12-Common pediatric fractures

Objectives:

1.Difference between Pediatric & adult

2.Physis fracture → Salter-Harris classification

3.Indications of operative treatment

4.Methods of treatment of Pediatric fracture & trauma

5.Common Pediatric fracture

- U. L → clavicle, humeral supracondylar, distal radius

- L. L → femur shaft

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References: slides + 433 team + appley

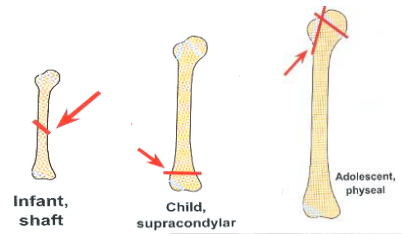
[Color index : Important | Notes | Extra] Editing file link

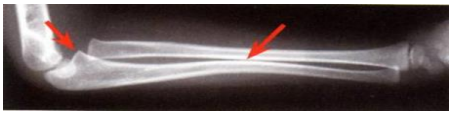
introduction

- Different from adult fractures
- Vary in various age groups:
  - ❑ Neonate (birth – 1 month)
  - ❑ Infant (1 month- 2 years)
  - ❑ Child (2 years – 12 years)
- Pediatric patient classification is arbitrary
- Boys are prone to break their bones more than girls.
- Vary in various age groups.
- Adults are skeletally mature/ pediatrics are skeletally immature. In Saudi Arabia pediatric age range is 14 "18 in the west" and below

Age related fractures:

- ◆ Infants: diaphyseal fractures
- ◆ Children: metaphyseal fractures
- ◆ Adolescents: epiphyseal injuries



Q: why are fractures in pediatrics different?	
A: Bones are still growing.	This will only occur if the fracture is in the physis. they may not grow properly/ symmetrically e.g. Angular deformity, Leg length inequality. The bone itself has more collagen than bone → do not fracture easily and it can bend sometimes, this is what we call plastic deformation
B: bones are easier to break	Increased collagen/bone ratio makes the bone Picture shows the cortex and periosteum are intact, It's not a fracture it's called plastic deformation this is not the normal bowing of ulna . The younger the patient the more you will see this. ❑ Less brittle ❑ deformation  we know that greenstick fractures are more likely to occur in children and that's because of the bone composition, osteoid density is lesser in comparison with adults, and is loosely attached to tissue beneath.

	Juvenile bone has more harversian canals (forms a network in bone which contains blood vessels). As we mentioned that the children's bones have more harversian canals, which means better blood supply rare delayed and non-union in case of fractures (upside).
C: Cartilage Hard to evaluate	Children and adolescents have more cartilage that's why in an X-ray we see spaces.  **(red arrow):** Left elbow joint. You might think that the elbow has fracture without displacement (less than 2mm) so we can go conservative. the red arrow is pointing to the ossification center (this is not the radial head). this child is so young that the ossific nucleus of radius did not appear yet. this is the ossific nucleus of the this is the ossific nucleus of the capitulum and it should be higher up. **(yellow arrow):** This is an elbow of an older child, the whole epicondyle is fractured and rotated → we call it fracture of necessity2 (always going intra- articular) we don't go with conservative it should be anatomical reduction to prevent the risk of premature osteoarthritis . x-ray is difficult to assess; articular fragments are often underestimated. plate often mistaken for fracture on x-ray and vice versa (x-ray opposite limb for comparison especially in the elbow.
D: Ligaments are stronger than bones	Which means that an injury in the ligaments will most likely cause a bone fracture. You can't tear something as strong as a ligament without affecting the bone which is vulnerable in that age due to density that we mentioned before.
E: Periosteum	• **Metabolically active** more callus, rapid union, increased remodeling • **Thickness and strength** Intact periosteal hinge affects fracture pattern In adults, it becomes thinner but it's very strong in pediatric, where we need scalpel to cut it. We can't resuture it, but we can bring back the two ends close to each other

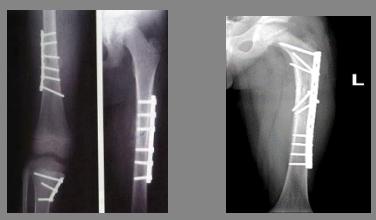
Inductions of operative treatment:

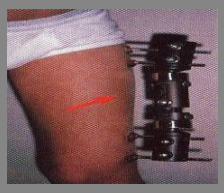
- Head injury
- Multiple injuries
- Open fractures
- Displaced intra articular fractures
  - (Salter-Harris III-IV)
- Adolescence
- Failure of conservative means (irreducible or unstable fractures)
- Severe soft-tissue injury or fractures with vascular injury
- Neurological disorder
- Malunion and delayed union
- Compartment syndrome

Methods of treatment of pediatric fracture and trauma

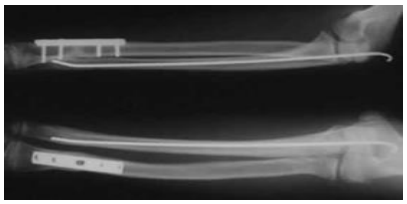
-Never forget to check neurovascular status before and after any kind of management whether it's reduction or casting.

Type	Indication	Note
casting 	Generally: acute fractures or sprains, or for initial stabilization of reduced, displaced, or unstable fractures before orthopedic intervention. Used to correct deformities especially in pediatrics	-Most common type -In infants we don't use cast, instead we use tongue depressor.
K-wires  	1-Fractures in epi-/metaphyseal areas 2-Fractures of small bones (e.g. hand and foot) 3- Small bony fragments 4- For fragment reposition in multi-fragmentary fractures in addition to stable fixation	Most commonly used internal fixation (I.F) Usually used in → metaphyseal fractures

intramedullary wires 	When you bend a K wire it will bend but elastic wire will recoil. The elastic wire uses the technique of 3-points fixation (2C shaped wires, they come straight, and we bend them to give a push in the center. Usually used in mid-shaft diaphysis → stabilizes the fracture (3 points: upper crossing/ lower crossing/ central push). In the radius and ulna, we don't have enough space in the medulla to put 2 wires, so we put 1 wire. Used mainly in pediatrics but can be used in adults	
screws 	Are used for internal fixation more often than any other type of implant.	
plates 	To hold broken pieces of bone together. Can be left after Healing	for multiple trauma
Intramedullary nailing 	Closed Winquist types III and IV fractures, acute fractures, long oblique fractures, and closed reconstructive defects or malrotations.	Used in patients over 12 years.

External -fixing 	used as a temporary treatment for fractures. Because they are easily applied, external fixators are often put on when a patient has multiple injuries and is not yet ready for a longer surgery to fix the fracture	

A combination could be used

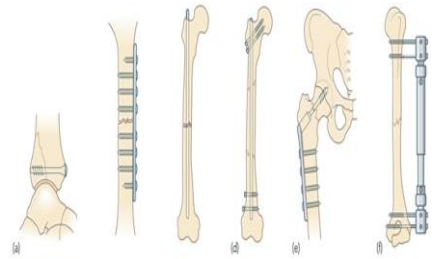


●Usually in pediatrics we remove the screws

●We always remove Plate and screws in pediatrics once it heals bc later on it will grow on top of it through which I will have to cut the cortex for removal →potential area for pathological fracture. That's why we use wires which can be removed very easily. Plates and screws has limited use.

●In adults: upper limb we don't remove the screws cause there is a lot of nerves and blood vessels.

●In the lower limb we have to remove, cause after it heals, we will have something called shear force (breaks in the sites of the screws)



12.2 Bone fixation Several methods of fixation are used, depending on site and circumstances. (a) A lag screw for interfragmentory compression. (b) Plate and screws. (c) Intramedullary nail. (d) Locked intramedullary nail. (e) Dynamic hip screw. (f) External fixator.

●Fellow level info: if the pt have some sort of handicap and walks on the upper limb then we have to remove it

Common pediatric fractures

Clavicle:

- Incident:8-15% of all pediatric
- 80% of clavicle fractures occur in the shaft.

Mechanism of Injury:

- Indirect: Fall onto an outstretched hand
- Direct: it carries the highest incidence of injury to the underlying neurovascular and pulmonary structures
- Birth injury

Clinical Evaluation:

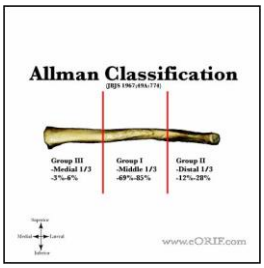
- Painful palpable mass along the clavicle
- Tenderness, crepitus, and ecchymosis
- May be associated with neurovascular injury
- Pulmonary status must be assessed.

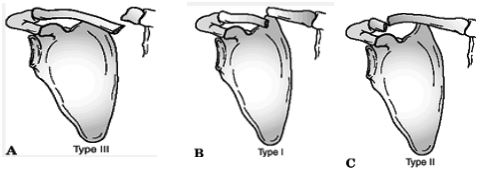
Classification:

- Location
- Open or closed
- Displacement
- Fracture type
  segmental, comminuted, greenstic

Allman classification:

A. Type I:
   Middle third (most common)
B. Type II:
   Lateral third
C. Type III:
   Medial third





Bone	Treatment			Note
	Category	Treatment	Time	
clavicle	Newborn (< 28days):	No orthotics. (artificial devices such as splints and braces.)	Unite within 1 week	The periosteal sleeve always remains in the anatomic position (remodeling is ensured)
	1 month – 2 years	Figure-of-eight	2 weeks	
	2 year– 12 year	Figure-of-eight or sling	2-4 weeks	

Indications of operative treatment: (ORIF)

- Open fractures
- Neurovascular compromise

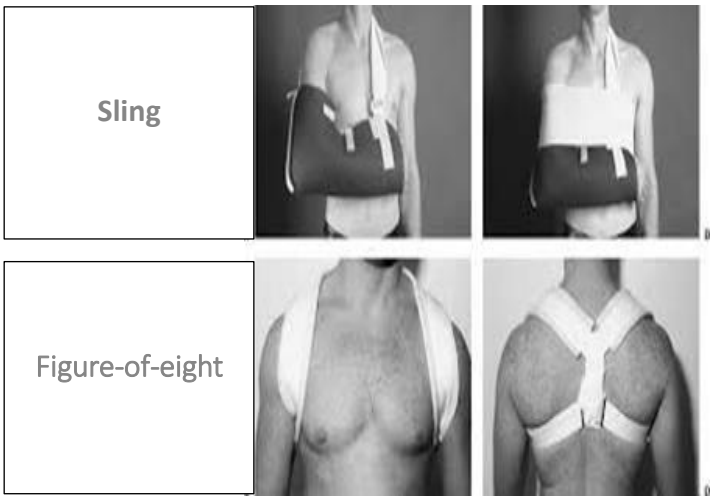
Complications:

Rare

- Neurovascular compromise
- Malunion
- Nonunion
- Pulmonary injury

Radiographic Evaluation:

AP view



Humeral supracondylar:

- 55-75% of all elbow
- M:F 3:2
- Age 5 - 8 years
- Left (non-dominant) side most frequently

Mechanism of injury :

•Indirect: Extension type, >95%

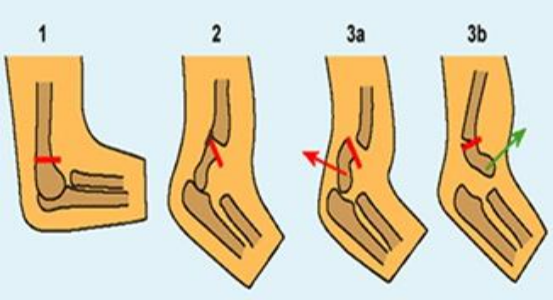
•Direct: Flexion type, < 3%

Clinical Evaluation:

Following a fall, the child is in pain and the elbow is swollen; with a posteriorly displaced fracture, the **S-deformity of the elbow is usually obvious**. It is essential to feel the pulse and check the capillary return.

- Swollen, tender elbow with painful ROM
- Pucker sign (dimpling of the skin anteriorly)(red arrow in picture)
- Feel & Move (it's difficult to do that)
- Neurovascular exam.
- The commonest nerve to be injured is:
  Anterior interosseous nerve, which is branch from the median nerve.
  The way to assess: ask the patient **to do (ok) sign.**
  Vascular: Brachial. Capillary refill and distal pulses should be documented.

Gartland Classification:[1]



Type 1: No displacement.

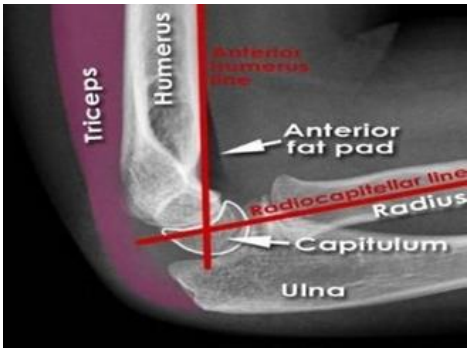
Type 2: Minimal displacement.

Type 3: Complete displacement, if it's going backward

(3a): Extension fracture "indirect trauma" … Forward

(3b): Flexion fracture "direct trauma"

Type-III Complete displacement (extension type) may be:



- Posteromedial (75%)
- Posterolateral (25%)

If the distal fragment went posteromedially

→ it will strip the periosteum in the same side

→ the blood vessels in the same side got injured with formation of micro-hematoma which is good

→ contained callus formation. But bc this is a sharp end it will cut the periosteum on the opposite side

→ not a stabilizing factor any more in the opposite side. when I want to reduce this fracture, I want to maintain the periosteum to help me in the healing. So, incision will be in the lateral side.

FIGURE 14-5 Relationship to neurovascular structures. The proximal metaphyseal spike penetrates laterally with posteromedially displaced fractures and places the radial nerve at risk; with posterolaterally displaced fractures, the spike penetrates medially and places the median nerve and brachial artery at risk.

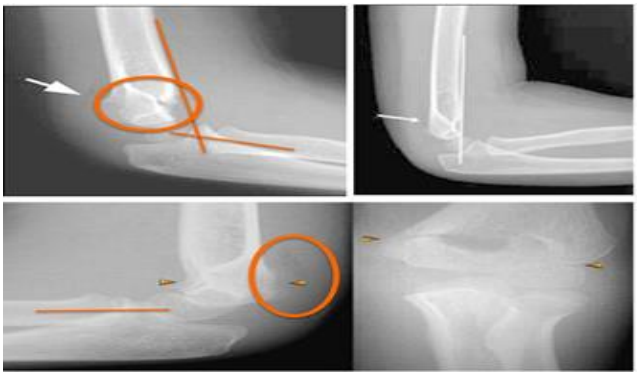
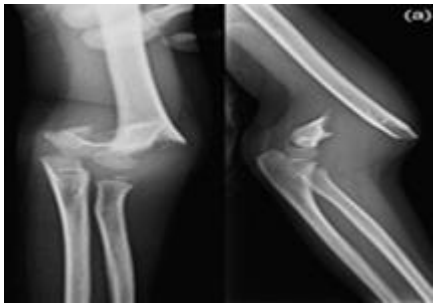
Normal X-ray line:

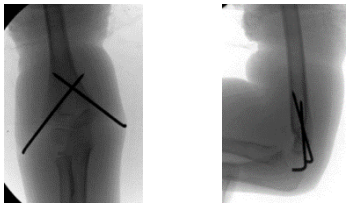
Anterior Humeral Line The anterior humeral line is a radiographic line that is drawn down the anterior margin of the humerus and through the middle third of the capitellum.

- Hour-glass appearance
- Fat-pad sign Triceps is attached to olecranon and with fracture there is hematoma. The hematoma will elevate the triceps under periosteum → you see fat pad sign (posterior not anterior)
- Radio-capitellar line is intact → (Radiocapitellar joint is intact) bc supracondylar fracture is just a fracture above the elbow joint (the elbow joint is ok). This line should be intact always in the supracondylar fractures.

[1] The Gartland classification is a system of categorizing supracondylar humerus fractures, clinically useful as it predicts the likelihood of associated neurovascular injury, such as anterior interosseous nerve neuropraxia or brachial artery disruption.

<table>
<tr><th colspan="3">Reading X-RAY AP and Lateral</th></tr>
<tr><td>Type 1</td><td colspan="2">•Anterior Humeral Line is intact
•Hour-glass appearance partially disrupted
•Fat-pad sign Triceps is attached to olecranon and with fracture there is hematoma. The hematoma will elevate the triceps under periosteum → you see fat pad sign (posterior not anterior)

•Radio-capitellar line (Radiocapitellar joint is intact) bc supracondylar fracture is just a fracture above the elbow joint (the elbow joint is ok). This line should be intact always in the supracondylar fractures
  </td></tr>
<tr><td>Type 2</td><td colspan="2">They can’t do full AP because they are in pain. Diagnosis is always with lateral X-ray. posterior cortex is still in contact with each other
● Displaced anterior humeral line
● Disrupted hourglass (you don’t see the 2 bellies and neck)
● Fat pad sign is present
   </td></tr>
<tr><td rowspan="2">type 3</td><td>Flexion type
  </td><td>Extension
  </td></tr>
<tr><td colspan="2">(Extension type)
Loss of contact (posterior and medial displacement) type 3A.
(Flexion type) What is seen in the x-ray is a type of temporary immobilizer</td></tr>
</table>

Bone	Treatment		
	Category	Treatment	Time
Humeral supracondylar	Type I	Immobilization in a long arm cast or splint at 60 to 90 degrees of flexion	2-3 weeks
	Type II	Closed reduction followed by casting or pinning if unstable or sever swelling	4-6 week
	Type III	-Attempt closed reduction and pinning -Open reduction and internal fixation may be necessary for unstable fractures, open fractures, or those with neurovascular injury 	4-6 weeks

Humeral supracondylar Complications :

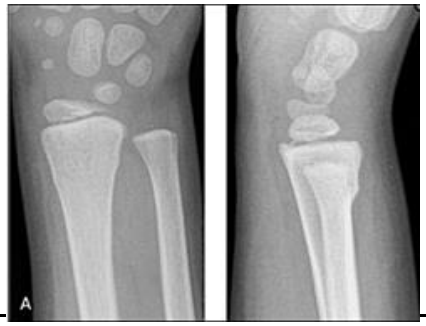
- Neurologic injury (7% to 10%):
  - ❑ Median and anterior interosseous nerves (most common)
  - ❑ Most are neuropraxias
  - ❑ Requiring no treatment

- Vascular injury (0.5%):
  - ❑ Direct injury to the brachial artery, or
  - ❑ Secondary to swelling (compartment syndrome)

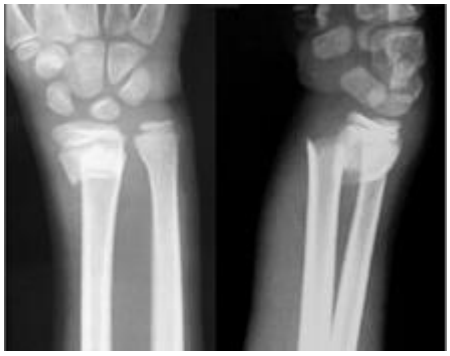
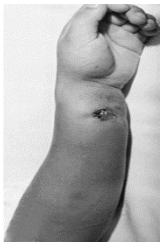
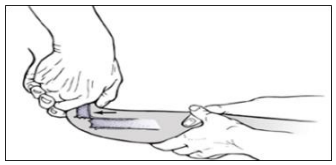
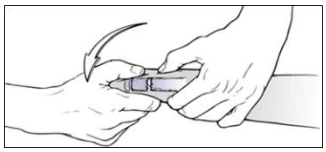
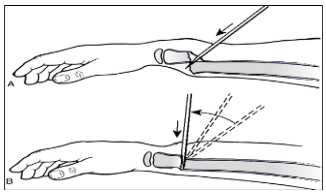
- Other:
  - Loss of motion (stiffness)
  - Myositis ossificans specifically to the muscles unlike the heterotrophic ossification "Ossification that occurs in muscles. Bone in muscles ---> Complete stiffness" Ca deposit in the muscle
  - Angular deformity (cubitus varus)
  - Compartment syndrome

26.16 Supracondylar fractures – complications (a) Varus deformity of the right elbow following incomplete correction of the varus displacement in a supracondylar fracture. (b) The 'gun-stock deformity' becomes more obvious when the arms are raised. (c) X-ray showing the malunion.

Distal radius (Metaphyseal):

Bone	Management		
	Types [2]according to: -Direction of displacement -Involvement of the ulna -Biomechanical pattern	Treatment	Time
Distal radius	**Torus (buckle)** → only one cortex is involved ● Stable ● Immobilized for pain relief 	Immobilized for pain relief in below elbow cast  	2-3 weeks (team 435) 
	Incomplete(greenstick) Greater ability to remodel in the sagittal plane. Greater ability to remodel (why?) 1- The periosteum is still intact 2-It's incomplete fracture 3- It's close to the growth plate Intact one cortex and minimally displaced (depending on the force direction) other cortex 	♦ Closed reduction and above elbow cast with supinated forearm to relax the brachioradialis muscle ♦ We do above elbow cast to prevent supination /pronation. It happens in both the proximal and distal radioulnar joint. 	4-6 weeks (team 435) 

[2] The usual injury is a fall on the outstretched hand with the wrist in extension; the distal fragment is usually forced posteriorly (this is often called a 'juvenile Colles' fracture'). Lesser force may do no more than buckle the metaphyseal cortex (a type of compression fracture, or torus fracture).

	Complete    	♦ Closed reduction Well molded long arm cast   ♦ Indications for percutaneous pinning without open reduction: 1-loss of reduction 2-Excessive swelling 3-Floating elbow 4-Multiple manipulations   ♦ Indications for ORIF: 1-Irreducible fracture 2-Open fracture 3-Compartment syndrome	3 to 4 weeks

Distal radius complications:

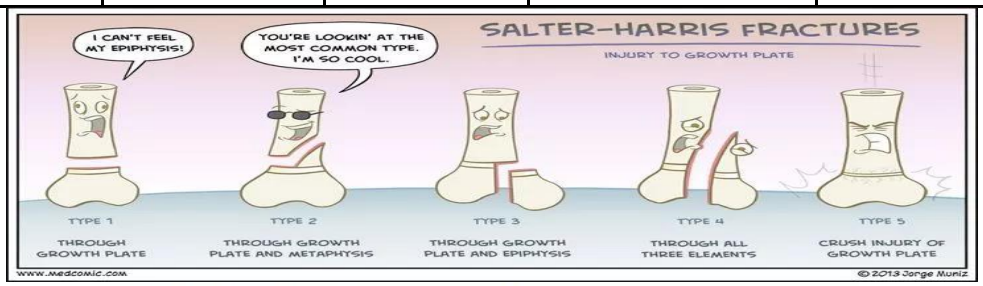
1. Malunion: Residual angulation may result in loss of forearm rotation
2. Nonunion → Rare
3. Refracture: With early return to activity (before 6 w) "needs surgery" If a fracture went conservatively and healed then the patient came back with refracture within 6 months I have to go for surgery
4. Growth disturbance: Overgrowth or undergrowth
5. Neurovascular injuries: With extreme positions of immobilization

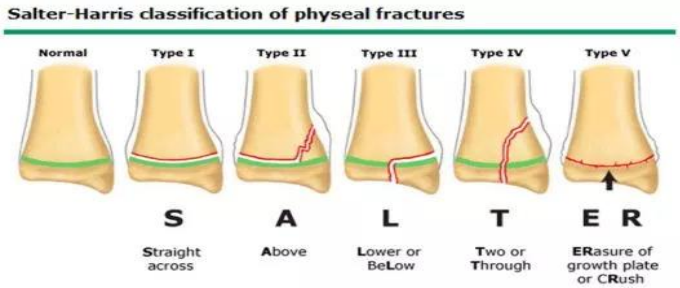
Distal radius (Metaphyseal):

[3]

They follow the salter Harris classification

Physeal injuries					
salter Harris classification:(very important)	Type 1	Type 2	Type 3	Type 4	Type 5
General characteristic	■ a transverse fracture through the hypertrophic or calcified zone of the plate.	■ this is similar to Type 1, but towards the edge the fracture deviates away from the physis and splits off a triangular piece of metaphyseal bone. ■This is the commonest type.	■ this fracture runs partly along the physis and then veers off through all layers of the physis and the epiphysis into the joint. ■ needs anatomic reduction, usually it will go to surgery.	■ this fracture splits the epiphysis, but it continues through the physis into the metaphysis ■ needs anatomic reduction, usually it will go to surgery.	■crush injury to Physis ■the worst Type





[3] Physeal fractures are almost invariably Salter– Harris Type 1 or 2, with the epiphysis shifted and tilted backwards and radially.

growth disturbance	Even if the fracture is quite alarming displaced, the growing zone of the **physis is usually not injured and growth disturbance is uncommon**	Growth is usually not affected.This is similar to Type 1, but towards the edge the fracture deviates away from the physis and splits off a triangular piece of metaphyseal bone **Growth is usually not affected**.	Inevitably the reproductive zone of the physis is damaged and this may result in growth disturbance.	The fracture is particularly liable to displacement and a consequent misfit between the separated parts of the physis, resulting in asymmetrical growth.	There is no visible fracture but the growth plate is crushed and this may result in growth arrest
Intra or extra:	Extra - articular",	Extra - articular",	Intra- articular"	Intra-articular"	Intra-articular"
Diagnosis	sometimes in X-Ray you see a fracture slightly translated but don't forget your **history and examination in which you can reach a diagnosis up to 70 % just by proper history.**	X-Ray	X-Ray	X-Ray	X-Ray sometimes you have to do X-ray for both limbs to compare. There is no visible fracture but the growth plate is crushed
					

Physeal bridging or barshutdown of the factory < 1%

As we know you can't fracture the whole physeal plate, so the healthy part will keep growing and that will result in either valgus or varus Statistically small bridges and central bridges are more likely to lyse. While peripheral bridges are more likely to cause deformity.

- this will affect growth (varus, valgus, or even leg length inequality).
- Keep in mind:
  - Small bridges (about <10%) may lyse spontaneously.
  - Central bridges →more likely to lyse.
  - Peripheral bridges →more likely to cause deformity.
- Take care with physeal injuries:
  - Avoid injury to physis during fixation.
  - Monitor growth over a long period (18-24 month) Varus or valgus will not appear immediately, it will take time to appear. Bc in the period of 18-24 months, the body is still healing.
  - When suspecting physeal bar do MRI

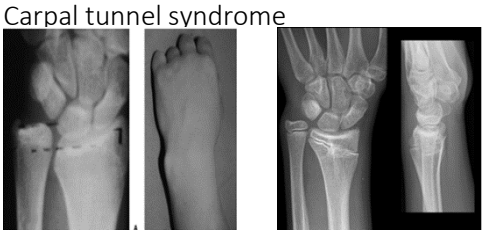
- Physeal bridging: is a rare condition 1% where the bone stops growing due to trauma (fracture) or infection in the physis.

❖ As we know you can't fracture the hall physeal plate, so the healthy part will keep growing and that will result in either valgus or varus.

❖ Statistically small bridges and central bridges are (<10%) likely to lyse. While peripheral bridges are more likely to cause deformity.

❖ whenever you are doing a surgery make sure not to injure the physeal plate, and if you suspect it do (CT,MRI).

Type	Treatment	Complications
Type I and II	Closed reduction followed by above elbow cast	Physeal arrest –Shortening –Angular deformity Ulnar styloid nonunion Carpal tunnel syndrome
Type III	ORIF	



This pic includes both meta and physeal, from appley.

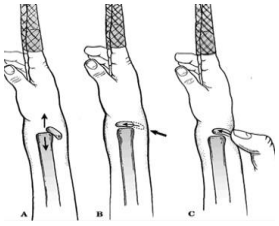
25.12 Distal forearm fractures in children (a,b) In older children the fracture is usually slightly more proximal than a true Colles', and often merely a greenstick or buckling injury. (c,d) In young children physeal fractures are usually Salter–Harris type I or II. In this case, accurate reduction has been achieved (e,f).

Salter-Harris Types I and II

- Closed reduction followed by long arm cast with the forearm pronated
- 50% apposition with no angular or rotational deformity is acceptable
- Growth arrest can occur in 25% with repeated manipulations
- Open reduction is indicated:

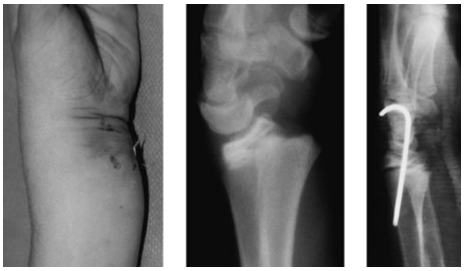
1- Irreducible fracture

2-Open fracture



Salter-Harris Type III

- Anatomic reduction is necessary
- ORIF with smooth pins or screws



Salter-Harris Types IV and V

- Rare injuries
- Need ORIF

Femoral Shaft:

- 1.6% of all pediatric
- Boys > girls
- Age:
    - ❑ (2 – 4) years years old
    - ❑ In children younger than walking age, 80% of these injuries are caused by child abuse
    - ❑ Adolescence >90% due to RTA

Mechanism of Injury:

- Direct trauma
  RTA, fall, or child abuse
- Indirect trauma
  Rotational injury
- Pathologic fractures
  Osteogenesis imperfecta, nonossifying fibroma, bone cysts, and tumors

Clinical Evaluation:

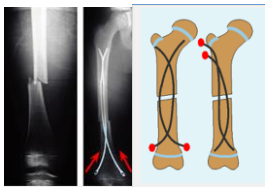
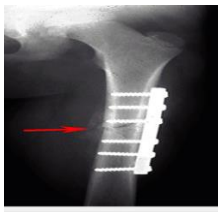
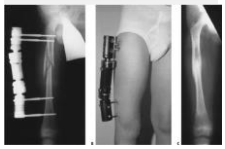
- Pain, swelling, inability to ambulate, and variable gross deformity
- Careful neurovascular examination is essential
- Careful examination of the overlying soft tissues to rule out the possibility of an open fracture

Radiographic Evaluation

- AP and lateral views
- Must include hip, knee joints

Classification

- Descriptive
    - ❑ Open or closed
    - ❑ Fracture pattern: transverse, spiral, oblique, butterfly fragment
    - ❑ Comminution
    - ❑ Displacement
- Anatomic
    - ❑ Subtrochanteric
    - ❑ Shaft
    - ❑ Supracondylar

Bone	Treatment		
	Category	Treatment	Pic
Femoral Shaft	< 6 months	♦ Pavlik Harness ♦ Closed reduction & immediate hip spica casting ♦ Or traction then hip spica casting	 
	6 months- 4 years	♦ Close reduction and immediate casting (>95%) ♦ Traction followed by spica casting if there is difficulty to maintain length and acceptable alignment.	
	4 y -12 years	-Flexible IMN	
	6 y -12 years	-Bridge Plating -External Fixation: ❑ Multiple injuries ❑ Open ❑ Comminuted ❑ Unstable patient ❑ it must be diaphyseal fracture	 
	12y to skeletal maturity	Intramedullary fixation with either flexible or interlocked nails	

Operative induction:

1-multiple trauma including head injury

2-Open fracture

3-Vascular injury

4-Pathologic fracture

5-Uncooperative patient

Femoral Shaft Complications:

1-Malunion: Remodeling will not correct rotational deformities

2-Leg length discrepancy: Secondary to shortening or overgrowth

3- Muscle weakness

4- Nonunion (rare)

5-Osteonecrosis with antegrade IMN <16 year

MCQ

1- Which of the following is true regarding Physis injury?

A. Common in dominant lower limb

B. Common in dominant upper limb

C. Common in non-dominant lower limb

D. Common in non-dominant upper limb

Ans: B

2- Which of the following is true regarding Supracondylar injury?

A.Common in dominant limb

B.Common in non-dominant limb

Ans: B

3- Which of the following is NOT an indication for surgery?

A.Non-union of the fracture

B.Malunion of the fracture

C.Delayed union of the fracture

D.Uncooperative patient

Ans: A

4- Which of the following is the most common method of fixation?

A.Plates

B.Cast

C.Screws

D.I.M.N

Ans:B

5-Which of the following methods of fixation is commonly used in metaphyseal fractures?

A.Screws

B.Plates

C.I.M.N

D.K-wires

Ans: D

6-Which of the following methods of fixation is suitable for a 13y old boy who had a femur diaphysis fracture?

A.Intramedullary fixation with flexible nails

B.K-wires

C.Screws

D.Cast

Ans:A

7- Which of the following methods of fixation is suitable for a 7y old boy who had an open femur diaphysis fracture?

A.K-wires

B.External fixation

C.Casting

D.I.M.N

Ans: B

8-What are the common fracture pattern in Infants?

A.Infants: diaphyseal fractures

B.Infants: metaphyseal fractures

C.Infants: epiphyseal injuries

Ans: A

9-What are the most important systems you have to check in Clavicle Fracture?

A. Neurovascular

B.Pulmonary function

C. a & b

Ans: C

10-What are the most common type of Clavicle Fracture?

A. Type I: Middle third

B. Type II: lateral third

C. Type III: Medial third

Ans: A

11-What is the cause of Femoral Shaft Fractures in children younger than walking age?

A. Child abuse.

B. RTA.

C. Birth injury.

Ans: A

12-Which of the following methods is the most suitable for multiple trauma fixation?

A.Cast

B.Screws

C.K-wires

D.Plates

Ans: D

13- A 3-year-old patient presented with painful swollen left thigh and unable to bare weight after falling from 3 meters. Patient is stable. X-ray with left femur fracture provided.
What's the management of choice for this patient?

A. Hemiarthroplasty.

B. Open reduction and flexible IM.

C. Closed reduction + hip spica

Ans: C

14-A 4-year-old boy was in an accident that result in closed right thigh injury as it shown the x-ray of femur. Multiple trials of reduced of fraction was done by an orthopedic resident on call before he calls his senior. Eventually the reduction and fixation was done. The fracture healed in 8 weeks. What is the most likely complication can happen to this patient?

A-knee fraction contracture.

B-leg length discrepancy.

C-femoral condyle a vascular necrosis.

D-femurs chronic osteomyelitis.

Ans: B

15-16-year-old came through the ER after he sustained a 3-meter fall from a building, he was cleared except for a solitary left femur injury (X-ray shows mid femoral shaft fracture) how would you manage this injury?

A-External fixation.

B-Screws and plate.

C-Rigid IM.

D-Flexible IM.

Ans: D