IN THE NAME OF GOD
Ankle fractures account for approximately

- 5% of pediatric fractures
and
- 15% of physeal injuries
Fractures occur twice as frequently in boys.

Peak incidence is in the age range of 8 to 15 years.
Ligamentous injuries in the growing child are unusual.

due to

ligaments are generally stronger than open physes.
The ankle is a true hinge joint and is stable due to its inherent articular congruity and the surrounding ligamentous structures.
Because the dome of the talus is wider anteriorly than posteriorly, there is potentially more translation and rotation when the ankle is plantar-flexed.

Therefore

*plantar-flexion places the ankle at a higher risk for injury*
Closure of the distal tibial physis progresses from central to medial and then lateral over the course of approximately 18 months.
Progression of normal distal tibial physeal closure at puberty.

A) Begins centrally
B) Spreads medially
C) Then laterally
D) Until complete closure
Progression of normal distal tibial physeal closure at puberty.
The **distal tibial physis** provides:

- 3 to 4 mm of growth annually
- contributes approximately 15% to 20% of the length of the lower extremity
- 35% to 40% of tibial length.
Distal tibial physeal closure is generally completed by age 14 years in girls and age 16 years in boys.
Pediatric ankle fractures can be classified by using either:

- an anatomic (radiographic) scheme.
- a mechanism of injury scheme.

✓ ananatomic (radiographic)

or

✓ amechanism of injury scheme.
Dias and Tachdjian classification of pediatric ankle fractures using four basic mechanisms:

- supination - inversion
- supination–plantar flexion
- supination–external rotation
- pronation/eversion–external rotation

In the description of each mechanism:

**first term** refers to the **position of the foot**, 
**second term** refers to the **direction of the applied force** at the time of injury.
Two additional fracture patterns were included:

- the juvenile Tillaux fracture
- the triplane fracture

These are termed transitional fractures to indicate their occurrence during the time of physeal closure.
Salter-Harris classification of physeal fractures is the most commonly used anatomic system, because of its simplicity and the prognostic significance of each injury type.

Type I and II injuries have lower risks of physeal arrest than injuries classified as types III, IV, and V.
Salter-Harris classification of fractures
Rang added a **sixth type**, comprising **perichondral ring injuries** that result from direct open injuries (e.g., those due to lawnmower accidents) or from the trauma of surgical dissection.
Salter-Harris I Fractures

- account for approximately 15% of distal tibial physeal fractures

- generally disrupt the physis through the zone of hypertrophy.
Salter-Harris II Fractures

the fracture line extends through the zone of hypertrophy but then exits through the metaphysis, creating a

*triangular Thurston-Holland fragment.*
Salter-Harris II Fractures

The periosteum is typically torn on the side opposite to the Thurston-Holland fragment
Salter-Harris III Fractures

Because these fractures traverse the physis and exit through the epiphysis, there is often an intra-articular step-off.
Salter-Harris III Fractures

These are commonly seen with medial malleolus fractures as well as with Tillaux fractures.
Tillaux fractures are Salter-Harris III fractures of the anterolateral portion of the distal tibia, and result from an epiphyseal avulsion at the site of attachment of the anterior inferior tibiofibular ligament.
Tillaux Fractures

- It is a Salter Harris type III fracture of the distal tibial epiphysis and is only seen in adolescents.
Tillaux Fractures

These fractures are most commonly seen in children nearing skeletal maturity (generally 12 to 14 years old) during the approximately 18-month period during which the distal tibial physis is closing.
Tillaux Fractures

The mechanism of injury is typically supination–external rotation.

It is caused by:

- forced external rotation of the foot
- or
- internal rotation of the tibia if the foot fixed on the ground
Pediatric Triplane Ankle Fracture
The triplane fracture is sometimes referred to as the **Marmor-Lynn fracture**.
Pediatric Triplane Ankle Fracture

The pediatric triplane ankle fracture represents a unique spectrum of injury that does not fit neatly into the Salter-Harris classification of physeal injury.
Pediatric Triplane Ankle Fracture

Triplane fractures have components in the sagittal, coronal, and transverse planes.
Pediatric Triplane Ankle Fracture

- The patient most susceptible to the triplane fracture is aged 12 to 15 years who is transitioning to skeletal maturity.
  
  *(girls: 12 to 14 years & boys: 13 to 15 years)*

- This injury usually does not occur in patients younger than age 10 years or older than age 16.7 years.
Pediatric Triplane Ankle Fracture

Numerous variations have been described, including:

- two-, three-, and four-fragment types
- medial and lateral involvement
- extra- and intra-articular configurations
Pediatric Triplane Ankle Fracture

Radiographic views of the ankle demonstrate:
- **Salter Harris type III fracture** on AP radiographs
- **Salter Harris type II fracture** on lateral radiographs.

thus it is sometimes classified as a **Salter Harris type IV fracture**.
Pediatric Triplane Ankle Fracture

The fibula is fractured in approximately 50% of triplane ankle fractures
The two-part triplane fracture either is:

- **lateral**, with the coronal fragment posterolateral (A)
- **medial**, with the coronal fragment posteromedial (B)
Both intra- and extra-articular intramalleolar variants also have been described.
Pediatric Triplane Ankle Fracture

- Such extraarticular variants are important to recognize because fractures without distal tibial articular surface disruption may be managed nonsurgically.

- In contrast, the presence of articular surface disruption in the typical triplane fracture often necessitates open reduction and internal fixation (ORIF).
A quadrileplane fracture
(typical triplane Fx + a metaphyseal fragment): A combination of external rotation & vertical compression have been proposed as the mechanism of injury.
Pediatric Triplane Ankle Fracture

Plain radiographs do not consistently demonstrate the number of fracture fragments.

Thus

CT scans are necessary for identifying the configuration of the fracture and evaluating residual displacement, as well as for preoperative planning.
Pediatric Triplane Ankle Fracture

The characteristic "Mercedes-Benz" three-pointed star configuration has been noted on CT scans of classic triplane fractures.
Salter-Harris V Fractures

- A compressive force across the germinal layer of the physis.

- Displacement of the epiphysis is rare.

- These fractures are generally categorized as type V injuries when a patient is noted to have a LLD or angular deformity months or years after a suspected type I physeal injury.
Salter-Harris V Fractures

The prognosis of this injury is poor due to the sequelae of physeal arrest.
stabilization of airway, breathing, and circulation always takes precedence.
Child abuse and pathologic lesions should be considered if the reported mechanism of injury does not appear to match the fracture type present.
3 radiographic views should be obtained in the evaluation of pediatric ankle injuries.
Mortise X-ray

The tibiofibular line should be congruent and parallel to each surface of the talus.
Mortise X-ray

Tilt of the talus in the mortise indicates instability
Mortise X-ray

Talocural angle is normally 8°–15°.

<8° or 2° difference from other side indicates fibular shortening.
Mortise X-ray

4 mm is normal widening indicates syndesmotic disruption
Although some authors have recommended **stress views** for the diagnosis of nondisplaced Salter-Harris I fractures, they are probably **unnecessary** and may result in iatrogenic physeal damage.
CT is a useful diagnostic aid, especially for the evaluation of intra-articular fractures, including transitional fractures.
Treatment of Distal Tibial Fractures
There are two important goals when treating children with ankle fractures:

1- achieving a satisfactory reduction
2- avoiding physeal arrest so as to minimize the risks of angular deformity, early arthrosis, leg-length inequality, and joint stiffness.
Salter-Harris I and II fractures have a low incidence of physeal arrest and are generally treated in similar fashion.
Salter-Harris I and II Fractures

- Salter-Harris I and II fractures should be reduced so as to minimize physeal injury.

- Reduction should be attempted only once or twice.
Salter-Harris I and II Fractures

- Closed reduction is used for displaced fractures.

- Generally, reduction within a few millimeters is possible, and cast treatment for 4 to 6 weeks results in a successful outcome.
Salter-Harris I and II Fractures

If closed reduction is not successful, open reduction should be performed.
Salter-Harris I and II Fractures

- Internal fixation is rarely necessary.

- If fixation is required for an unstable fracture and the metaphyseal fragment is large and accessible, a 3.5- or 4.0-mm cannulated lag screw parallel to the physis is effective.

- If the physis must be crossed with hardware, smooth wires should be used.
Salter-Harris III Fractures

- Risks following Salter-Harris III fractures are joint incongruity and growth disturbance.

- Closed reduction under sedation may be attempted.
Salter-Harris III Fractures

**ORIF** is recommended for all such fractures with more than 2 mm of residual displacement.
Salter-Harris III Fractures

- If possible, fixation devices should be placed parallel to (and avoiding) the physis.

- Screw fixation is preferable, but smooth wires may be used.
Salter-Harris III Fractures

- If smooth wires are inserted parallel to the physis, the two wires should not be exactly parallel in all planes, as postoperative displacement may occur after such fixation.

- Screws or threaded wires should never be placed across an open physis.
Tillaux Fractures

Nondisplaced fractures are immobilized with a long leg cast for 4 weeks.

A short leg cast may be used for an additional 2 weeks if physeal tenderness is present on removal of the long leg cast.
Tillaux Fractures

- Patients with displaced fractures are treated with closed reduction under sedation.

- For reduction must reverse the mechanism of injury (supination–external rotation).
Tillaux Fractures

- After reduction, plain radiographs and CT scans will confirm the adequacy of reduction.

- If the intra-articular step-off measures 2 mm or more, reduction and internal fixation is warranted.
Tillaux Fractures

- If an essentially anatomic reduction can be obtained, percutaneous fixation with cannulated screws or wires may be used.

- However, if such a reduction is not possible, open reduction should be performed through an anterolateral approach to the ankle.
Tillaux Fractures

It is believed that an anatomic reduction is mandatory to prevent degenerative changes and ankle stability.

However, fracture reduction is difficult to assess adequately in part because the fracture fragments are obscured by the cast so some prefer an open reduction in all Tillaux fractures that have 2 mm or more of fracture displacement.
Tillaux Fractures
Triplane Fractures
Triplane Fractures

As with Tillaux fractures, nondisplaced triplane fractures may be treated with immobilization in a **long leg cast** for 4 weeks,

followed by use of a **short leg walking cast** for an additional 2 weeks.
Triplane Fractures

Closed reduction is performed under general anesthesia, with \textit{axial traction} on the ankle and \textit{internal rotation} of the foot.

For \textit{medial fractures}, the foot is positioned in \textit{external rotation}, and for \textit{lateral fractures}, in \textit{internal rotation}.
**Triplane Fractures**

Postreduction CT scans and serial radiographs are needed to assess adequacy of reduction.
Triplane Fractures

Fractures with >2 mm displacement require reduction, either closed or open.
Triplane Fractures

Displacement >3 mm bodes poorly for successful closed reduction secondary to the energy of the injury, soft-tissue interposition at the fracture, and swelling.
Triplane Fractures

Intra-articular displacement of 2 mm or more or displacement at the level of the physis of more than 2 mm in a child with more than 2 years of growth remaining mandates the use of open reduction and internal fixation.
Triplane Fractures

Surgical indications for ORIF include initial fracture displacement >3 mm as well as failure to achieve adequate reduction, usually defined as >2 mm of intra-articular step-off.
Triplane Fractures

If more than 2 years of growth remains, fixation traversing the physis should be avoided if possible.
Triplane Fractures

ORIF can be performed through an anterolateral approach (lateral fractures) or an anteromedial approach (medial fractures), with additional incisions made for adequate exposure.
Triplane Fractures
Triplane Fractures

Arthroscopic reduction and internal fixation of two-part triplane fractures has been described to have advantages over traditional ORIF.
The anteromedial portal was first located by introducing an 18 gauge needle into the ankle joint, medial to the tibialis anterior tendon.
Triplane Fractures

The ankle joint was then injected with 10–20 ml of saline to distend the joint and the needle removed. A stab wound was then made in the skin only.
**Triplane Fractures**

- An arthroscope (2.7mm scope with 30 obliquity) is introduced into the joint and the fluid was made to run using a pump.

- An anterolateral portal was then made with the help of the light source shining under the skin at the chosen spot anterolaterally (lateral to extensor communis tendons).
Triplane Fractures

Fixation was then achieved using a 4-mm cannulated cancellous screw inserted percutaneously.

With the aid of the image intensifier and arthroscopy, screws were accurately positioned to ensure that there was no intra-articular placement and that they did not cross the physis.
Triplane Fractures

Postoperatively patients were initially placed in a below knee plaster splint for 2 weeks before being supplied with a removable splint to initiate range of motion exercises.

A nonweight bearing status using crutches was maintained for 6 weeks
Triplane Fractures
Triplane Fractures
Salter-Harris IV Fractures

Patients with nondisplaced fractures should be treated in a non-weight-bearing long leg cast for 4 weeks, which may be followed by a short leg walking cast for another 2 weeks.
If there is more than 2 mm of residual displacement, treatment is open reduction and internal fixation to minimize articular incongruity and the risk of physeal bar formation.
The perichondral ring should not be elevated from the physis, and screw fixation should be parallel to the physis.
Salter-Harris IV Fractures

- Fibular fractures accompanying Salter-Harris IV distal tibial fractures are most commonly Salter- Harris I and II injuries.

- The fibular fracture is usually stable after reduction of the tibial fracture.
Salter-Harris IV Fractures

If the fibula remains unstable after reduction of the tibial fracture, internal fixation is indicated, often with an intramedullary Kirschner wire.
Salter-Harris V Fractures

If the fracture is accurately identified as a type V injury initially, excision of the damaged portion of the physis and placement of a fat graft may prevent the development of growth arrest.
Treatment of Distal Fibular Fractures
Isolated Fractures

An isolated Salter-Harris I fracture can be distinguished from a lateral ankle sprain by the presence of local tenderness over the distal fibular physis rather than over the anterior talofibular, calcaneofibular, and posterior talofibular ligaments.
Isolated Fractures

Heal well within 3 weeks in a short leg walking cast.

Salter-Harris III and IV injuries are rare and must be distinguished from an accessory ossification center (os fibulare).
Fractures Combined With Distal Tibial Fractures

Fibular fractures seen in conjunction with distal tibial fractures are routinely reduced with reduction of the tibial fracture.

These fibular fractures tend to be stable after reduction and rarely require fixation in the skeletally immature individual.
Fractures Combined With Distal Tibial Fractures

Fixation may be indicated for the child nearing skeletal maturity with a severely comminuted fracture at risk for shortening.
Complications of Ankle Fractures
Growth arrest is most common after distal tibial Salter-Harris III and IV fractures, and often leads to both a leg-length discrepancy and an angular deformity of the ankle. Leg length discrepancy is related to the child’s age at the time of fracture and usually is between 1 and 2 cm.
Osteoarthritis

Osteoarthritis may result from chondral damage at the time of injury or articular incongruity at the time of fracture healing.
Ankle Stiffness

Posttraumatic ankle stiffness is likely due to a combination of injuries to both the soft tissues and the osseous structures.
Ankle Stiffness

Physical therapy should be used to treat all patients with severe injuries as well as to treat those patients with marked residual ankle stiffness 1 month after cast removal.
Reflex Sympathetic Dystrophy (RSD)

RSD in children is characterized by pain out of proportion to an injury in conjunction with signs of autonomic dysfunction of the injured extremity.
Reflex Sympathetic Dystrophy (RSD)

Potential components of treatment include:

- physical therapy
- psychological counseling
- drug therapy
- sympathetic blockade
رو هر پله که باشی،
خدا یک پله از تو بالاتره;
نه به خاطر اینکه خداست،
به خاطر اینکه دست تو بکیره.