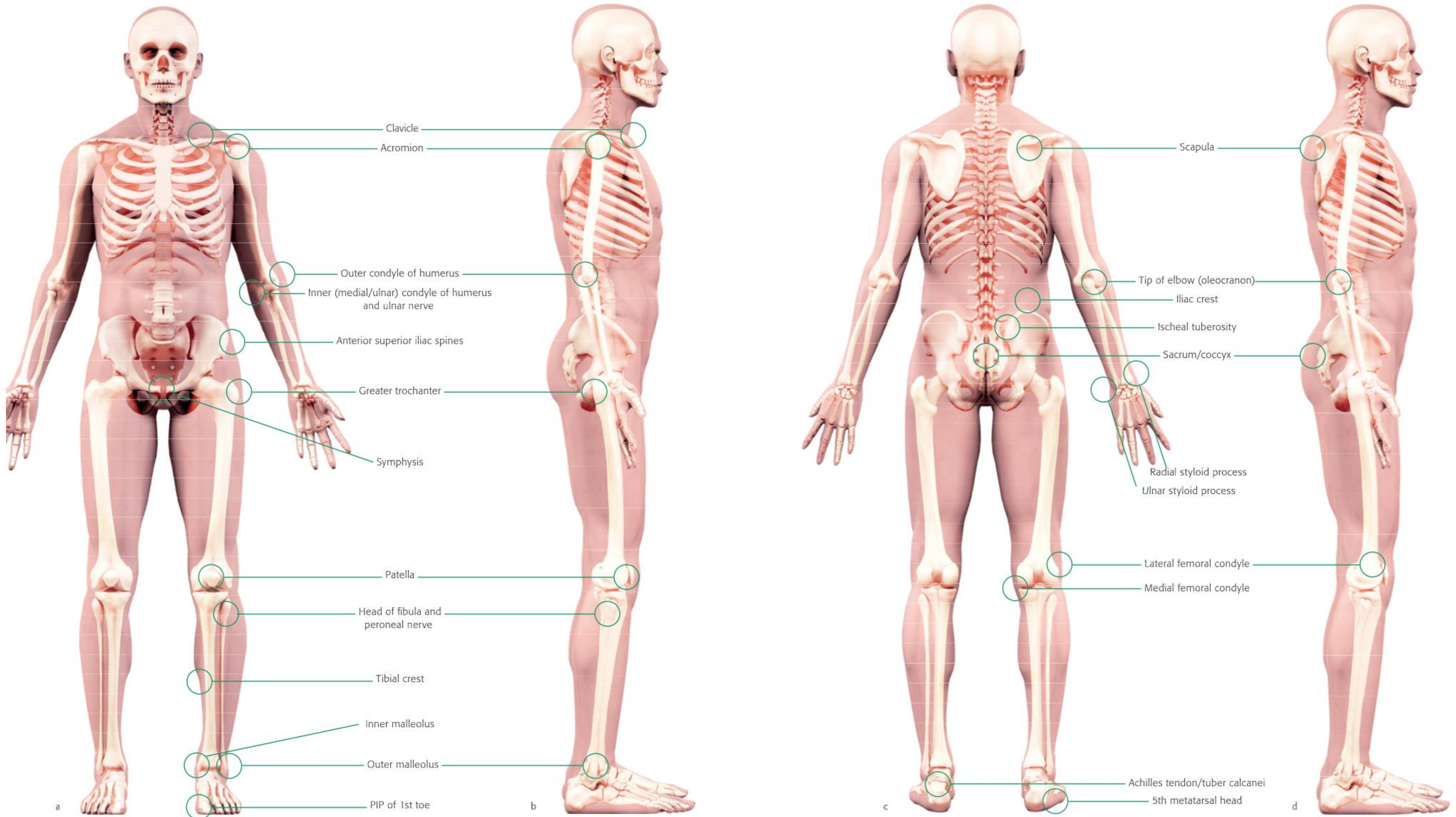


Fig 14.1-3a–d Bony prominences, nerves, and vessels needing extra padding.

Cast Application Principles

- **Measure length of the splint**
  - **Number of cast layers depends on:**
    - Casting material used
    - Patient's weight
    - Body region (LL vs UL)
      - 12-14 layers in UL, 14-16 in LL
    - Expected compliance

- **Importance of Molding:**
  - Dry layers reduce the quality and strength of the splint

  (puff pastry plaster)

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

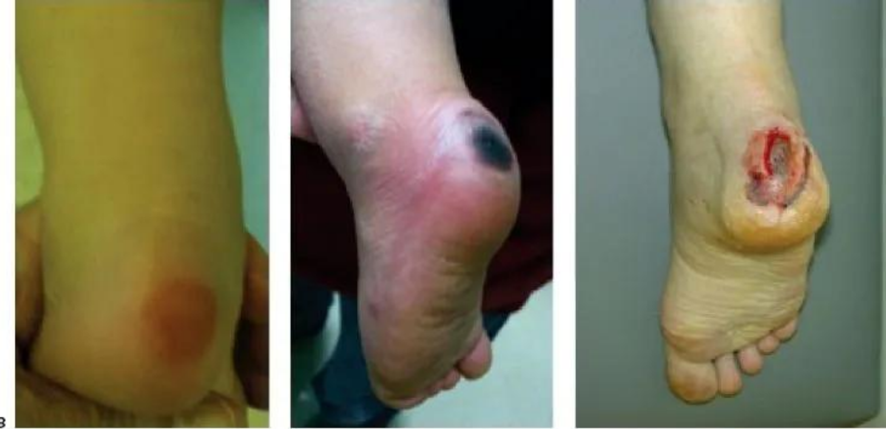
Fig 14.1-33 Puff pastry plaster.

Casts, Splints, and Support Bandages: Nonoperative Treatment and Perioper
Klaus Dresing, Peter G Trafton

- Plaster of Paris
- Padding
- Crepe
- Scissors
- Tape
- Water
- Bucket
- PPE
- Protective sheet

Complications

- ***Pressure sores***
  - The signs and symptoms of pressure sore progression
    - pain and burning sensation
    - localized heat
    - cast odor
    - staining through the cast and pyrexia (in children)
  - Application of adequate padding over **bony prominences**, **pressure points** and **cast edges** is recommended.

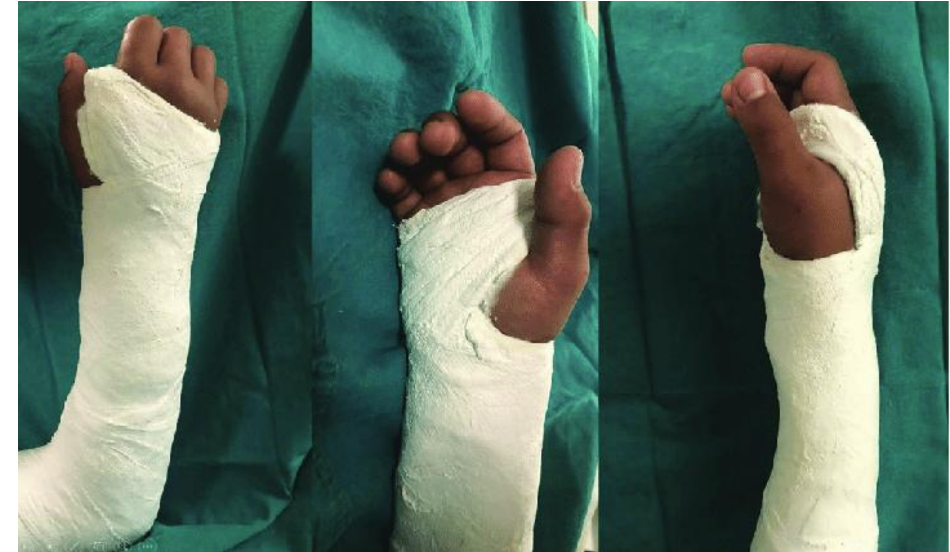


- ***Skin irritation and maceration***
  - **Itching** due to **wetting** of the casts or sweating, which results in **foul odour** and **skin irritation**
  - Patients are warned against using sharp objects to scratch beneath the cast as this can risk **infection** and **skin abrasion.**
  - Temporary treatments for cast related skin irritation include antihistamine medication and blowing cool air down the cast

Ekanayake, C., Gamage, J. C. P. H., Mendis, P., & Weerasinghe, P. (2023).
Revolution in orthopedic immobilization materials: A comprehensive review. Heliyon, 9(3), e13640.

Complications

- ***Compartment syndrome***
  - Increased tissue pressure within a limited space, compromising circulation and tissue function can lead to compartment syndrome



- ***Deep vein thrombosis (DVT)***
  - Significantly seen in the **adult** population with **prolonged lower extremity immobilization**
  - Studies have shown that the probability of DVT is 15–36% in adults, when placed in lower extremity casts for an average of 21 days.
  - **Prophylactic anticoagulants** recommended in **risky** patients

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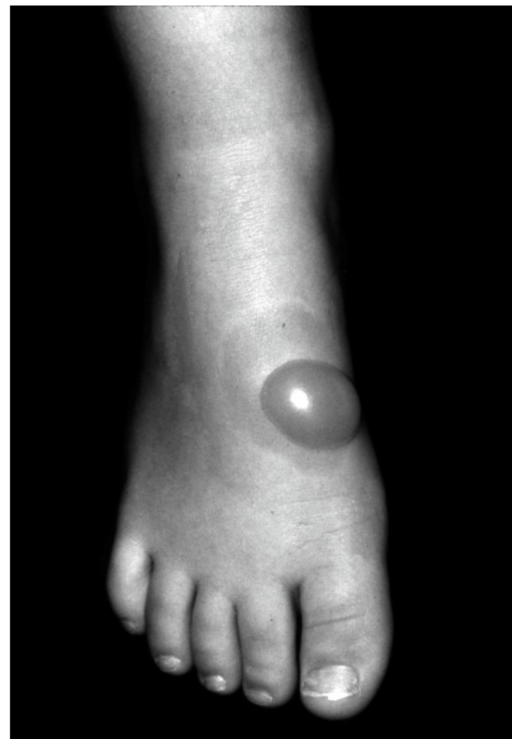
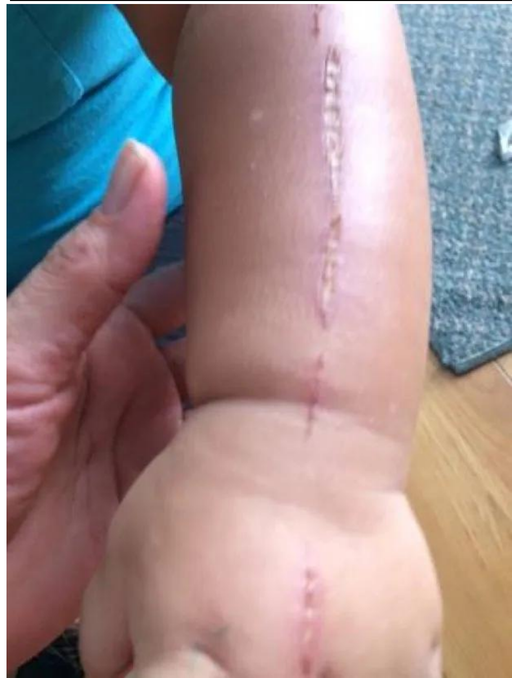
Complications

- ***Thermal burns***
  - The risk of thermal injury is strongly associated with elevated temperatures underneath the cast.
  - **The contributing factors** include
    - High dip water temperature (>50 ◦ C)
    - Thicker casts (more than 24 layers)
    - Lower ventilation during application.

- ***Cast saw burns***
  - Technicians have to **take precautions** to avoid cast removal complications especially when using cast saws for removal of casts with waterproofing liners.





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Complications

Technicians have to be careful

- **Not to overheat the saw** blades when cutting long casts
- **Proper inspection of the blades**
- **Frequent blade changes**
- **Use of sharp blades**
- **Avoiding sliding** of the oscillating saw along the cast
- **Using proper cutting techniques** can greatly reduce the risk.

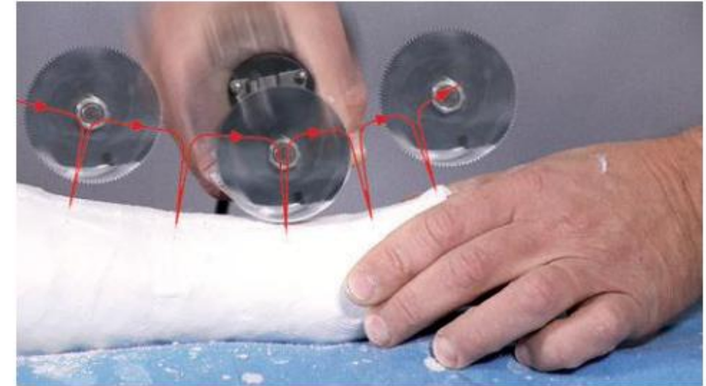

Fig 14.1-47 Lifting the saw blade, rotating the blade slightly by hand, then reapplying the saw further along the cast greatly reduces heat generation.

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

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Follow-up

- Time to follow-up and length of immobilization are **extremely variable**
  - Depending on the site, type, and stability of the injury and on patient characteristics (e.g., age, accessibility, compliance).
- Most splints and casts require initial follow-up **within one to two weeks after application.**

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Patient Eduaction

- Emphasizing the “do’s and dont’s” of cast care is **imperative on preventing complications.**

- After each cast application, **the practitioner should have a discussion with the child and family** that touches on numerous factors on cast care maintenance that should include
  - How to prevent cast from becoming wet,
  - Avoiding inserting objects into the cast
  - How to handle certain irritating symptoms such as itchiness.
  - Limb elevation
  - If can bear weight on it or not

- It is extremely important that patients continually check for signs of compartment syndrome and report immediately to an urgent or emergent care facility for removal of the cast or splint at the first sign of vascular compromise

Nguyen, S., Schlechter, J., & McDowell, M. (2016).
Casting: Pearls and pitfalls learned while caring for children’s fractures. World Journal of Orthopedics, 7(9), 539.

Types of Casts

Table 2. Commonly Used Splints and Casts

Area of injury	*Type of splint*	*Type of cast*
Hand/finger	Ulnar gutter, radial gutter, thumb spica, finger	Ulnar gutter, radial gutter, thumb spica
Forearm/wrist	Volar/dorsal forearm, single sugar-tong	Short arm, long arm
Elbow/forearm	Long arm posterior, double sugar-tong	Long arm
Knee	Posterior knee, off-the-shelf immobilizer	Long leg
Tibia/fibula	Posterior ankle (mid-shaft and distal fractures), bulky Jones	Long leg (proximal fracture), short leg (mid-shaft and distal)
Ankle	Posterior ankle ("post-mold"), stirrup, bulky Jones, high-top walking boot	Short leg
Foot	Posterior ankle with or without toe box, hard-soled shoe, high-top walking boot	Short leg, short leg with toe box for phalanx fracture

Splints and casts: indications and methods - PubMed. (n.d.).
https://pubmed.ncbi.nlm.nih.gov/19725490/

Upper Limb Splints

- **Dorsal Short Splint**
  - **Use:**
    - **Nondisplaced or minimally displaced fractures of the distal wrist,**
      - Colles and Smith fractures
      - greenstick, buckle, and physeal fractures in children
    - **Carpal bone fractures**
  - **Application:**
    - Extends from proximal forearm to MCP distally on the dorsal side
  - **Position of Function:**
    - The wrist is in a neutral position and slightly extended; the MCP joints are free.

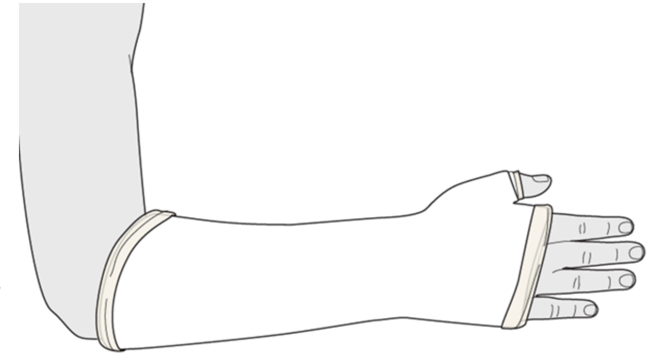

Fig 14.1-37 When applying a cast, joint motion should be possible without any restriction. During flexion, a gap of two fingers breadth (approximately 2-3 cm) should exist between the proximal cast and the proximal limb segment, as shown here for the elbow. On the extensor side, the cast can approach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

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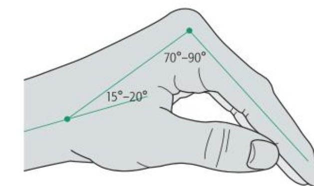
Upper Limb Splints

- **Volar Splints**
  - **Use:**
    - Soft tissue injuries of the **hand** and **wrist**
    - Temporary immobilization of **carpal bone dislocations or fractures**
    - **Metacarpal fractures**
  - **Application:**
    - Extends from proximal forearm to the tip of the little finger
  - **Position of Function:**
    - Wrist in 15 deg extension, MCP in 70 deg flexion, IPJs in extension

Fig 14.1-18 Functional position of the fingers.



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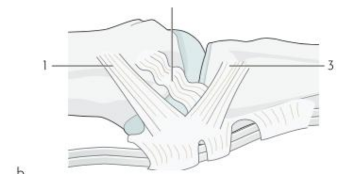
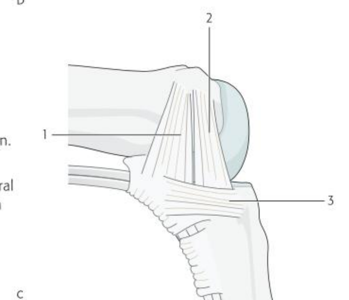


b



c

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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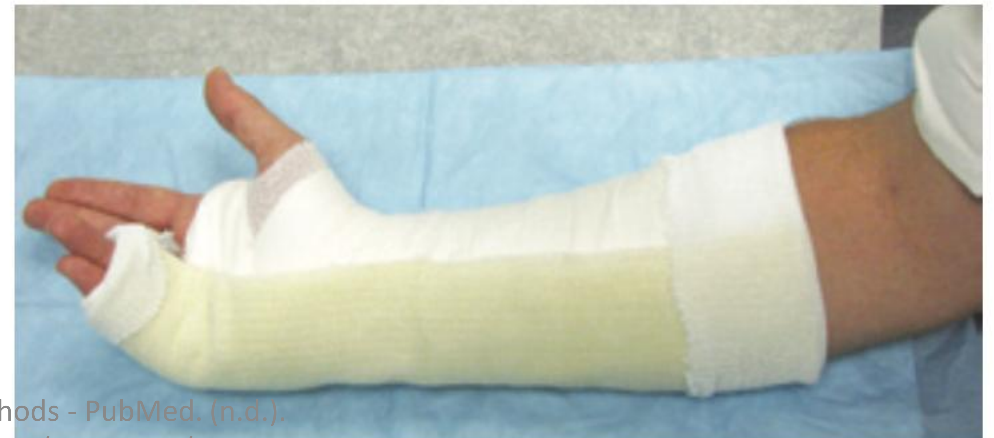
Upper Limb Splints

- **Ulnar Gutter:**
  - **Use:**
    - Nondisplaced, stable fractures of the head, neck, and shaft of the **fourth or fifth metacarpal or phalanges** with mild angulation and no rotational deformities;
    - **Boxer’s** fractures
  - **Application:**
    - The splint begins at the proximal forearm and extends to just beyond the distal interphalangeal (DIP) joint
  - **Position of Function:**
    - Wrist in 15 deg extension,

    MCP in 70 deg flexion, IPJs in extension



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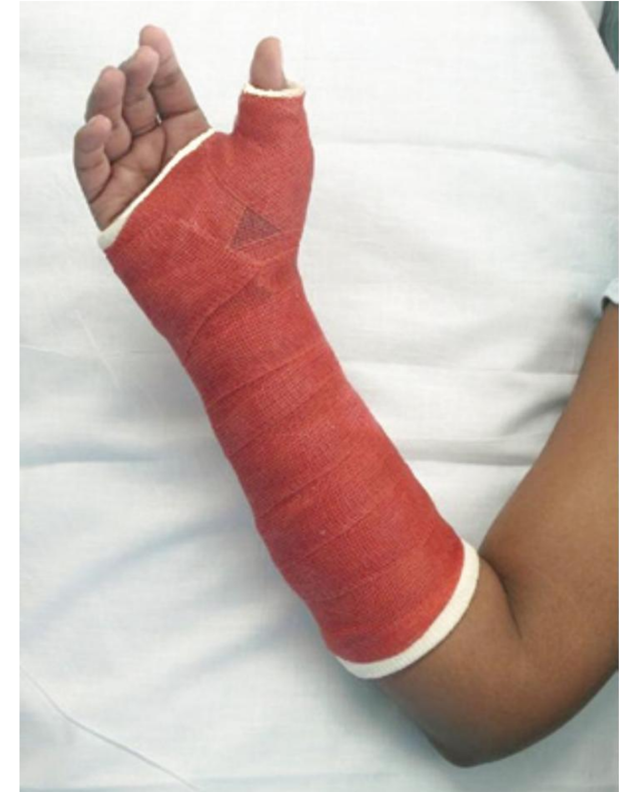
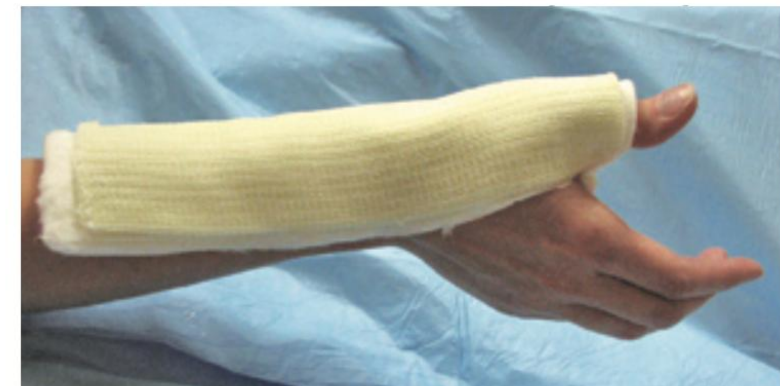
Upper Limb Splints



- **Thumb Spica**
  - **Use:**
    - Suspected injuries to the **scaphoid**;
    - Stable **ligamentous injuries to the thumb;**
    - Initial treatment of **non-angulated, nondisplaced, extra-articular fractures of the base of the first metacarpal**;
    - De Quervain tenosynovitis.
  - **Application:**
    - The splint covers the radial aspect of the forearm, from the proximal one third of the forearm to just distal to the interphalangeal joint of the thumb, **encircling the thumb**



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Upper Limb Splints

- **Above Elbow Cast:**
  - **Use:**
    - Acute and definitive management of **elbow**, **proximal and mid-shaft forearm**, and **wrist** injuries;
    - acute management of distal radial (nonbuckle) and/or ulnar fractures in children.
  - **Application:**
    - The splint extends from the axilla over the posterior surface of the 90-degree flexed elbow, and along the ulna to the proximal palmar crease
  - **Position of Function:**
    - The elbow is flexed to 90 degrees

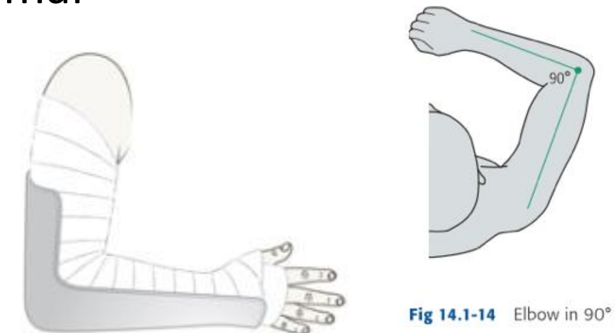

Fig 14.1-14 Elbow in 90° flexion.

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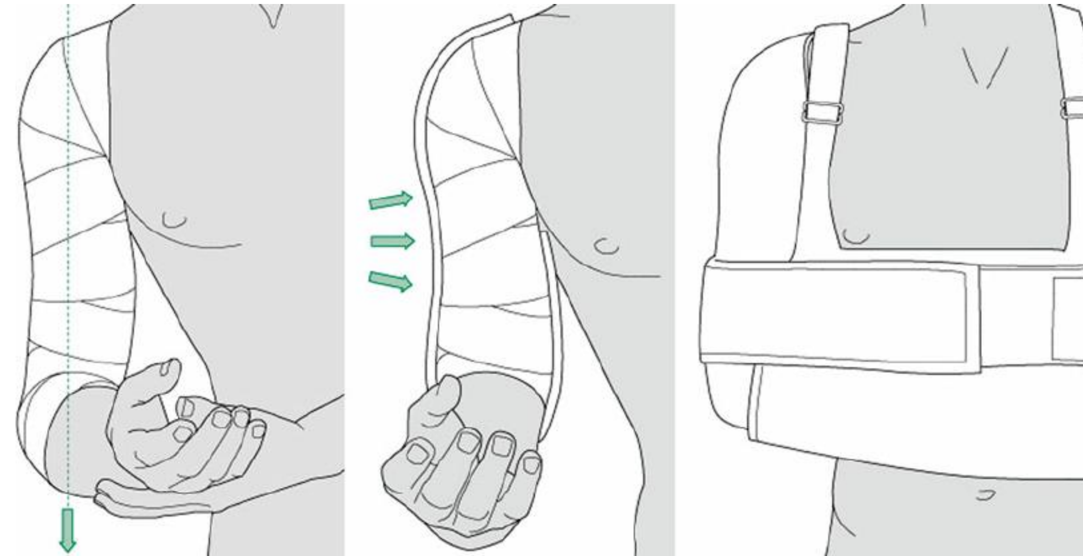
Upper Limb Splints

- **Coaptition splint**
  - **Use:**
    - Accepted alignment proximal humerus and spiral or oblique humeral shaft
  - **Application:**
    - U-shape, with padding under the axilla. Wrap it from medial to lateral and over the shoulder



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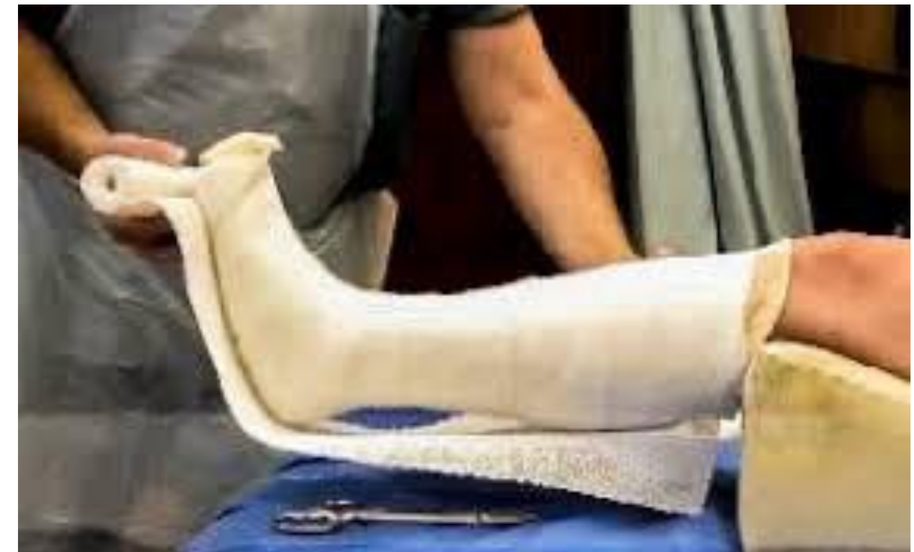
Lower Limb Splints

- **Below knee Back slab**
  - **Use:**
    - Acute, severe **ankle sprain**
    - **Nondisplaced, isolated malleolar fractures;**
    - Acute **foot** fractures and soft tissue injuries
  - **Application:**
    - The splint extends from the plantar surface of the **metatarsal heads** along the posterior lower leg and **ends 2 inches distal to the fibular head** to avoid compression of the common peroneal nerve
  - **Position of Function:**
    - Ankle dorsiflexed to 90 degrees.



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Lower Limb Splints

- **Long Leg Cast**
  - **Use:**
    - Undisplaced or minimally displaced **Tibia shaft,**
    - **Leg both bone** fracture, to maintain reduction of displaced fractures
  - **Application:**
    - Extended to above knee level

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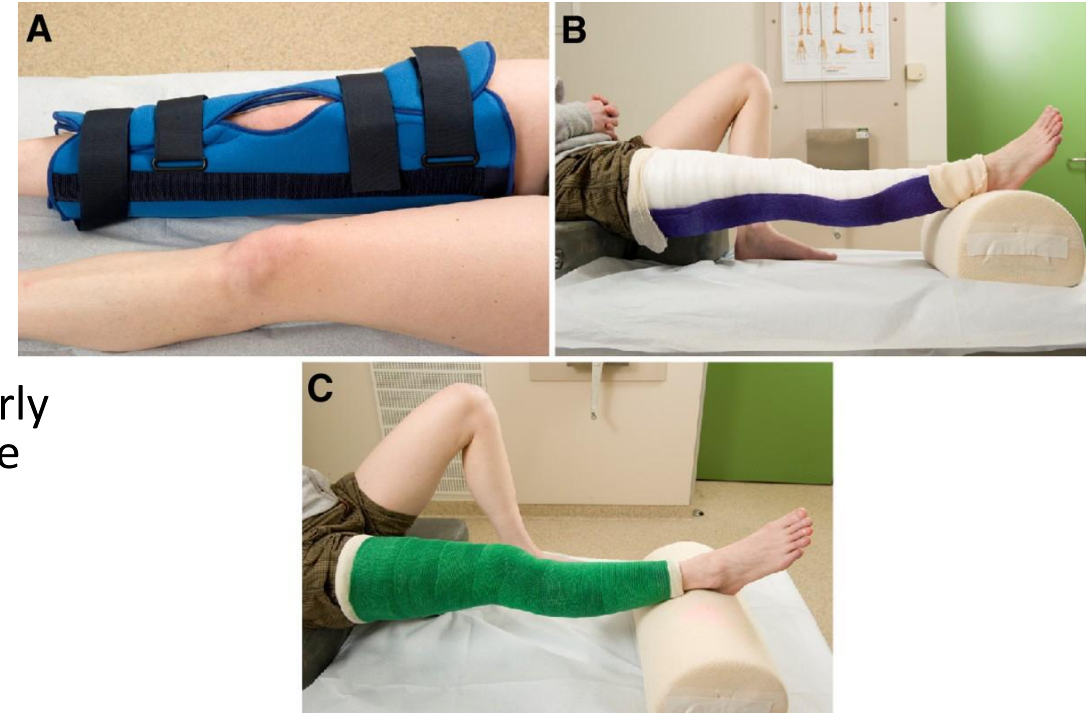
Lower Limb Splints

- **Cylindrical Cast:**
  - **Use:**
    - Stabilization of acute **soft tissue injuries** (e.g., quadriceps or patellar tendon rupture, anterior cruciate ligament rupture),
    - **Patellar** fracture or dislocation
    - Other traumatic lower extremity injuries, particularly when a knee immobilizer is unavailable or unusable because of swelling or the patient's size.
  - **Application:**
    - start just **below the gluteal crease** and end just **proximal to the malleoli**
  - **Position of Function:**
    - The knee is positioned in slight flexion.



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