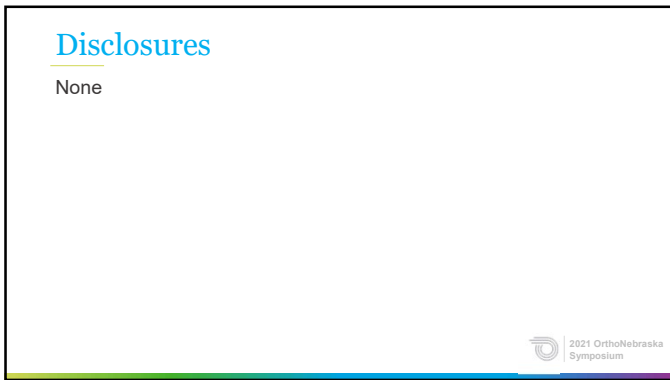
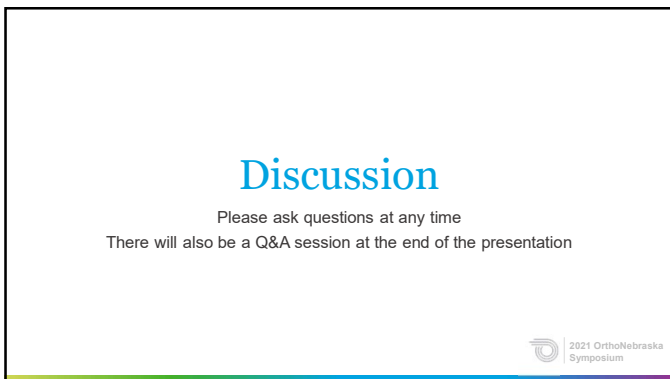




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Learning Objectives

- Identify physeal fractures in pediatric and adolescent patients
- Review appropriate fracture management for physeal injuries



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4

Overview

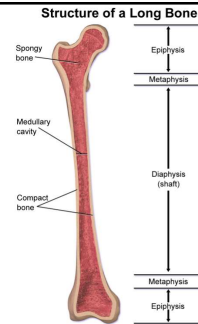
- Long Bone Anatomy
- Physeal Anatomy
- Salter-Harris Physeal Fracture Classification
- Treatment of Physeal Injuries
 - When to Refer a Physeal Injury
 - Surgical vs. Non-surgical treatment
- Consequences of Missed or Maltreated Physeal Injuries

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5

Long Bone Anatomy

- So we are all on the same page
 - Diaphysis
 - Shaft of the long bone
 - Metaphysis
 - Transition between diaphysis and epiphysis
 - Narrowing of the cortical bone with increased trabecular bone
 - Epiphysis
 - End of the long bone associated with joint
 - Thin cortex with significant amount of trabecular bone



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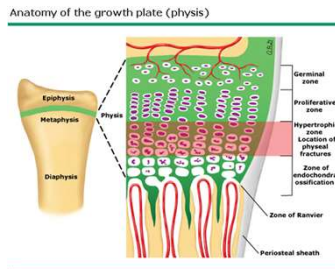
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Questions

7

Physeal Anatomy

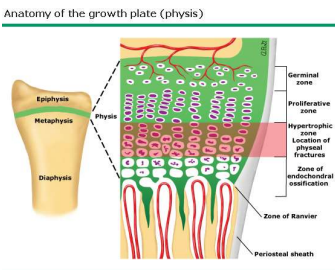
- The physis a complex structure with multiple layers visible on microscopy
- The layers of the physis correspond to their function
- Physeal injuries typically occur through one layer of the physis
- This only applies to long bone formation



8

Physeal Anatomy

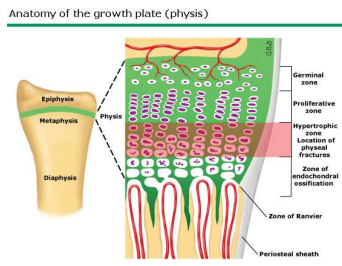
- The layers of the physis are as follows
 - Reserve/Germinal zone
 - Proliferative zone
 - Hypertrophic zone
 - Physeal fractures through here
 - Primary spongiosa
 - Secondary spongiosa



9

Physeal Anatomy

- Reserve/Germinal zone
 - Storage site for later growth and matrix formation
 - Glucose
 - Glycogen
 - Proteoglycan



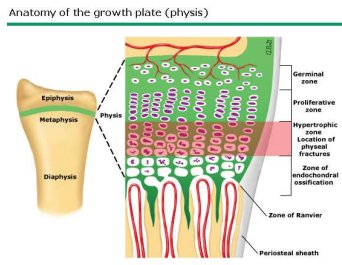
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10

Physeal Anatomy

- Proliferative zone
 - Proliferation of chondrocytes with longitudinal growth and stacking of cells
 - Highest rate of extracellular matrix production



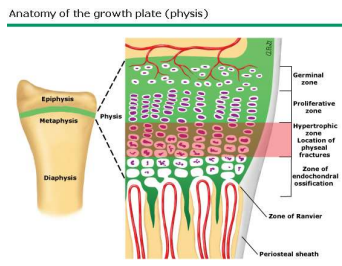
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11

Physeal Anatomy

- Hypertrophic zone
 - Zone of chondrocyte maturation
 - Maturation Zone
 - Calcification preparation happens here
 - Degenerative Zone
 - Chondrocytes grow in size up to 5x
 - Provisional calcification zone
 - Chondrocytes die and matrix calcifies



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Physeal Anatomy

- Primary spongiosa
 - Vessels invade the area
 - Osteoblasts align on cartilage bars to expand the physis
 - This area will mineralize to form woven bone and remodel to become secondary spongiosa

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13

Physeal Anatomy

- Secondary spongiosa
 - Internal remodeling
 - Replacement of fiber bone with lamellar bone
 - External remodeling
 - Funnelization

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14

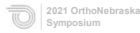
Questions

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15

Salter-Harris Physeal Fracture Classification

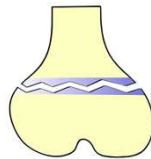
- Growth plate fractures are classified by severity 1-5
- The severity of the injury increases as you go up the scale
- The chance of physeal arrest increases as you go up the scale
- Type 2 is by far the most common fracture type



16

Salter-Harris Physeal Fracture Classification

- Salter-Harris 1 fracture
 - Compression or separation of the physis
 - This injury can be displaced or non-displaced
 - Pain is common over the physis even if no fracture is visualized
 - MRI may be the only way to diagnose this injury
 - Not recommended initially as most patients will be better after 4-6 weeks of immobilization
 - Displaced SH1 fractures may require a reduction



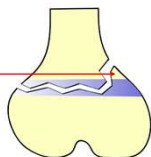
Type 1 - 5%



17

Salter-Harris Physeal Fracture Classification

- Salter-Harris 2 fracture
 - Fracture through the physis and exiting the metaphysis
 - By far the most common
 - Thurston-Holland fragment
 - The metaphyseal bone attached to the epiphysis portion of the fracture



Type 2 - 75%



18

Salter-Harris Physeal Fracture Classification

- Salter-Harris 2 fracture
 - Thurston-Holland fragment
 - The metaphyseal bone attached to the epiphysis portion of the fracture
 - Not to be confused with this guy...

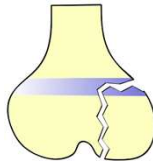


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19

Salter-Harris Physeal Fracture Classification

- Salter-Harris 3 fracture
 - Fracture traverses the physis and exits the epiphysis
 - Uncommon fracture type
 - When seen commonly requires surgical intervention due to instability of the joint



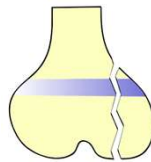
Type 3 - 10%

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20

Salter-Harris Physeal Fracture Classification

- Salter-Harris 4 fracture
 - Fracture passes through the
 - Epiphysis
 - Physis
 - Metaphysis
 - Usually requires higher energy
 - If displaced will require intervention



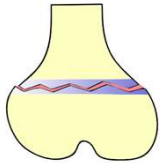
Type 4 - 10%

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Salter-Harris Physeal Fracture Classification

- Salter-Harris 5 fracture
 - Crush injury to the physis
 - These fractures are uncommon
 - When they occur, it is common to see physeal arrest



Type 5 - uncommon

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Questions

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23

Treatment of Physeal Injuries

- Treatment of the physeal injury depends upon the severity of the injury and the displacement of the fracture
- The injury on the right requires reduction and immobilization with possible surgery
- The injury on the left requires a well molded cast



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24

Treatment of Physeal Injuries

- Initial immobilization is recommended
- If a physeal injury is to be reduced, it should not be attempted multiple times as this will increase the chances of growth arrest
- If you are not comfortable reducing the physeal injury, please refer on for treatment as soon as possible



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25

Treatment of Physeal Injuries

- Radiographic follow up is generally indicated
 - Follow up is continued until a normal growth rate can be established radiographically
 - This may require years of radiographic follow up depending upon the age of the child and severity of the injury
 - Currently further research is being dedicated to the radiographic and clinical factors that would indicate lower need for radiographic follow up



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26

Questions

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27

Consequences of Missed or Maltreated Physeal Injuries

- Physeal arrest
 - Physeal injury may cause growth arrest at all or part of the physis
- Complete physeal arrest
 - Leads to complete arrest at the injured physis
 - No further growth occurs
 - May lead to leg/arm length discrepancy



Lossy, 2011
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28

Consequences of Missed or Maltreated Physeal Injuries

- Physeal arrest
 - Physeal injury may cause growth arrest at all or part of the physis
- Incomplete physeal arrest
 - Further growth occurs at a portion of the physis
 - May lead to angulated growth at the physis
 - May lead to angular deformity of the limb in question

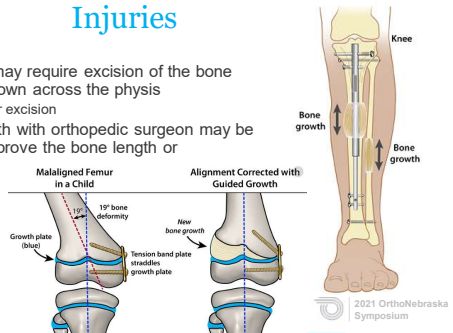


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29

Consequences of Missed or Maltreated Physeal Injuries

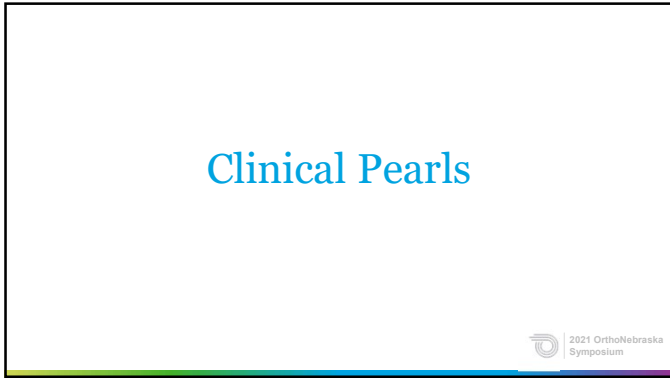
- Physeal arrest
 - Such injury may require excision of the bone which has grown across the physis
 - Physeal bar excision
- Guided growth with orthopedic surgery may be utilized to improve the bone length or angulation



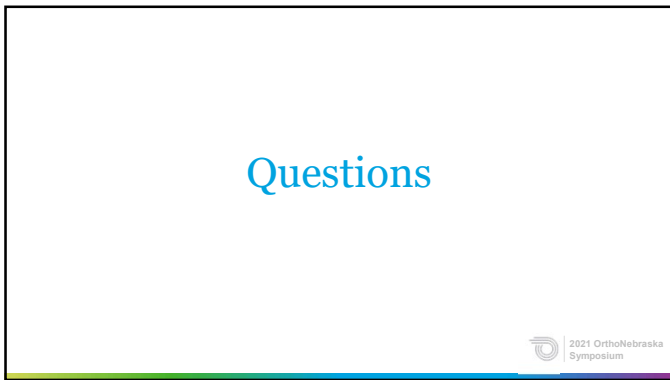
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30



31



32
