

COMMON PAEDIATRICS FRACTURES



Lecture objectives:

1. Introduction
2. Difference between Ped & adult
3. Physis: Salter-Harris classification
4. Indications of operative treatment
5. Methods of treatment of Ped # & trauma
6. Common Ped #:
 - U.L clavicle, humeral supracondylar, distal radius
 - L.L femur shaft
7. Example

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References: Slides, notes, 436 teamwork

INTRODUCTION:

- Fractures account for ~15% of **all** injuries in children.
- **Boys > girls** it's **that simple** شقاوة
- Rate increases with age **till adolescent**.
- Types of fractures vary in various age groups (infants, children, adolescents).
- Pediatric fractures have **great remodeling potentials, growth plates and periosteum** are **important in remodeling**.
A good number of cases can be treated conservatively, operative fixations aid in avoiding complications.
- **Adults are skeletally mature/ peditrics are skeletally immature. In Saudi Arabia pediatric age range is 14“18 in the west” and below.**

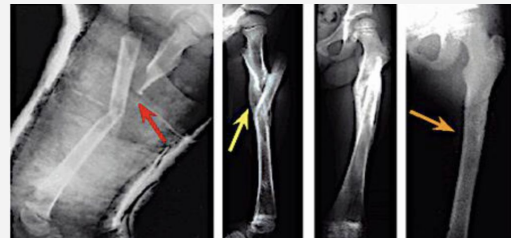
EXAMPLES OF REMODELING IN CHILDREN

This is more evident **the younger the child**. Don't expect this in child aged 13-14-year-old.
We only realign the bone then apply casting. Fractures near to a joint that moves everywhere (**shoulder**) and near to epiphysis → **Better for remodeling**.



This radiograph shows diaphyseal humeral fracture

- Note the tremendous amount of callus at day 7
- 6 months → almost normal.

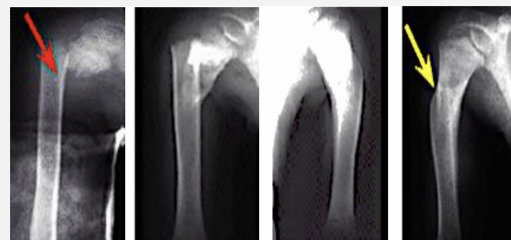


Femur fracture Big callus forms
Remodeling 3 segments fracture

You can see the POP cast in the first pic



100% translation of femur bone fracture Union happened at 15 weeks.



Fracture in the humerus surgical neck with remodeling

WHY ARE CHILDREN'S FRACTURES DIFFERENT?

Children have different physiology and anatomy

1- Growth plate

- o Provides perfect remodeling power.
- o **Injury of growth plate causes deformity.**
may cause:
Angular deformity or "Leg Length Inequality" (L.L.I)
- o A fracture might lead to overgrowth.
The growth plate gives the length in long bones, while the periosteum increase the width of a bone.

In the picture lateral side is arrested and medial is continue to grow "genu valgus deformity"

- If there is an injury to the **medial** growth plate and the lateral side is normal and the bone continues to grow, we will have **Varus deformity**.
- If the injury is in the **lateral** growth plate we will end up having **valgus deformity**.
- If there is destruction to both sides the whole bone will shorten (leg length discrepancy).



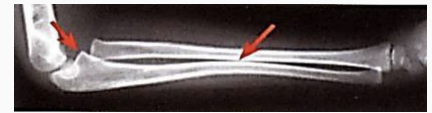
Procurvatum/recurvatum: This refers to the movement of a single bone; where a procurvatum deformity describes backward bending of the bone and recurvatum deformity is the forward bending of the bone.

2- Bone

- Increased (collagen: bone) ratio
 - o Less brittle.
 - o Deformation.

The bone itself has more collagen than bone → do not fracture easily and it can bend sometimes, this is what we call plastic deformation.

(Bowing deformity)



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.

3- Cartilage

- o **Difficult X-ray evaluation.**
 - o Size of articular fragment often underestimated.
We always operate if it involves the lateral condyle because the size of fracture is underestimated.
- Children and adolescents have more cartilage that's why in an X-ray we see spaces.



Collateral condyle must be treated surgically

Right picture (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 capitulum and it should be higher up.

4-Ligaments

Functionally stronger than bone. Therefore, Higher proportion of injuries that produce sprains in adults result in fractures in children. You'll never hear a child with ACL tear



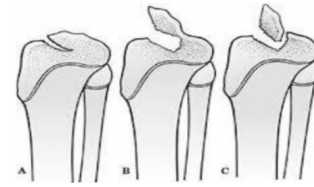
ACL is attached to the tibial eminence; tibial spine fracture is not normally seen in adults. It causes avulsion of the tibial spine.

X-ray shows abnormal knee (tibial plateau should be smooth), we use a headless screw to stabilize it (arthrotomy or arthroscopy).

Left picture (yellow arrow): This is an elbow of an older child, the whole epicondyle is fractured and rotated, we call it fracture of necessity 2 (always going intra-articular) we don't go with conservative it should be anatomical reduction to prevent the risk of premature osteoarthritis.



ACL is intact, the injury happened in the epiphysis.



The only exception not to do surgery for intraarticular fracture is if it's <2mm, will heal with its articular cartilage

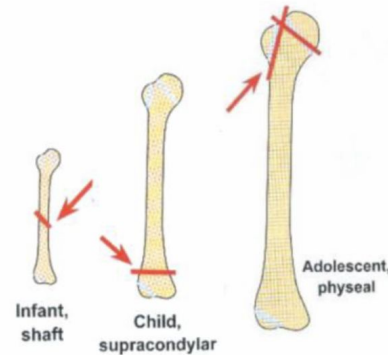
5- Periosteum is an actual layer

- o Metabolically active: More callus, rapid union, increased remodeling.
- o Thickness and strength: Intact periosteal hinge affects fracture pattern, May aid reduction if it's intact.

In adults, it becomes thinner but it's very strong in pediatric, where we need scalpel to cut it. We can't restore it, but we can bring back the two ends close to each other. If the bone breaks, we don't feel the pain in the cortex + medulla, we only feel the pain from the nerve endings which are in the periosteum. So, fracture movement is what causes pain that's why the first line of analgesia for any fracture is immobilization.

6- Age related fracture pattern

- o Infants → diaphyseal
- o Children → metaphyseal
- o Adolescents → epiphyseal



7. Physiology

- o Better blood supply. AKA periosteum. So, the remodeling potential is so high.
- o Rare incidence of delayed and non-union (because of second hand smoker no the children themselves).

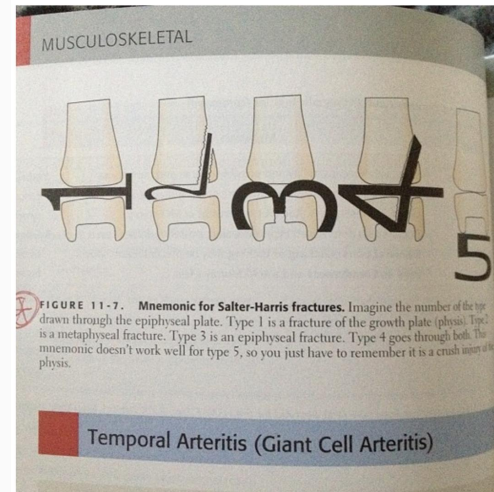
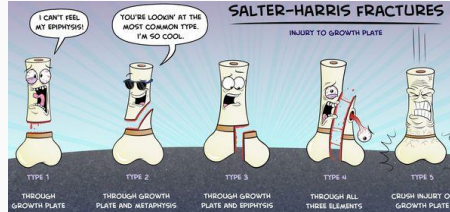
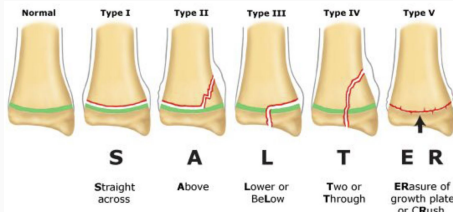
Age in pedia MCQs is very IMP, in 2 Qs same case but different age the answer will be totally different.

PHYSIS FRACTURE:

The growth plate, or physis, is the translucent, cartilaginous disc separating the epiphysis from the metaphysis and is responsible for longitudinal growth of long bones.

- Account for ~25% of all children's fractures.
- More in boys شقاوة, More in upper limb **more in dominant hand**.
- **Most** heal well rapidly with good remodeling, but Growth **may** be affected.
- Classified by Salter-Harris classification.

★ Salter-Harris Classification: (Important)



<p>Type I:</p>	<p>Through the growth plate. It doesn't appear on the x-ray, so usually request an x-ray to the other side. In type 1, you go with history and examination mainly (A Child fell down and he is crying and holding his knee, he can't weight bear (femur)) 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. A transverse fracture through the hypertrophic or calcified zone of the plate. Even if the fracture is quite alarming displaced, the growing zone of the physis is usually not injured and growth disturbance is uncommon.</p>	
<p>Type II:</p>	<p>Growth plate with metaphysis. بالعادة نشوف مثلث صغير احيانا تقوته 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. This is the commonest type</p>	
<p>Type III:</p>	<p>Growth plate with epiphysis. "Intra-articular", needs anatomic reduction, usually it will go to surgery. This fracture runs partly along the physis and then veers off through all layers of the physis and the epiphysis into the joint. Inevitably the reproductive zone of the physis is damaged and this may result in growth disturbance. one of the complications is premature osteoarthritis.</p>	
<p>Type IV:</p>	<p>Growth plate with metaphysis and epiphysis needs anatomic reduction, usually it will go to surgery. As with Type 3, this fracture splits the epiphysis, but it continues through the physis into the metaphysis. The fracture is particularly liable to displacement and a consequent misfit between the separated parts of the physis, resulting in asymmetrical growth. (corrected with K-wires and screws).</p>	
<p>Type V:</p>	<p>A longitudinal compression injury of the physis, doesn't cause angle deformity, it only causes leg-leg discrepancy. Sometimes you have to do X-ray for both limbs to compare. There is no visible fracture, but the growth plate is crushed, and this may result in growth arrest. The worst Type.</p>	

COMPLICATIONS OF PHYSEAL INJURIES:

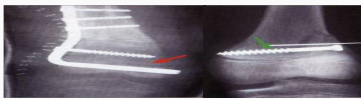
•Physeal bridging a < 1%, Cause as affecting growth (varus, valgus, or even L.L.I)

Keep in mind:

- Small bridges (<10%) may lyse spontaneously.
- Central bridges more likely to lyse.
- **Peripheral bridges more likely to cause deformity.** مشكلتنا الكبيرة هنا.

Take care with:

1. Avoid injury to physis during fixation.
2. Monitor growth over a long period (18-24 m). Varus or valgus will not appear immediately, will take time to appear. Because in the period of 18-24 months, the body is still healing.
3. Image suspected physeal bar (CT/MRI) **Not CT only MRI.**



Distal tibia , medial malleolus injury the growth plate was continued and then stopped it will case varus or valgus if it is at the edges and if it is in the middle will cause LL. this ankle go to into varus and do MRI

When suspecting physeal **bar** do **MRI/CT** because you are looking for soft tissue (growth plate) **(MCQ)**





اجيب سيناريو واحد وطاح وتعالج كويس بعدين جاء كم سنة يعاني من ديفورميتي او فلكس وتجيب ذا موست ريسنت x-ray وش النكست ستيب عشان اشوف البار؟؟

GENERAL MANAGEMENT

Indication for surgery: **(MCQ) Golden slide (the doctor said that)!**

- o Open fractures.
- o Severe soft-tissue injury to do debridement.
- o Fractures with vascular injury actual cut of the vessels.
- o Compartment syndrome “it depends when patient came to hospital”.
- o Multiple injuries.(like both femur fractures)
- o Displaced intra articular fractures (Salter-Harris III-IV).
- o Failure of conservative means (irreducible or unstable fractures).
- o Malunion and delayed union very rare bcs rich blood supply “when you see nonunion in MCQs don’t choose it. We know that a child healing is much faster”. One of the causes of nonunion is exposure to smoking.
- o Adolescence we tend to treat them as adult, because the remodeling potentials are really low.
- o Head injury **(MCQ)** in RTA. If asked look for operative ones. When the patient loses consciousness, the body starts healing. At the beginning catabolic stage caused by the injury → they’ll develop a lot of callus” what happen in week 4 can happen in weeks 2 that’s why we should fix it as soon as possible before it malunite. Except if the fracture is nondisplaced and immobilizes properly → we don’t need surgery.
- o Neurological disorder cerebral palsy, myelomeningocele pts. (they're not normal and sometimes their bones don't heal in a normal way)
- o Uncooperative patient like pts with ADHD.

METHODS OF TREATMENT (FIXATION) OF PEDIATRIC FRACTURES & TRAUMA

Method	Indication	
<p>Casting</p> 	<p>Acute fractures or sprains, or for initial stabilization of reduced, displaced, or unstable fractures before orthopedic intervention. Used to correct deformities especially in pediatrics.</p>	<p>Still the commonest.</p> <p>Casting is the first option of treatment. In infants we don't use cast, instead we use tongue depressor.</p>
<p>K-wires(Kirschner wires) (relative fixation)</p> 	<ul style="list-style-type: none"> - Fractures in epi-/metaphyseal areas. Fractures of small bones (e.g. hand and foot). - Small bony fragments. - For fragment reposition in multifragmentary fractures in addition to stable fixation. 	<ul style="list-style-type: none"> o Most commonly used internal fixation (I.F). o Usually used in à metaphyseal fractures supracondylar fractures. o Inserted percutaneously in OP under GA. o You can go through growth plate, but it done by senior. <ul style="list-style-type: none"> - Not good for bone fixation in adult
<p>Intramedullary (Elastic nails):(relative fixation)</p> 	<p>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 "Only in long bones" → stabilizes the fracture (3 points: upper crossing/lower crossing/central push).</p> <p>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.</p>	
<p>Plates (absolute fixation)</p> 	<p>Especially in multiple trauma.</p>	<p>Comminuted fracture and we use bridging plate. In comminution we don't search for each single piece to fix but what is important is to keep length to prevent LLD.</p>

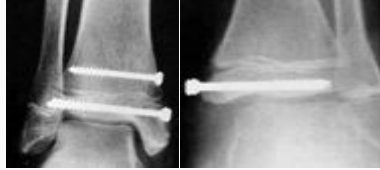
Screws (relative fixation)

Before



Salter harris 4 Salter harris 3

After

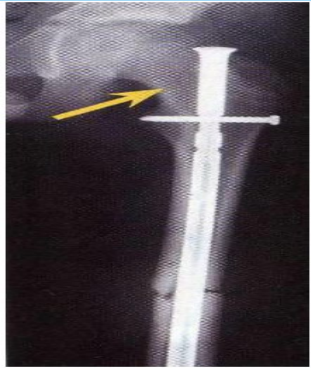


- We usually treat it with 2 screws in salter harris 4: one for epiphysis and the other for metaphysis.
- In salter harris 3: two screws in the medial malleolus (you can see 2 heads and 2 tips).

We **NEVER** cross a physis with a screw because it will destroy the growth plate, with a k-wire yes because it's smooth.

Remember in SCFE (salter harris 1) we put a screw for in situ fixation, but we won't fuse it into the growth plate.

^a Intramedullary Nailing [I.M.N] (relative fixation)



Only in **adolescents (>12y) (MCO)**

There are many blood vessels come for head of femur and other for greater trochanter. The area between the greater trochanter and the neck is called piriformis fossa (blood supply of the growth plate of the greater trochanter) if I go there with an IM nail I will interfere with the blood supply "AVN" of the greater trochanter, it will affect the growth plate and it will grow into valgus and if it goes into too much valgus it will dislocate.

IF I give you MCO and the options are IM nail, K wire, Elastic nail, traction please look at the age: If it's 14 year old patient choose IM nail / If it's 4 year old patient choose elastic nail.

^a External fixator



Usually in open fractures.

Valid in pts who have skin conditions. "crush injury"

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



Usually in pediatrics we remove the screws.

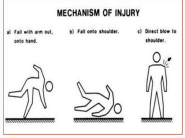

We always remove Plate and screws in pediatrics once it heals bc later on, it will grow on top of it through which I will have to cut the cortex for removal → potential area for pathological fracture. That's why we use wires which can be removed very easily. Plates and screws have limited use.

- In adults: upper limb we don't remove the screws because there is a lot of nerves and blood vessels.
- In the lower limb we have to remove, because after it heals, we will have something called shear force (breaks in the sites of the screws).
- 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

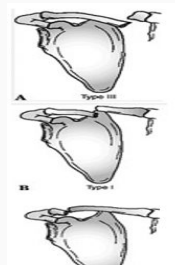
- Upper limb: (Clavicle, Humeral supracondylar, Distal radius)
- Lower Limbs: (Femur shaft “diaphysis”)

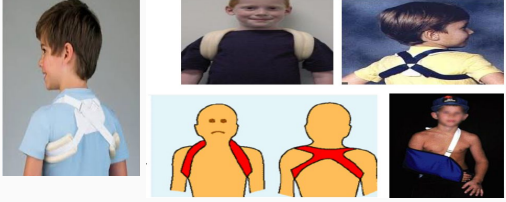
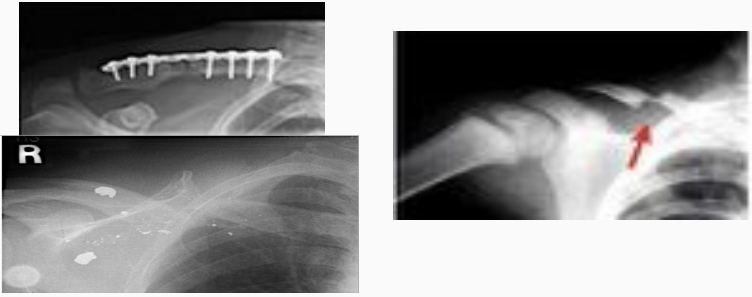
1- Clavicle Fractures كسر الترقوة:

Incidence not going to ask about it	Mechanism of Injury
<ul style="list-style-type: none"> o 80% occur in the <u>shaft</u>. o The periosteal sleeve always remains in the anatomic position. Therefore, remodeling is ensured. It's thicker in the pediatric group o Incidents: <ul style="list-style-type: none"> - 8-15% of all pediatric fractures - 0.5% of normal SVD - 1.6% of breech deliveries - 90% of obstetric fractures 	<ul style="list-style-type: none"> o Indirect (fall onto an outstretched hand) o Direct: <ul style="list-style-type: none"> - The most common mechanism - Has highest incidence of injury to the underlying: <ul style="list-style-type: none"> - Neurovascular (e.g Subclavian artery) - Pulmonary structures (Apex of the lung) o Birth injury may present with or without Erb's palsy 
Clinical Examination	Reading X-Ray: AP view
<ul style="list-style-type: none"> o Look: Ecchymosis, swelling, bruises, tenting of the skin. o Feel: <ul style="list-style-type: none"> - Extreme tenderness at fracture site. - As a palpable mass along the clavicle (as in displaced fracture) when presented late you can feel the callus. - You feel crepitus of the fracture (when lung is compromised) emphysema. o Special tests: Must assess for any: <ul style="list-style-type: none"> - Neurovascular (N.V) injury examine the brachial plexus, subclavian vessels they run behind clavicle . - Pulmonary injury If the fracture went downward 	<ul style="list-style-type: none"> o Location: (medial, middle, lateral) 1/3, commonest middle 1/3 fracture site: Junction of middle & lateral 1/3 o Fracture type: transverse, segmental, comminuted, greenstick. o Displacement in percentage % o Open or closed: see air on XR it's skin on bone, you have to exclude open fracture. o If pneumothorax you will see air in the x- ray. o If subclavian and moved down it will cause vessel injury. 

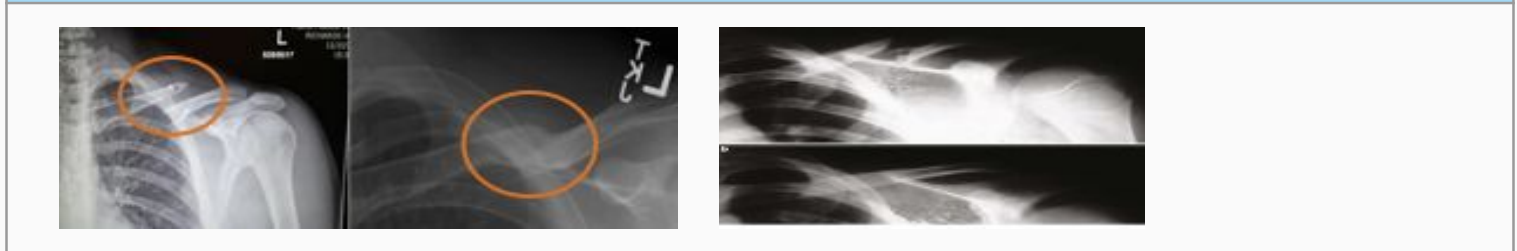
Allman Classification

- o Type I medial 1/3
- o **Type II middle 1/3 (most common)**
- o Type III lateral 1/3



Treatment	Indications of operative treatment
<p>Newborn (< 28 days):No orthotics, unite in 1 week because the sensory nervous system is not fully developed, we just tell the mother handle, Just leave it.</p> <p>1m – 2y: Figure-of-eight it just help in realignment for 2w.</p> <p>2 – 12y: Figure-of-eight or slings for 2-4 weeks.</p> 	<ol style="list-style-type: none"> 1) Open fractures (tinting of the skin) 2) Neurovascular, pulmonary compromise <ul style="list-style-type: none"> – If it is an open fracture, pneumothorax or vascular injury 

Clavicle fracture - Remodeling



Complications

<p>From the fracture:</p> <ul style="list-style-type: none"> - Malunion - Nonunion - Secondary from healing: <ul style="list-style-type: none"> • Neurovascular compromise • Pulmonary injury 	<p>In the wound of surgery:</p> <ul style="list-style-type: none"> - <u>Bad healed scar</u> major indication not to do surgery, keloid in this area is very bad because we are crossing the fibers → heals very bad. - Dehiscence - Infection
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2- Humeral Supracondylar Fractures it's so common it's so common in children !!!

Incidence	Mechanism of Injury
<ul style="list-style-type: none"> o 55-75% of all <u>elbow</u> fractures. o M:F 3:2 o <u>Age 5 - 8 years</u> can present in younger or older ages. o Left (non-dominant) side most frequently fracture. <p style="color: #008000;">Supracondylar fracture think of humerus. If we want femoral we'll mention it in the scenario.</p>	<ul style="list-style-type: none"> o Indirect (>95%): Extension type the elbow is extended o Direct (<3%): Flexion type. Anterior dislocation type, when the child falls into the elbow نفس المصارع لما يطيح على خصمه

Clinical Examination

- o **Look:** Swollen, **S-shaped angulation**, **Pucker sign** (dimpling of the skin anteriorly), May have bursae.
- o **Feel:** Tender elbow
- o **Move:** Painful & can't really move it. **Please don't move a suspected fracture.** You can shift a non-displaced fracture into displaced and cause **NV injury**.
- o **Neurovascular examination.**

What are the most important elements in vascular status assessment of an extremity? Hand/fingers temperature, color, and capillary refilling are more reliable than the pulse

Make sure that the Ulnar/Radial nerves are not injured.

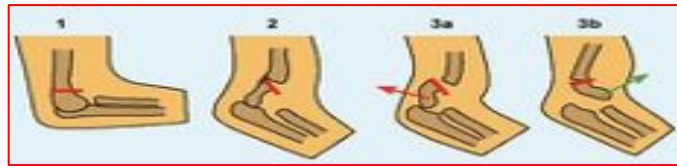


S-shaped deformity



Pucker sign

Gartland Classification for supracondylar fractures



- Type 1: No displacement
- Type 2: Minimal displacement. Posterior cortex and periosteum intact. Anterior is open.
- Type 3: Complete displacement, if it's going **backward**
(3a): (posteromedial displacement) Extension fracture "indirect Trauma", **Forward**
(3b): Flexion fracture "direct trauma".

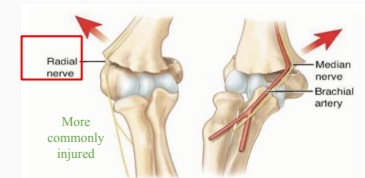
Type-III Complete displacement (extension type) may be:

-Posteromedial (75%) If you get an MCQ asking what is the most commonly injured nerve in the extension type the answer is : **Radial nerve** since posteromedial displacement is more common.

-Posterolateral (25%): : **Median nerve** injury



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 because 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.**



- Posteromedial displacement → you think about the structures that run laterally → radial nerve injury.
- Posterolateral displacement → you think about structures that run medially → median nerve (anterior interosseous) + brachial artery.
- Ulnar injury is seen in flexion fracture (3b).

Reading X-Ray AP + Lateral view & treatment

Normal X-Ray Lines (Golden Slide)

- o Anterior Humeral Line Always should cross the acetabulum
Tells if there is a fracture
- o Hour-glass appearance.
- o Fat-pad sign.
- o Radio-capitellar line.(to show if there is displacement)



Type-I



- o Anterior Humeral Line is intact
- o Hour-glass appearance **partially disrupted**
- o 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)
- o Radio-capitellar line is intact → (Radio-capitellar joint is intact) b/c 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.

Treatment: Above elbow cast (or splint or back slab if severely swelling), at 60-90 degrees for 2-3 weeks.

Type-II



They can't do full AP cause 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.

Treatment:

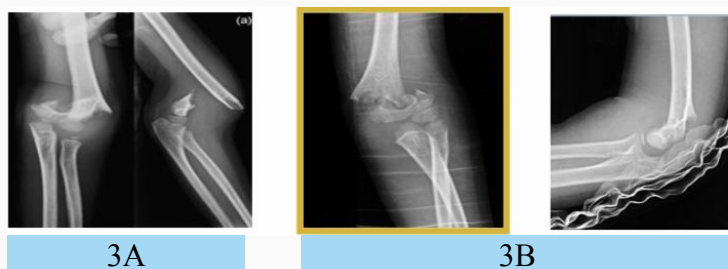
- Closed reduction and above elbow casting we give the patient conscious sedation and we try to reduce fracture. If it fails → close reduction with K-wire fixation.
- Closed reduction with percutaneous pinning with K-wire (if unstable or severe swelling), and above elbow cast (splint) for 4-6 weeks

In the pic → milking of fracture fragments (we try to push it in front).



The classic treatment → 2 crossing smooth k-wires (from the 2 epicondyles and we cross). But what is the problem here? Ulnar nerve, sometimes the fracture itself didn't injure the ulnar nerve but when you went through the epicondyle you injured the nerve. The treatment now is 2 lateral 1 medial. If we're obligated to remove medial wire bc of iatrogenic ulnar nerve injury → at least we have 2 lateral good wires holding the fracture.

Type-III

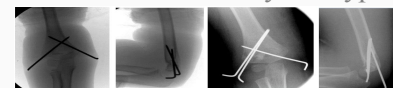


First 2 pics: (Extension type)

Loss of contact (posterior and medial displacement) type 3A. Last 2 pics: (Flexion type) What is seen in the x-ray is a type of temporary immobilizer.

Treatment:

- We attempt closed reduction (in younger age) and percutaneous pinning, if fails open reduction and percutaneous pinning (ORIF) for 4-6 weeks When they are older, we usually have to go in for surgery, we still do the close reduction and we do our K-wire. If we did the close reduction and it's not stable, we need an open reduction
- Direct ORIF if open fracture or with neurovascular injury.



In this open fracture → median nerve and brachial artery are injured.



Complications

Neurologic injury (7% to 10%):

- Median and anterior interosseous nerves (most common)
- Most are neurapraxias requiring no treatment

Or ulnar (iatrogenic)



Others:

- o Loss of motion (stiffness).
- o 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 around the elbow joint → at the beginning there is little bits of movements → when this becomes mature. خلاص انتهى الموضوع

Vascular injury (0.5%)

Direct injury to the brachial artery or secondary to swelling (compartment syndrome) we tend to go in quickly to prevent compression.



- o Angular deformity (Cubitus Varus) the body tends to remodel it.
- o Compartment syndrome we do fasciotomy.



3- Distal Radial Fractures

A. Metaphysis

Classification: depending on pattern

Torus (buckle)

Purely pediatric, never seen in adults.

Only one cortex is involved while periosteum is intact either one side or both sides بعجة

They are stable. So, you depend on history and examination in order to know its location.

Incomplete (greenstick)

Purely pediatric, never seen in adults.

Intact one cortex and minimally displaced (depending on the force direction) another cortex.

Greater ability to remodel (why?)

- 1- The periosteum is still intact.
- 2- It's incomplete fracture.
- 3- It's close to the growth plate.

Complete



Fracture of both bones **adult** هنا زي اي

#Treatment:

- 1- We always attempt closed reduction, (we pull the distal fragment until cortex come in contact then ننزل) then well molded above elbow cast for 6-8 weeks
Cast for 4/6 wks never less!

Treatment:
Immobilized for pain relief in below elbow cast, 2-3 weeks.
 Biocritical injuries should be treated in long arm cast.



Treatment:
Closed reduction and above elbow cast, with supinated forearm to relax the brachioradialis muscle.



2-Or open reduction if we cannot achieve closed reduction or we can do closed reduction but it's not stable and fixation (internal or external)

#Indications for ORIF:

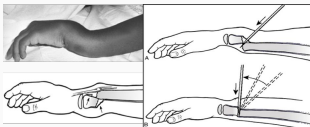
- Irreducible fracture.
- Open fracture. pic (transverse fracture)
- Compartment syndrome.



Internal fixation with 2 crossing wires (no place for plates and screws → you need 3 screws above and 3 below fractures).

Complete # indications for percutaneous pinning without open reduction:

- Loss of reduction, Excessive swelling
- Floating elbow, Multiple manipulations



Details about the management from student work (19 S)

Complication

- Malunion:** Residual angulation (more than 20%) may result in loss of forearm rotation
- Nonunion (Rare)**
- Refracture:** With early return to activity (before 6 weeks) 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.*
- Growth disturbance:** Overgrowth or undergrowth (3mm/9-12yrs)
- Neurovascular injuries:** With extreme positions of immobilization (to much flexion , comparement)

B. Physis:

“S.H” Type I	“S.H” Type II	“S.H” Type III
	<p>Fracture and it's displaced It's not intraarticular → not SH 3 once you see small triangle (orange arrow) → this is type 2</p> <div style="text-align: center;"> </div>	<p>There could be SH 1 in the distal ulna (growth plate is wider than usual)</p> <div style="text-align: center;"> </div>

Treatment (Majority treated with closed reduction and casting)

For Type I and II

- Closed reduction followed by above elbow cast, with the forearm pronated.

We can accept deformity: 50% translation

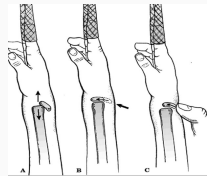
(The body is able to correct it by itself) with no angulation or rotation. (The body cannot correct angulation and rotation.)

#Complication:

Growth arrest can occur in 25% with repeated closed reduction manipulations.

- Open reduction is indicated in:

1. Irreducible fracture.
2. Open fracture.



In the pic: 2 parallel wires (we can use crossing, according the available space “there are a lot of tendons and NV structures”) In the



For Type III

- Anatomic reduction necessary à intra-articular.
- ORIF with smooth pins or screws in epiphysis. Or k-wire



For Type IV & V

- Rare injuries.
- Need ORIF.

Type 5 is really rare. Sometimes we pick it up only with complications: LLD

#COMPLICATIONS

1. Physeal arrest (MRI to assess)
 - Shortening ulna should be shorter than radius.
 - Angular deformity.
2. Ulnar styloid nonunion.
3. Carpal tunnel syndrome.



4- Femoral Shaft Fractures (diaphysis)

Incidence:	Mechanism of Injury:
------------	----------------------

- o 1.6% of all pediatric fracture.
- o M > F
- o Age: (2 – 4) years old learning to walk & Mid-adolescence. **2 peaks**
- o Adolescence >90% due to RTA.
- o If in a child <1y old 80% will be “Child Abuse”
In children younger than walking age, 80% of these injuries are caused by child abuse; this decreases to 30%

- o Direct trauma: **RTA**, Fall, Child abuse.
- o Indirect trauma: Rotational injury.
- o Pathologic fractures: Osteogenesis imperfecta, Non-ossifying fibroma, Bone cysts or tumors.

How to know if it’s direct or indirect from x-ray?
 Transverse and Comminuted fractures are direct; the spiral is indirect.

Clinical Evaluation	Reading X-ray: AP and lateral view
---------------------	------------------------------------

o Look:
 Pain, **swelling of the thigh**, Inability to ambulate, and Variable gross deformity.
 Careful O/E of the overlying soft tissues to rule out the possibility of an open fracture (puncture wound).

o Feel:
 Tender at fracture site
Careful neurovascular examination is essential.

This is usually how they appear “like a spike” → risk of open fracture.



Classification		Radiographic Evaluation
----------------	--	-------------------------


Descriptive

- Open or closed.
- Fracture pattern: transverse, spiral, oblique, butterfly fragment.
- Comminution.
- Displacement.

Anatomic

- Subtrochanteric.
- Shaft.
- Supracondylar.

- AP and lateral views.
- Must include hip & knee joints.



< 6m:

- o Pavlik Harness.
- o Closed reduction & immediate hip spica casting.
- o Or **traction** (a lot of overlap) 1-2w, **then hip spica** casting.



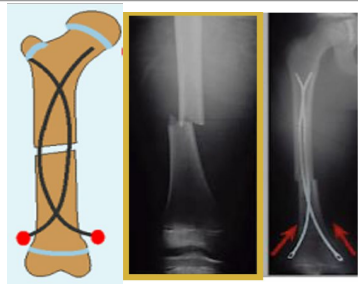
6m – 6y:

- o **Closed reduction & immediate hip spica** casting (>95%)
- o Or **traction** in the pic: 90-90 "hip is 90 and knee is 90" skeletal traction to disimpact the fracture. we almost never do this .1-2w, **then hip spica** casting (if there is difficulty to maintain length and acceptable alignment)



6– 12y:

Flexible I.M.N.
it must be diaphyseal fracture

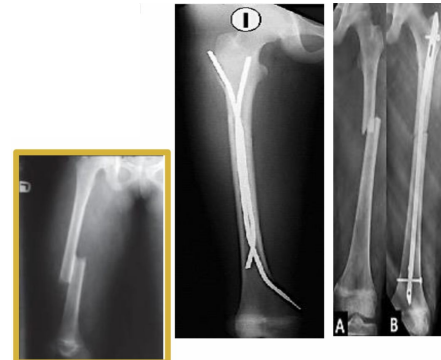


Bridge Plating. Bridging plate is when we use the most proximal and most distal screws.
Direct plate when we use all the screws.

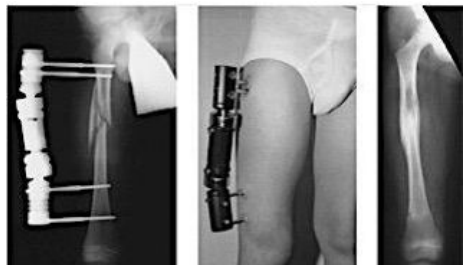


12y to skeletal maturity:

Intramedullary fixation with either:
– Flexible nails, or
– Locked I.M nail



- External fixation:**
- 1-Multiple injury
 - 2-Open injury
 - 3-Comminuted fracture.
 - 4- Unstable fracture.



OPERATIVE INDICATIONS:

1. Multiple trauma, including head injury.
2. Open fracture.
3. Vascular injury.
4. Pathologic fracture.
5. Uncooperative patient.

COMPLICATIONS:

1. Malunion: remodeling will not correct rotational deformities.
2. **Leg length discrepancy**: secondary to **shortening** or **overgrowth** of (1.5-2) cm is common in 2-10 year of age.
3. Muscle weakness.
4. Nonunion (rare).
5. Osteonecrosis (AVN) of femoral head with antegrade IMN <12 year.

Remember

- Pediatric fractures have great remodeling potentials.
- The importance of growth plates & periosteum in remodeling.
- **A good number of cases can be treated conservatively.**
- Operative fixations aids in avoiding complications.

Torus: Only back slab 2 weeks "Immobilization, below elbow"

Green stick:

- No displacement → back slab 3 weeks
- Angulation or Displacement → closed Reduction + Back Slab 3 weeks Above elbow

Complete: Start with closed Reduction then

- if Stable → **Cast 4-6 weeks** (Long arm)
- if UNstable or Percutaneous Pinning "K-wire" → then **Cast 4-6 Weeks**
- if UNable to do reduction or open fracture → do open reduction + K-wire then **Cast 4-6 weeks** if complete fracture **6 weeks** is best

Distal Radius Metaphyseal Injur

Complete fracture

- Indications for percutaneous pinning without open reduction
- loss of reduction
- Excessive swelling
- Floating elbow
- Multiple manipulations

Distal Radius Metaphyseal Injur

Complete fracture

- Closed reduction
- Well molded long arm cast for 3 to 4 weeks

A patient came with complete Radius fracture fixed and casted for 3 week
 What's the most common complication? **Refracture (4-6)**
 how to manage? **Surgery (Ikk what though)**

Special thanks to Nawaf Alsubaie

Fractures in Children

- type of fracture
 - thicker, more active periosteum results in pediatric-specific fractures: greenstick (one cortex), torus (i.e. 'buckle', impacted cortex) and plastic (bowing)
 - distal radius fracture most common in children (phalanges second), the majority are treated with closed reduction and casting
 - adults fracture through both cortices
- epiphyseal growth plate
 - weaker part of bone, susceptible to fractures
 - plate often mistaken for fracture on x-ray and vice versa (X-ray opposite limb for comparison), especially in elbow
 - tensile strength of bone < ligaments in children, therefore clinician must be confident that fracture and/or growth plate injury have been ruled out before diagnosing a sprain
 - intra-articular fractures have worse consequences in children because they usually involve the growth plate
- anatomic reduction
 - gold standard with adults
 - accept greater angular deformity in children (remodelling minimizes deformity)
- time to heal
 - shorter in children
- always be aware of the possibility of child abuse
 - make sure stated mechanism compatible with injury
 - high index of suspicion with fractures in non-ambulating children (<1 yr); look for other signs, including X-ray evidence of healing fractures at different sites and different stages of healing
 - common suspicious fractures in children: metaphyseal corner fracture (hallmark of non-accidental trauma), femur fracture <1 year old, humeral shaft <3 year old, sternal fractures, posterior rib fractures, spinous process fractures

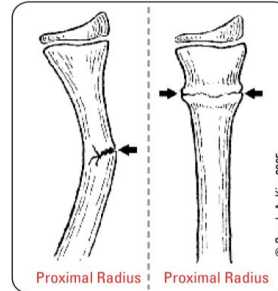


Figure 50. Greenstick (left) and torus (right) fractures



Greenstick fractures are easy to reduce but can redisplace while in cast due to intact periosteum

Physeal Injury

Table 24. Salter-Harris Classification of Epiphyseal Injury

SALT(E)R-Harris Type	Description	Treatment
I (Straight through; Stable)	Transverse through growth plate	Closed reduction and cast immobilization (except SCFE - ORIF); heals well, 95% do not affect growth
II (Above)	Through metaphysis and along growth plate	Closed reduction and cast if anatomic; otherwise ORIF
III (Low)*	Through epiphysis to plate and along growth plate	Anatomic reduction by ORIF to prevent growth arrest, avoid fixation across growth plate
IV (Through and through)*	Through epiphysis and metaphysis	Closed reduction and cast if anatomic; otherwise ORIF
V (Ram)*	Crush injury of growth plate	High incidence of growth arrest; no specific treatment

* Types III - IV are more likely to cause growth arrest and progressive deformity

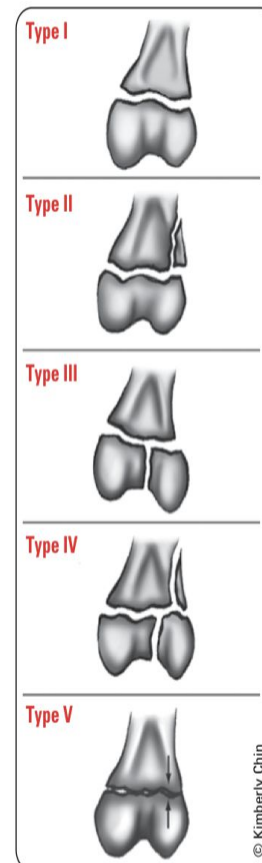


Figure 51. Salter-Harris classification



Non-Operative Treatment Compared with Plate Fixation of Displaced Mid-Shaft Clavicular Fractures. A Multicentre, Randomized Clinical Trial

J Bone Joint Surg. Am. 2007; 89(1),1-10

Purpose: To compare non-operative treatment with plate fixation in displaced mid-shaft clavicular fractures.

Results: Constant shoulder scores and DASH scores were significantly improved in the operative fixation group at all time-points ($p = 0.001$ and $p < 0.01$, respectively). The mean time to radiographic union was 28.4 weeks in the non-operative group compared with 16.4 weeks in the operative group ($p = 0.001$). At one year after the injury, the patients in the operative group were more likely to be satisfied with the appearance of the shoulder ($p = 0.001$) and with the shoulder in general ($p = 0.002$) than were those in the non-operative group.

Conclusions: Operative fixation of a displaced fracture of the clavicular shaft results in improved functional outcome and a lower rate of malunion and nonunion compared with non-operative treatment at one year of follow-up.

Clavicle Fracture

- incidence: proximal (5%), middle (80%), or distal (15%) third of clavicle
- common in children (unites rapidly without complications)

Mechanism

- fall on shoulder (87%), direct trauma to clavicle (7%), FOOSH (6%)

Clinical Features

- pain and tenting of skin
- arm is clasped to chest to splint shoulder and prevent movement

Investigations

- evaluate NVS of entire upper limb
- X-ray: AP, 45° cephalic tilt (superior/inferior displacement), 45° caudal tilt (AP displacement)
- CT: useful for medial physeal fractures and sternoclavicular injury

Treatment

- medial and middle-third clavicle fractures
 - for nondisplaced fractures, simple sling x 1-2 wk prn
 - early ROM and strengthening once pain subsides
 - if fracture is shortened >2 cm, consider ORIF
- distal-third clavicle fractures
 - undisplaced (with ligaments intact): sling x 1-2 wk
 - displaced (CC ligament injury): ORIF

Specific Complications (see General Fracture Complications, OR7)

- cosmetic bump usually only complication
- shoulder stiffness, weakness with repetitive activity
- pneumothorax, brachial plexus injuries, and subclavian vessel (all very rare)



Associated Injuries with Clavicle Fractures

- Up to 9% of clavicle fractures are associated with other fractures (most commonly rib fractures)
- Majority of brachial plexus injuries are associated with proximal third fractures



Three Joints at the Elbow

- Humeroradial joint
- Humeroulnar joint
- Radioulnar joint



Normal carrying angle of elbow is ~10° of valgus

Supracondylar Fracture

- subclass of distal humerus fracture: extra-articular, fracture proximal to capitulum and trochlea, usually transverse
- most common in pediatric population (peak age ~7 yr old), rarely seen in adults
- AIN (median nerve) injury commonly associated with extension type

Mechanism

- >96% are extension injuries via FOOSH (e.g. fall off monkey bars); <4% are flexion injuries

Clinical Features

- pain, swelling, point tenderness
- neurovascular injury: median and radial nerves, radial artery

Investigations

- X-ray: AP and lateral views of the elbow
 - disruption of anterior humeral line suggests supracondylar fracture
 - fat pad sign: a sign of effusion and can be indicative of occult fracture
 - assess NVS: median and radial nerves, radial artery

Treatment

- non-operative
 - nondisplaced (pediatric): long arm plaster slab in 90° flexion x 3 wk
- operative
 - indications: displaced >50%, vascular injury, open fracture
 - requires percutaneous pinning followed by limb cast with elbow flexed <90°
 - in adults, ORIF is necessary

Specific Complications (see General Fracture Complications, OR7)

- stiffness is most common
- brachial artery injury (kinking can occur if displaced fracture), median or ulnar nerve injury, compartment syndrome (leads to Volkmann's ischemic contracture), malalignment cubitus varus (distal fragment tilted into varus)

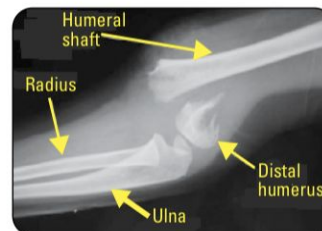


Figure 16. X-ray of transverse displaced supracondylar fracture of humerus with elbow dislocation

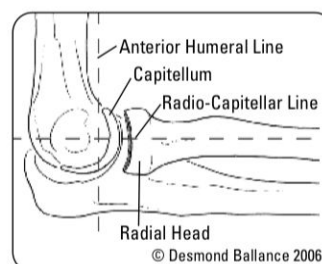


Figure 17. Lateral view of elbow

MCQS

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

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

- A. Common in dominant limb
- B. Common in non-dominant limb

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

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

- A. Plates
- B. Cast
- C. Screws
- D. I.M.N

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

- A. Screws
- B. Plates
- C. I.M.N
- D. K-wire

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

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

8-What are the common fracture pattern in Infants?

- A.Infants: diaphyseal fractures
- B.Infants: metaphyseal fractures
- C.Infants: epiphyseal injuries

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

- A. Neurovascular
- B.Pulmonary function
- C. a & b

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

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

- A. Child abuse.
- B. RTA.
- C. Birth injury.

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

- A.Cast
- B.Screws
- C.K-wires
- D.Plates

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

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 avascular necrosis.
- D-femurs chronic osteomyelitis.

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

Answers:

1-B 2-B. 3-A. 4-B. 5-D. 6-A
7-B. 8-A. 9-C. 10-A. 11-A. 12-D
13-C. 14-B. 15-D

SAQS

1- Why Children do not get anterior cruciate ligament tears?

Answer: Because ligaments are stronger than bones in the pediatric age group (Injuries that produce ACL tear in adults will produce bone fractures in children)

2- Why we do not use intramedullary nail (IMN) to fix a femur shaft fracture in children below 12 years of age?

Answer: Because it may lead to leg length discrepancy and avascular necrosis.