MUSCULOSKELETAL

Conceptual Orthopedics
The Learning Never Ends

# Concepts of
# Musculoskeletal Trauma Management



## Striving to Restore Form & Function Through Optimum Trauma Management

Authored By The Faculty of Conceptual Orthopedics

# Concepts of Musculoskeletal Trauma Management

First Edition



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Section 1

# General Principles

# 1.1 Chapter

# Biology of Fracture Healing

One should know the types of bone healing- primary and secondary healing and how it happens

## Endochondral ossification and intramembranous ossification

- These are the two methods of bone formation
- Endochondral ossification has a cartilaginous phase before getting converted into the osteogenic phase. This is seen in development of most of the long bones and in fractures which attempt to heal with relative stability or secondary healing. The endochondral ossification has an anabolic phase where there is increase in chondroblasts and a catabolic phase when there is increased activity of osteoclasts and osteoblasts.
- Membranous ossification does not have a cartilaginous phase and hence skips the stage of soft callus. This is seen in development of flat bones and also fractures that attempt to heal with primary healing or absolute stability. Remember that this healing occurs as result of cutting cone action by the osteoclasts and the osteoblasts lay new bone in this cone.

## Fracture healing stages

When a bone fractures there is stripping of the periosteum and the vessels

This leads to bleeding at the fracture site and causes hematoma formation

If the fracture is not reduced the hematoma remains and if is immobilized the hematoma causes inflammation and this leads to exposure of the hematoma to progenitor cells.

This helps in the formation of cartilage cells in this hematoma and it is called the soft callus

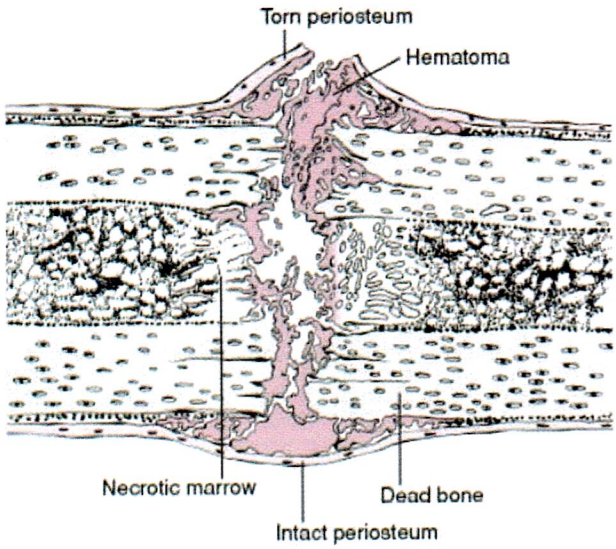
**So the stages of healing are**

1. Stage of hematoma
2. Stage of inflammation
3. Stage of soft callus
4. Stage of hard callus
5. Stage of remodeling

**Stage of hematoma and inflammation:**

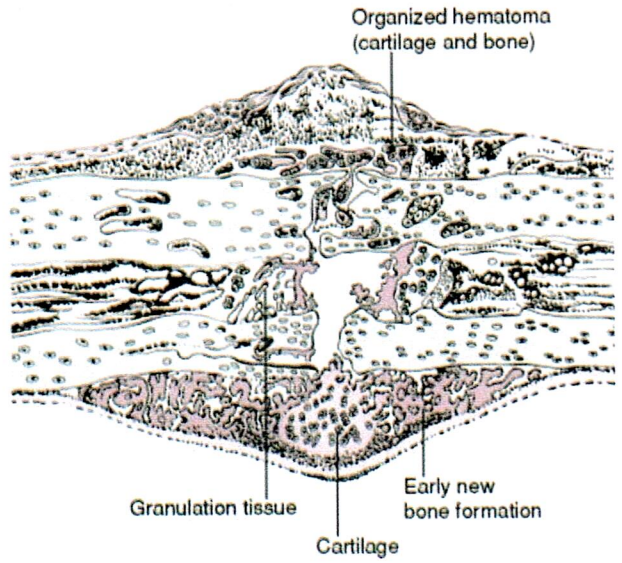
At the time of fracture the following happen-

- The periosteum ruptures
- The blood vessels rupture
- The marrow close to the fracture site becomes necrotic
- The fracture site bone becomes dead
- There is hematoma below the periosteum and the fracture site
- This initiates an inflammatory response and there is increased in many mediator cells and chemicals in this fracture site.
- There is a complex interaction of inflammatory signals, modulators, and cellular components.
- Neutrophils are the earliest and most active cell populations and they remove the debris through their phagocytic mechanism.
- Inflammatory cytokines increase in concentration in early phases, including IL-1β, IL-6, IL-8, IFNγ, and TNFα
- It is always the progenitor cells that help in healing than the already existing mature cells.
- The healing of bone is different from that of any other tissue as the populations of cells that appear in the fracture site and the time at which each individual population appears is important in the final outcome of the union
- Depletion of macrophages or macrophage receptors in the fracture hematoma has deleterious effects on the healing process.
- Initially granulocytes, monocytes, hematopoietic stem cells, and lymphocytes are seen
- Once the above B cell population regress then there is activation of T- cell population in the fracture site
- The periosteum has an inner and an outer layer. The inner layer has periosteal progenitor cells are located
- This is also a source of fibroblasts, osteoblasts, chondrocytes, and a vascular network.
- The periosteum provides an early source of osteoblasts and mesenchymal cells that can directly contribute to calcium deposition and bone formation.
- The periosteal vascular network is responsible for approximately one-third of the cortical blood supply.



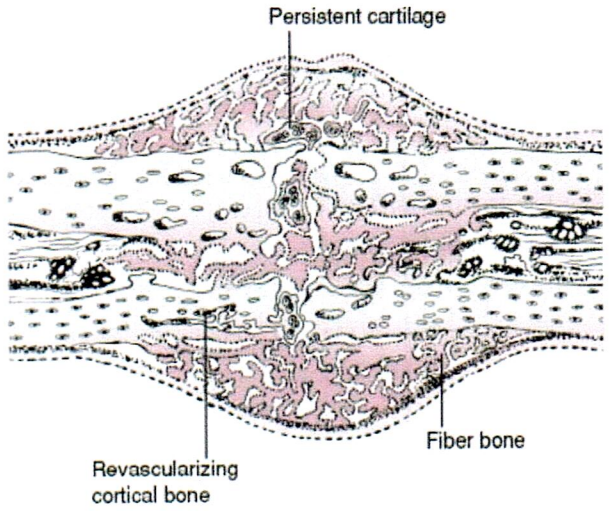

**Stage of soft callus**

- The mesenchymal cells are derived from the marrow, the endosteal layer of the cortex and peripheral blood. Another potential source of progenitor cells are the pericytes. And are a local cell population that resides in the perivascular space.
- The hematoma when exposed to the inflammatory cells and Sox transcription factor there is formation of chondrocytes which lay down cartilage. Remember Sox9 helps in hypertrophy of the chondrocytes and these remain beneath the periosteum and gets mobilized early once the fracture occurs.
- This chondral deposition is regulated by the TGF -beta and hedgehog signaling
- The chondrocytes get hypertrophied and later undergoes apoptosis and get converted into osteoblasts.




**Stage of hard callus**

- Osteoblasts lay down calcium and osteoid to transition from soft to hard callus
- These osteoblasts lay done new bone formation
- However due to the high catabolic activity there is osteoclastic activity as well which helps in remodeling




**Stage of remodeling**

- Osteoclasts help in the remodeling providing the normal shape of the bone
- These cells derive from the hematopoietic cell lineage found on the bone surface and form pits in the surface called Howship lacunae
- This activity is the reason why the bone tissue heals without any scarring

## FACTORS AFFECTING FRACTURE HEALING

**Internal factors**

**Blood supply**

- Initially the blood flow decreases with vascular disruption
- After few hours to days, the blood flow increases
  - This peaks at 2 weeks and normalizes at 3-5 months
- Un-reamed nails maintain the endosteal blood supply
  - Reaming compromises of the inner 50-80% of the cortex
  - Looser fitting nails allow quicker reperfusion of the endosteal blood supply versus canal filling nails

**Head injury may increase osteogenic response**

**Mechanical factors**

- Bony soft tissue attachments
- Mechanical stability/strain
- Location of injury
- Degree of bone loss
- Pattern (segmental or fractures with butterfly fragments)
  - Increased risk of nonunion likely secondary to compromise of the blood supply to the intercalary segment

**External factors**

**Low Intensity Pulsed Ultrasound (LIPUS)**

- Exact mechanism for enhancement of fracture healing is not clear

- Alteration of protein expression
- Elevation of vascularity
- Development of mechanical strain gradient

- Accelerates fracture healing and increases mechanical strength of callus (including torque and stiffness)
  - The beneficial ultrasound signal is 30 mW/cm2 pulsed-wave
- Healing rates for delayed unions/non-unions has been reported to be close to 80%

**Bone stimulators**

- Four main delivery modes of electrical stimulation
  - Direct current
    - Decrease osteoclast activity and increase osteoblast activity by reducing oxygen concentration and increasing local tissue pH
  - Capacitively coupled electrical fields (alternating current, AC)
    - Affect synthesis of cAMP, collagen and calcification of cartilage
  - Pulsed electromagnetic fields
    - Cause calcification of fibrocartilage
  - Combined magnetic fields
- They lead to elevated concentrations of TGF-Beta and BMP

**COX-2**

- Promotes fracture healing by causing mesenchymal stem cells to differentiate into osteoblasts

**Radiation (high dose)**

- Long term changes within the remodelling systems
- Cellularity is diminished
  - Patient factors

**Diet**

- Nutritional deficiencies
  - Vitamin D and calcium
  - Protein malnourishment decreases fracture callus strength
  - Amino acid supplementation increases muscle protein content and fracture callus mineralization
- Gastric bypass patients
  - Calcium absorption is affected because of duodenal bypass with Roux-en-Y procedure
    - Leads to decreased Ca/Vit D levels, hyperparathyroidism (secondary) & increased Ca resorption from bone
  - Treat these patients with Ca/Vit D supplementation
  - Gastric banding does not lead to these abnormalities because the duodenum is not bypassed

**Diabetes mellitus**

- Affects the repair and remodelling of bone
  - Decreased cellularity of the fracture callus
  - Delayed enchondral ossification
  - Diminished strength of the fracture callus
- Fracture healing takes 1.6 times longer in diabetic patients versus non-diabetic patients

**SMOKING**

- Decreases rate of fracture healing
- Inhibits growth of new blood vessels as bone is remodelled
- Increase risk of non-union (increases risk of pseudoarthrosis in spine fusion by 500%)
- Decreased strength of fracture callus
- Smokers can take APPROXIMATELY 70% longer to heal open tibial shaft fractures versus non-smokers

**HIV**

- Higher prevalence of fragility fractures with associated delayed healing
- Contributing factors
  - Anti-retroviral medication
  - Poor intraosseous circulation
  - TNF-Alpha deficiency
  - Poor nutritional intake

**Medications affecting healing**

- Bisphosphonates are recognized as a cause of osteoporotic fractures with long term usage
  - Recent studies demonstrated longer healing times for surgically treated wrist fractures in patients on bisphosphonates
  - Long term usage may be associated with atypical subtrochanteric/ femoral shaft fractures
- Systemic corticosteroids
  - Studies have shown a 6.5% higher rate of intertrochanteric fracture non unions
- NSAIDs
  - Prolonged healing time because of COX enzyme inhibition
- Quinolones
  - Toxic to chondrocytes and diminishes fracture repair

# 1.2 Chapter

# AO Principles of Fracture Management

## AO PRINCIPLES OF FRACTURE MANAGEMENT

These are the universal principles to be applied for the management of fractures of any bone. A good functional outcome could be anticipated as long as these principles are followed during the management.

**The 4 AO principles of Fracture Management**

1. Anatomical / Functional reduction
2. Stable fixation
3. Preservation of blood supply
4. Early mobilization.

**Reduction**

The reduction must be as anatomical as possible. This is mandatory in articular fractures as any step / gap in articular surface would preclude optimal outcomes. In metaphyseal and diaphyseal regions, a "functional" reduction is good enough in which length, alignment and rotations are maintained. It is not necessary to achieve perfect anatomical reduction of all the fragments in this region as to try to do so, one could cause significant soft tissue damage thereby hampering the biology which is quintessential in the healing of the fractures.

The reduction could be achieved by direct or indirect means. In Direct reduction, the forces / instruments are applied at or near to the fracture site to achieve realignment. In indirect reduction, the forces are imparted along the axis of the limb and using the action of soft tissues to achieve reduction.

| System | Advantages | Disadvantages |
|---|---|---|
| Direct reduction | Easy to visualize the reduction<br>Easy to reduce the fracture | Increases soft tissue insult |
| Indirect reduction | Difficult to visualize and reduce the fracture<br>More ionizing radiation exposure as judgement for reduction is based on Carm | Preserves soft tissue biology. |
| Examples | Reduction clamps<br>Pointed instruments<br>K wires | Traction (Manual / fracture table)<br>External fixator<br>Charnleys distractor |

**Stable Fixation**

Stability means that the fracture does not visibly displace under physiological load. It means that once the fracture is stabilized adequately with external / internal device, the limb can withstand physiological loading and the rehabilitation could be started early.

The degree of stability determines the type of fracture healing. There are 2 types of stability that can be achieved with fixation. Absolute and relative stability.

| Characteristics | Absolute Stability | Relative stability |
|---|---|---|
| Definition | No motion at fracture site under physiological loading | Some micromotion occurs at fracture site under physiological loading |
| Location where desired | Articular fractures | Metadiaphyseal fractures |
| Type of fracture pattern | Simple / Wedge | Comminuted |
| Type of bone healing | No callus | With callus |
| Also known as | Primary bone healing | Secondary bone healing |
| Prerequisite | Contact between fractured ends | No need of direct contact and some gap is tolerated |
| Type of reduction | Requires anatomical reduction | Anatomical / Functional reduction |
| Means to achieve | Lag screw, compression plating, buttress plating, Tension Band wiring | All other methods<br>Nailing, cast, external fixator, Bridge plating |

**Preservation of blood supply**

It must not be forgotten that the bone is a living tissue with its root in the soft tissues thereby deriving the blood supply. Extensive stripping of periosteum / soft tissue mishandling could lead to devitalized bone leading to necrosis and infection. So a surgeon must be very careful during dissection, respecting the muscular planes and preserving as much as soft tissues around the bone as possible. Percutaneous techniques, indirect reduction techniques, minimally invasive surgeries are all towards preserving the biology.

**Early mobilisation**

A patient undergoing a surgery and then immobilised for a long time is bound to have stiff joints and poor functional outcome no matter how well the surgery was performed. The most important aspect of any surgery is how well the patient rehabilitates and hence essential that the neighbouring joints are mobilised early after surgery to prevent stiffness.

# 1.3 Chapter

# AO Classification (Old Vs New)

AO described the classification system of long bone fractures in 1987 and from then have incorporated the fractures of spine and flat bones and other regions too (pelvis, skull hand, foot), thereby making it a comprehensive system which can be used to describe any fracture pattern in any part of the human body.

**Uses of the AO system**

1. Universal comprehensive system
2. Less intra and inter observer variability
3. Can be used to prognosticate injury pattern
4. Alphanumerical code useful to store data in the ICD classification of patient details.

**The "Four Box" concept**

The classification system is alphanumerical and is described within 4 boxes.

1st box – describes which bone is injured

2nd box – which region of the bone is injured (proximal, middle or distal part)

3rd box – describes type of fracture

4th box – further describes the type of fracture

**1st box**

All the different bones have been assigned a numerical value.

- Humerus – 1
- Forearm bones – 2
- Femur – 3
- Leg bones – 4
- Spine – 5
- Pelvis – 6
- Hand – 7
- Foot – 8
- To note
  - Scapula – 14
  - Clavicle – 15
  - Patella – 34
  - Malleolus – 44

**2nd box**

The proximal and distal regions of the bone are given nos. 1 & 3 respectively. The middle diaphyseal segment is given no. 2.

How to define the proximal & distal region of a bone. It is done by following the "square" rule. A square is drawn with the maximum breadth of the bone as the breadth of the square. The region within the "square" is considered epi-metaphyseal and given nos. 1 or 3 depending on whether it lies in the proximal part of the bone or distal respectively.

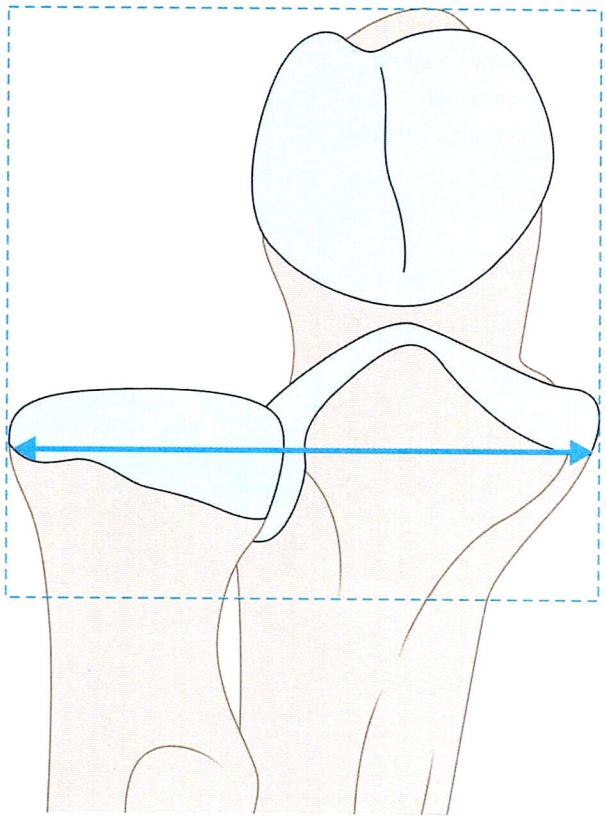


**Fig. 1: diagram depicting the proximal region of the area by drawing a square with the maximum width of the bone.**

**3rd box**

The 3rd box encompasses the description of the type of fracture and is an alphabet A, B or C. The description depends on whether the fracture lies within the diaphyseal segment of the bone or proximal / distal region of the bone.

**For diaphyseal fractures,**

- A – simple fracture
- B – wedge fracture
- C – comminuted fracture

**For proximal / distal regions,**

- A – extraarticular fracture
- B – partial articular fracture
- C – intraarticular fracture

**4th Box**

This further describes the pattern of fractures. It is either 1, 2 or 3.

**For A type diaphyseal fractures,**

- 1 – spiral (long oblique)
- 2 – oblique (short oblique)
- 3 – transverse

**For B type Diaphyseal fractures,**

- 1 – simple wedge
- 2 – bending wedge
- 3 – comminuted wedge

**For C type Diaphyseal fractures,**

- 1 – complex spiral
- 2 – segmental
- 3 – complex irregular

**The New/ modified AO Classification (2018)**

In 2018, the new / modified classification system was described which made changes to the existent system and tried to incorporate various other classification system into its own system thus making it more comprehensive.

**The notable changes to the old system are:**

1. Radius and ulna given separate number 2R & 2U respectively
2. Tibia fractures are given number 4 (as before), but fibula fractures are described with number 4F
3. In diaphyseal fractures, B1 & C1 fractures have been deleted. B2 denotes simple wedge & B3 denoted comminuted wedge. C2 denotes segmental fracture & C3 denotes comminuted fracture.

# 1.4 Chapter

# Principles of Non-Operative Fracture Management

- POP or Plaster of Paris is also known as gypsum plaster or calcined gypsum or roasted gypsum.
- The name POP is derived from a deposit of gypsum near Paris.
- POP bandages were first used by a Dutch military surgeon named Antonius Matthysen in 1952.
- POP bandages are made of muslin cloth stiffened using starch and suffused with hemihydrates of calcium sulfate. When water is added, the calcium sulfate takes up its w ater of crystallization:

$CaSo4{\cdot}2H2O$ + heat → $CaSo4{\cdot}0.5H2O$ + 1.5H2O (released as steam)

- Average setting time for these bandages is 4-10 minutes. Setting time is depended on various factors such as temperature of water, humidity, addition of salt or sugar etc.
- In field of orthopedics, POP is widely used to prepare POP bandages, which are used to make well known orthopedic plaster casts to hold, support, protect and align the fractured bones.
- Same POP bandages are also used to take impressions of the body parts in order to fabricate various types of orthoses for support, protection, prevention and correction of various deformities as well as fractures sites and to fabricate various prostheses as substitute for the amputated limb.
- POP casts are also used to stabilize, immobilize and support the joint in ligamentous injuries and limbs post operatively.
- POP's biggest advantage is the property which allows for moulding itself. This allows contouring of POP according to the limb to which it is being applied. It is sufficiently rigid and allows for immobilization to permit healing.
- There are some alternatives to POP are available too namely POP with melamine resin and fiberglass. But POP is relatively economic, easily available and easy to use.

## FUNCTIONAL CAST BRACING

### Introduction

- Described in the early 18th century
- Augusto Sarmiento → reestablished the ideology
  - Inspired by the PTB prosthesis of below knee amputees

### Principles

- Continuing function while a fracture is uniting
  - Encourages osteogenesis
  - Promotes the healing of tissues and
  - Prevents the development of joint stiffness
- Thus accelerating rehabilitation

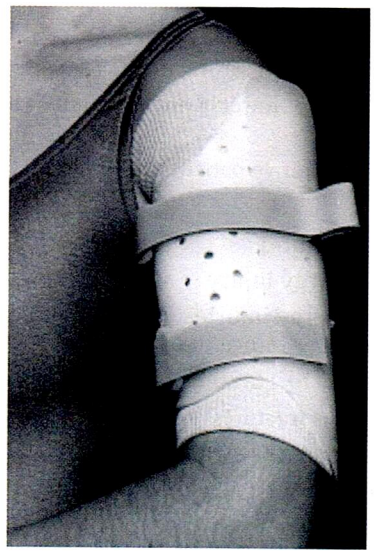


**Fig: Photo showing a prefabricated brace, held in place with Velcro straps, that compresses the soft tissues and permits unlimited motion of the shoulder and elbow joints**

### Salient features

- Requirements for fracture healing
  - Stability
- "Hydraulic container theory" → Sarmiento et al 1974
  - Fluid is not compressible
  - Fascia cannot be stretched beyond the confines of the cast
- Controlled limited movement at fracture site
  - Advantageous to osteogenesis
  - Axial displacement up to 0.5 cm
- Initial shortening did not increase with early activity & weight bearing
  - Interosseous membrane and soft tissues provide a tethering mechanism
    - Maintenance of reduction
- Firm compression of the soft tissues provided by the cast
  - Stiffens the area and controls alignment
- Stability is maintained by loading(mobilization) in a functional cast
- Pressure & Load is transmitted without further deformation
- Rotation is restricted by components of the brace

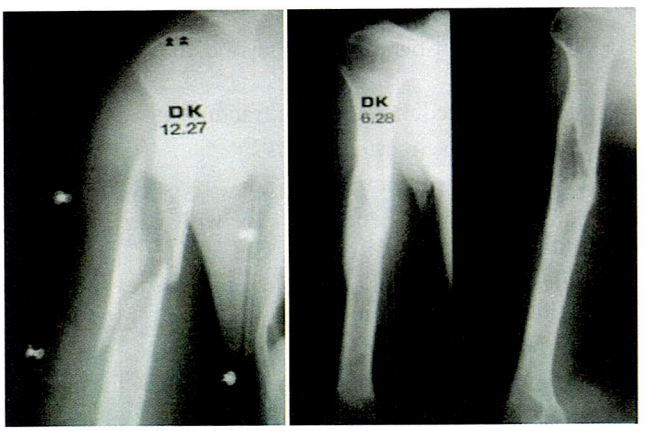
- Blood supply
- Increases Blood supply → Bridging callus
  - Loading
  - Contraction of muscle
  - Micromotion at fracture site
- Strength of callus which forms at site of a fracture where movements occurs
  - Greater than that seen after rigid immobilisation
- Local irritation of soft tissues surrounding a fracture
  - Produces vascular invasion
  - Responsible for greater degree of osteogenesis

**Indication**

- All middle third shaft fractures
- Middle third - lower third junction fractures in long bones
  - In co-operative patients

**Timing**

- For tibia fractures
  - Low energy injury → within first 2 wks
  - High energy injuries → wait till pain and swelling subsides ← more than 2 weeks
  - Removal → 16-20 weeks
- For humerus fractures
  - After pain and swelling subsides→ 7-10 days
  - Removal → 10 weeks
- Assessment
  - Fracture ends sticky
- Assess the fracture after pain and swelling have subsided
  - Minor movements at fracture site should be pain free
  - Any deformity should disappear once deforming forces removed
  - Reasonable resistance to telescoping
  - Shortening should not exceed 6mm for tibia and 12mm for femur




**Humerus shaft fracture treated with functional cast bracing (union achieved in six months)**

**Contraindications**

- Intra-articular fractures
- Compound fractures
- Uncooperative patient
- Patient with spastic disorders
- Bed-ridden & mentally incompetent pts.
- Deficient sensibility of the limb
  - Diabetes mellitus with peripheral neuropathy
- Fracture types
  - Galeazzi fractures
  - Monteggia fractures
  - Both bone forearm fractures
  - Subtrochanteric fractures
  - Isolated tibial fractures → delayed healing due to intact fibula

**Acceptable reduction**

- > 50% cortical contact
- < 5-10 degrees of varus / valgus angulation
- < 10-15 degrees of anterior / posterior bowing
- < 5 degrees of internal / external rotation
- < 10-15 mm of shortening

## CAST INDEX

**Introduction**

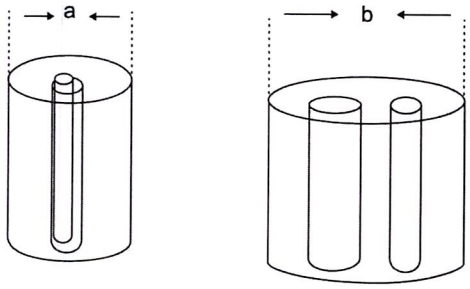
- Closed fractures of the forearm in children are often treated with closed reduction and immobilization in a well fitting plaster cast and achieve a satisfactory outcome in a majority of patients.
- Younger children the remolding is good age the age progress the remolding capacity decreases
- In spite of good reduction redisplacment of fractures remains a complication.
- The rates of redisplacment as high as 25%

**Risks for redisplacment of fracture**

- Initial displacement of the fracture
- Distance of the fracture from the physis,
- Obliquity of the fracture,
- Inadequate initial closed reduction,
- Poor cast molding → important modifiable risk factor
- Resolution of edema whilst in the cast

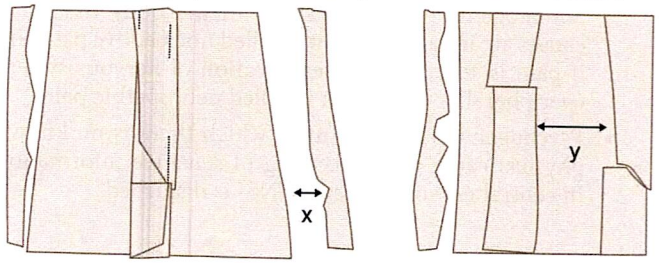
**Cast index(CI- a/b)**

- Described by Chess et al in 1994
- It is the ratio of cast width in lateral view (a) and the width of the cast in AP view (b).
- CI of over 0.8–0.84 → a poorly molded cast → carries a significant risk of redisplacement
- Traditionally → CI is for distal forearm fractures
- It is difficult to assess the quality of the cast proximal forearm fractures → more soft tissue and difficult to mold so to get ideal CI of <0.8 is more difficult to achieve in the proximal forearm




**Padding Index (x/y)**

- Described bybhatia and Housden → 2006
- Is the ratio of padding thickness in the plane of maximum deformity correction (x) and the greatest interosseous distance (y) in AP view.
- "x" is the padding thickness under the molded cast in lateral view in the planeof maximum deformity correction
- "y" is the maximum interosseous distance in the AP view
- Padding index must be < 0.3
- If there is an over-padded cast → then the value of "x" will increase → overall value of x/y → increase → loss of 3-point fixation of the fracture, as there would be a greater "play" between the plaster cast and the bone



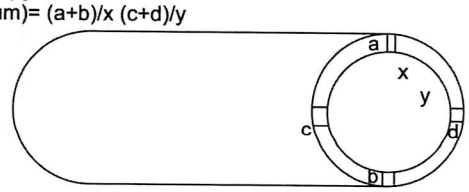

**Canterbury Index**

- Described bybhatia and Housden→ 2006
- It is the sum of cast index and padding index.
- If the sum is > 1.1 then the risk of redisplacment is high

**Gap index**

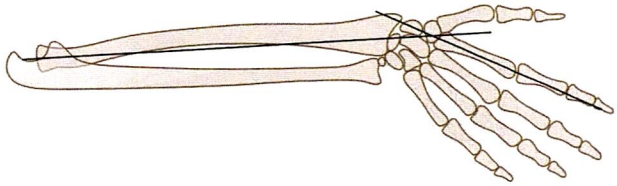
- Radiographic measurement by Malviya et al
- Ratios of the gaps in the cast at the level of the fracture to the entire inside width of the cast in two planes

Gap index- Lat view = (a+b)/x
AP view = (c+d)/y
Gap index (Sum)= (a+b)/x (c+d)/y




**Second metacarpal-radius angle(2007)**

- It is the angle between the second metacarpal and the long axis of the radius in the anterioposterior plane
- It represents the deviation (radial/ulnar) of a moulded cast.
- The greater the ulnar deviation →, the more likely the success of the initial cast.
- An ideal outcome if angles >0° (ulnar moulded)
- This is important for most dorsally displaced fractures



**Three point index(2008)**

- It is calculated by dividing the sum of three critical gaps seen on an anteroposterior radiograph by the transverse projection of the contact area of the fracture fragments ([a + b + c]/x) and by dividing the sum of three critical gaps seen on a true lateral radiograph by the sagittal projection of the contact area of the fracture fragments ([d + e + f]/y) .
- The critical gaps were selected on the basis of the most important points in the cast that maintain the reduction against the common displacement forces.




**Fig: a" and "c" are the distal and proximal radial gaps, and "b" is the ulnar-side gap at the level of the fracture. "a" is the narrowest gap around the radiocarpal or proximal carpal joint, "b" is the narrowest gap within 1 cm of the fracture line on the ulnar side, and "c" is the narrowest gap on the radial side about 3 to 5 cm proximal to the fracture site. "x" is the projection of the contact length between the proximal and distal fragments in the horizontal plane on the anteroposterior radiograph.**

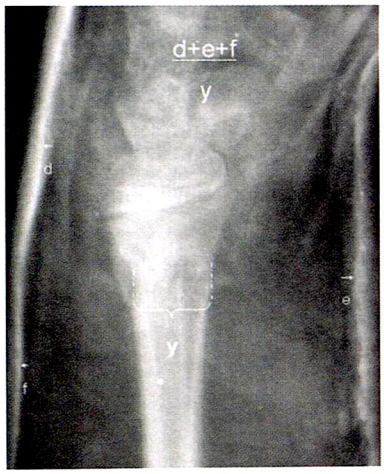



**Fig: 'd" and "f" are the distal and proximal dorsal gaps and "e" is the volar gap at the level of the fracture. "d" is the narrowest gap around the radiocarpal or proximal carpal joint, "e" is the narrowest gap within 1 cm of the fracture line on the volar side, and "f" is the narrowest gap on the dorsal side within 3 to 5 cm of the fracture site. "y" is the projection of the contact length between the proximal and distal fragments in the sagittal plane on the lateral radiograph.**

### Summary

- Redisplacement of a fracture can be predicted if
  - Cast index > 0.8
  - Padding index > 0.3
  - Canterbury Index > 1.1.
  - Gap index > 0.15
  - Second-metacarpal-radius angle < 0degree
  - Three point index> 0.8

## PAIN MANAGEMENT IN ORTHOPEDIC PATIENT

### Definition

Pain is a unique subjective experience of an individual, which cannot be adequately defined, identified, or measured by an observer.

### Components

- Sensory component describes the quality, quantity and geography of area involved in pain.
- The motivational-affective component explains the individuals approach to the pain
- Cognitive component decides that how much pain that individual is going to feel depending upon past experiences and modulations done by central and peripheral nervous system.

### Pain Threshold

It is defined at the point at which any stimulus is felt as pain. Aging increases the pain threshold and this change may be due to changes in the thickness of the skin or peripheral neuropathies.

### Perceptual Dominance

It is the phenomenon when increase in the pain threshold occurs at one point (part of body) due to severe pain in another point (part of body).

### Pain Tolerance

It is an intensity of pain that an individual will tolerate before any visible responses.

### Types of Pain

- Somatogenic pain is localized in the body tissue, if causes are inflammatory it is called nociceptive pain and if pain is secondary to sensitization of nervous system (peripheral or central), it is called neuropathic pain.
- Psychogenic pain is pain for which there is no known physical cause but processing of sensitive information in central nervous system (CNS) is disturbed.

### Acute and Chronic Pain

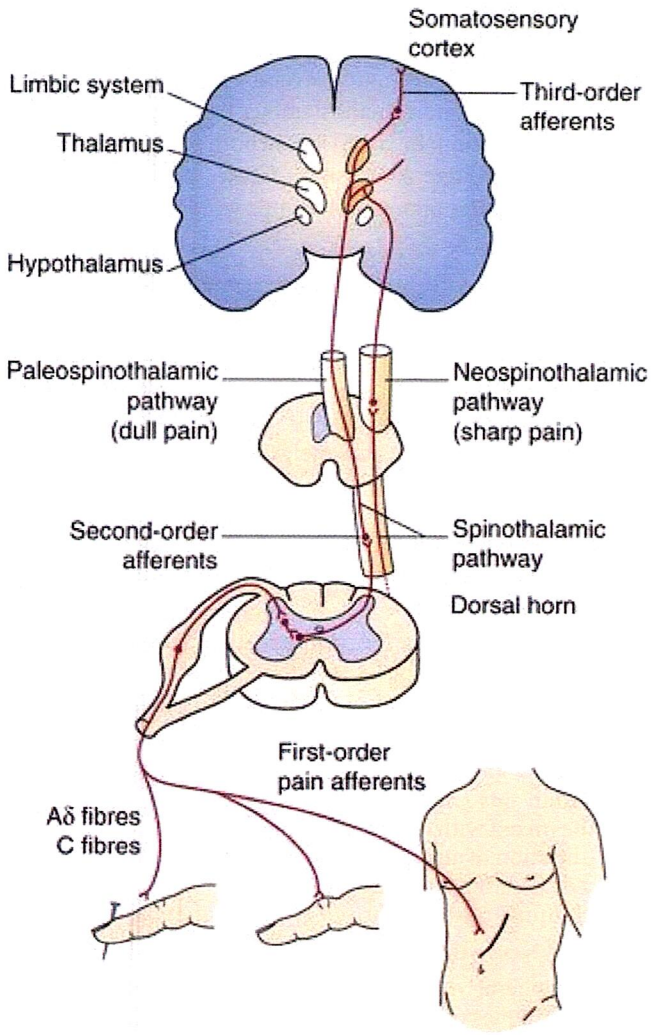
**Table: Difference between acute and chronic pain**

| Characteristics | Acute Pain | Chronic Pain |
|---|---|---|
| Temporal features | Short history of onset and does not last longer than days or weeks | Long history with often poorly-defined onset, duration unknown |
| Intensity | Variable | Variable |
| Associated effects | If pain is severe anxiety may be prominent and sometime instability | Depression and instability is prominent feature |
| Associated pain behaviors | When pain is severe pain behaviors (e.g., moaning, rubbing and splinting) may be prominent feaures | Specific behavior may or may not be present. If pain is severe and for long duration specific behaviors (e.g., assuming a comfortable position) may occur |
| Other associated features | Features of sympathetic hyperactivity when pain is severe (e.g, tachycardia, hypertension, sweating, mydriasis) | Usually have one or more vegetative signs such as lassitude, anorexia, weight loss, insomnia, loss of libido. Sometimes these signs may be difficult to distinguish from other disease-related effects |

**Types of acute pain**

1. Somatic :Pain arising from the skin or close to the surface of the body is called somatic pain
2. Visceral
   a. Localized: if it arising from internal organs, abdomen, or chest is visceral pain.
   b. If pain is felt away from its origin is known as referred pain.
   i. Mechanism
   - The area of origin of pain and referred area are supplied by the nerves from the same spinal segment or convergence of impulses occurs from viscera and skin in the CNS. The suggested mechanism is: an irritable focus is generated at the level of spinal cord where pain signals from viscera enter and these signals further facilitate the afferent impulses from the skin entering at the same segment resulting in cutaneous pain.
   - Sensitization of dorsal horn (DH) neurons.

**Pathways of Pain**




**Gate Control Theory (Pain production and Modulation Theory)**

- According to this theory, large A-δ and small C-fibers carry the nociceptive impulses to the spinal cord through and form synapses in SG. The cells in SG regulate transmission of impulses to CNS depending upon other inputs from other areas of spinal segments or brain and function as a gate.
- "Closed gate" is the situation where stimulation of A-α and A-β (larger nerve fibers) causes decreases stimulation of T-cells (the second afferent neuron) which decreases the transmission of impulses and diminishes pain perception.
- Stimulation of small fiber increases the stimulation of T-cells and inhibits cells in SG. This increased transmission of impulses (open gate) leads to enhance pain perception.
- Other factors in nervous system also influence the functioning of gate control. The CNS may close, partially close, or open the gate through efferent pathways and modulates pain perception. Naturally occurring opioids like endorphins (ED) also affects the transmission through gate. All ED act by attaching to opiate receptors on the plasma membrane of the afferent neuron. This result is inhibition of release of the neurotransmitter, thus blocking the transmission of the painful stimulus.

**Disturbances in Pain Perception and Nociception**

- Congenital analgesia is a condition when patient does not feel a pain because nociceptive stimuli are not processed and/or integrated at a level of brain.
- Congenital sensory neuropathy is a condition in which peripheral nerves and spinal afferent tracts are unable to transmitted nociceptive stimuli.
- Diseases of parietal lobe of brain, syringomyelia and acquired neuropathy, e.g. Neuropathy in chronic diabetes mellitus.

**Postoperative Pain and Its Management**

- Postsurgical pain is a complex response to tissue injury during surgery and also due to secondary inflammatory response which initiates hypersensitivity of the CNS.
- Adequate pain control results in better surgical outcome in terms of increased patients satisfaction, early mobilization and shorter hospital stay.

## ASSESSMENT OF PAIN

Various methods, i.e. Charts/questionnaire and other tools have been used to quantify the pain in postoperative period.

**Pain Assessment Tools**

- Numerical rating scales (NRS): The NRS is one of the most convenient ways of determining pain intensity. A 11-point (i.e. 0 = no pain–10 = maximum pain) NRS scale is commonly used.
- Verbal rating scales (VRS): It is another scale which is simple and fast to use. This scale uses verbal response in form of words to assess severity of pain like no pain, mild pain, moderate pain or severe pain.

- Visual analog scales (VAS): VAS is most popular scale for pain assessment. It usually consists of a line labeled at 0 or no pain at one end and 10 or 100 on other end to express extremes of the feeling to be measured.
- Pain measurement by pictures: The pictures are assigned a score and patients are asked to indicate their pain which matches with the expression of a picture.
- Pain assessment by questionnaire:
  a. The Mcgill Pain Questionnaire (MPQ): It is most commonly used questionnaire to assess qualitative and quantitative experience of pain. The MPQ consists of 78 words describing pain in sensory, affective and evaluative terms.
  b. Brief pain inventory (BPI): It includes three items to measure pain, severity and quality. It also includes seven additional items, e.g. Mood, function, sleep, interpersonal relationships which may be interfered or affected by pain.

**Systemic effects of poor pain control**

- Increased sympathetic response of the body which cause increase in heart rate (tachycardia), cardiac work and oxygen consumption.
- Increased risk of deep vein thrombosis and consequent pulmonary embolism
- Reduced gastrointestinal (GI) tract and urinary tract motility which may lead to postoperative ileus, nausea, vomiting and urinary retention.
- Psychological changes
- Increase in the morbidity and mortality
- Generates negative emotions like anxiety and depression and demoralization.
- Sleep deprivation
- Acute pain if not treated immediately and adequately leads to chronic pain conditions.
- Peripheral sensitization

**Strategies for adequate postoperative pain control**

- Prevention of central sensitization:
  - Treat acute pain adequately and timely.
  - Use drugs that prevent expression of c-fos. Drugs like opioids, local anesthetics, N-methyl-D-aspartate (NMDA) antagonist and alpha-2 agonists in acute stage to treat pain.
  - Use continuous regional anesthesia in operation and early postoperative period. Combined with tramadol and paracetamol in late postoperative period is a good option to prevent central sensitization.
- Management of central sensitization:
  - If central sensitization develops treat it early.
  - Nonsteroidal anti-inflammatory drugs (nsaids) are not the option to treat it. We should use drugs, which stimulate descending inhibitory systems and NMDA antagonistic actions.
  - Tramadol + Paracetamol ± Tricyclic antidepressants should be ideal to treat central sensitization.

**Methods for postoperative pain control**

**Multimodal Analgesia**

The multimodal analgesia is a combination of two or more analgesics, each with a different mode of action to improve analgesia and to decrease side effects through a reduction in doses of analgesics, particularly opioids.

**Pre-emptive Analgesia**

It is now believed that it requires less analgesic to control pain before it starts than after the noxious input has begun.

Mechanism of Action

The concept of pre-emptive analgesia is to block noxious signals prior to a surgical incision which gives some protection against postoperative pain. Surgical incision results in pain signals and nociceptors activation directly leads to the discharge of neuropeptides such as Neurokinin A, calcitonin gene-related peptide (CGRP), and substance P from peripheral terminals of the primary nerve fibers.

At the same time an inflammatory response is provoked by the release of contents from damaged cells. These two processes contribute to the presence of a "sensitizing soup" of inflammatory mediators that includes bradykinin, serotonin, histamine, nitric oxide, and several others. This leads to repetitive stimulation of small-diameter primary afferent fibers causing "sensitization" or "wind-up" of both peripheral and CNS neurons.. Pre-emptive analgesia decreases postoperative pain by the prevention or attenuation of this wind-up phenomenon.

**Methods**

Nonsteroidal anti-inflammatory agents (nsaids), opioids, α2 -agonists, and NMDA antagonists such as ketamine and dextromethorphan.

**Preventive Analgesia**

- Preventive analgesia can be defined as "when postoperative pain and analgesic
- Consumption are reduced relative to another treatment, a placebo treatment, or to no treatment, as long as the effect is observed at a point in time that exceeds the clinical duration of action of the target drug", i.e. 5.5 half-lives).

**Locoregional Analgesia for postoperative pain management**

- Local Wound Infiltration
- Local infiltration analgesia (LIA) technique involves infiltration of a large volume dilute solution of a long-acting local anesthetic agent at the time of surgery. Adjuvants (e.g. Epinephrine, ketorolac, an opioid) can be mixed with local anesthetic to improve the effect. The duration of analgesia can be prolonged by the placement of a catheter to the surgical site for postoperative administration of further local anesthetic.

**Peripheral Nerve Blocks (e.g.adductor canal block)**

- Peripheral nerve blocks (PNB) are safe and effective techniques of providing postoperative analgesia that cut down on time to hospital discharge, reduce postoperative pain and improve overall patient satisfaction.
- A catheter can be placed to give intermittent boluses or