Physeal Pediatric Injuries in the Young Athlete

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Introduction

• Participation in children’s and youth sports is widespread

• specialisation in their sports at a very early age

• may train 20 or more hours a week
Risk and Severity of Injury

- **tolerance limits of the physis** may be exceeded by the mechanical stresses

- **Disturbance of physeal growth** as a result of injury can result in
  - length discrepancy,
  - angular deformity,
  - or altered joint mechanics
  - may cause significant **long term disability**
Anatomy & Physiology of Physis

- Growing parts of the bone include
  - the physis
  - the epiphysis
Anatomy & Physiology of Physis

- Two types of epiphyses are found in the extremities:
  - traction
  - pressure
Traction epiphyses (or apophyses)

- located at the site of attachment of major muscle tendons to bone
- are subjected primarily to tensile forces
- contribute to bone shape but not to longitudinal growth
Overuse apophyseal conditions

- Osgood-Schlatter disease,
- Sever’s disease,
- medial epicondylopathy in the throwing arm
Pressure epiphyses

- situated at the end of long bones
- are subjected to compressive forces
Pressure epiphyses

- essential mechanism of endochondral ossification

- injury to pressure epiphyses and their associated growth plates may result in growth disturbance
Ogden classification

Zone of “growth”

• germinal cells are attached to the epiphysis and obtain their vascular supply from the epiphyseal artery.

• Longitudinal growth is accomplished by the proliferation of these cells.

• The zone of growth is the area of greatest concern with any fracture involving the growth plate,

• damage to cells in this zone may have long term consequences for normal growth patterns.
Ogden classification

 Zone of cartilage “maturation”

- Increased **extracellular matrix** is formed in this zone, primarily between columns.

- The extracellular matrix exhibits cell mediated **biomechanical changes**, then calcifies.

- The cells align in **vertical columns as they hypertrophy** and are eventually replaced by osteoblasts.

- Fractures most commonly occur at the **junctior of calcified and uncalcified hypertrophic cells** because it is structurally the weakest portion of the growth plate.
Ogden classification

Zone of cartilage “transformation”

• the cartilaginous matrix is penetrated by metaphyseal vessels,

• break down the transverse cartilaginous septa,

• allowing invasion of mature cell columns.

• The cartilage and the bone are remodelled, removed, and replaced by a more mature, secondary spongiosa,

• eventually containing no remnants of the cartilaginous precursor
Susceptibility to injury

- Physeal injuries may produce **irreversible damage** to the growing cells, resulting in growth disturbance.

- Growth plate cartilage is **less resistant to stress** than adult articular cartilage.\(^5,6\)

- It is also less resistant than adjacent bone to **shear and tension forces**

- The physis may be **2–5 times weaker** than the surrounding fibrous tissue
Susceptibility to injury

- Injury mechanisms that in an adult may result in a complete tear of a ligament or in a joint dislocation may produce a separation of the growth plate in a child.

- Especially pronounced during periods of rapid growth.

- Decrease in physeal strength during pubescence.
Susceptibility to injury

- Increase in the rate of growth is accompanied by structural changes that result in a **thicker and more fragile plate**.\(^9,12\)

- **Bone mineralisation may lag** behind bone linear growth during the pubescent growth spurt, rendering the bone **temporarily more porous** and more subject to injury.

- The **peak fracture** rate probably occurring at the time of **peak height velocity**
Muscle-tendon imbalance

- long bones of the extremities, and the muscle-tendon units elongate in response to growth.

- temporary disparity between muscle-tendon and bone lengths.

- excessive muscular stress is applied, a muscle-tendon imbalance is produced that may predispose to injury.

- growth cartilage, is the weak link in this assembly, it is believed that the risk of injury may be increased at this site during the growth spurt. 

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Acute physeal injury

Salter and Harris

- **Type I complete separation of the epiphysis** from the metaphysis without any bone fracture. The germinal cells of the growth plate remain with the epiphysis, and the calcified layer remains with the metaphysis.
Acute physeal injury

Salter and Harris

- **In type II**, the most common physeal injuries, the line of separation **extends along the growth plate, then out through a portion of the metaphysis**, producing a triangular shaped metaphyseal fragment sometimes referred to as the Thurston Holland sign.

![Diagram showing different types of physeal injuries](image-url)
Acute physeal injury

Salter and Harris

- **Type III, which is intra-articular**, extends from the joint surface to the weak zone of the growth plate and then extends **along the plate to its periphery**.
Acute physeal injury

Salter and Harris

- **In type IV**, often involving the **distal humerus**, a fracture extends from the joint surface through the epiphysis, across the full thickness of the growth plate and through a portion of the metaphysis, thereby producing a **complete split**.
Acute physeal injury

Salter and Harris

- **In type V**, a relatively uncommon injury, there is a **compression of the growth plate**, thereby extinguishing further growth.
Prognosis

Types I & II

• good prognosis

• if the germinal cells remain with the epiphysis,

• and circulation is unchanged
Prognosis

Type III

- good prognosis
- if the **blood supply** in the separated portion of the epiphysis is still intact
- if the fracture is **not displaced**.
- Surgery is sometimes necessary to restore the joint surface to normal.
Prognosis

Type IV

• surgery is needed to
  • restore the joint surface to normal
  • perfectly align the growth plate
• poor prognosis

• unless the growth plate is completely and accurately realigned.
Variation in fracture propagation

- extent of physical maturity,
- the amount of force applied,
- rates of loading,
- and particularly the application of forces.\textsuperscript{4,8,29,30}
- important finding is microdisruption in the germinal zone that is separate from the main cleavage plane.
Chronic Physeal Injuries

- **sport training**, if of sufficient duration and intensity, may precipitate
  - **pathological changes** of the growth plate and, in extreme cases,
  - produce **growth disturbance**.
Chronic Physeal Injuries

- This injury appears to occur through repetitive loading,

- alters metaphyseal perfusion

- interferes with the mineralisation of the hypertrophied chondrocytes, which typically occurs in the zone of provisional calcification.

- The hypertrophic zone continues to widen because of constant growth in the germinal and proliferative zones
Chronic Physeal Injuries

- changes may be localised and cause asymmetric growth,
- or they may involve the entire physis and result in an overall slowdown of the rate of growth or even complete cessation of growth.
- In either case, premature closure of some or all of the physis may occur.
Reasons for concern

• Acute growth plate injuries do occur in sport and may account for as much as 30% of injuries, as reported in one study.78

• However, the proportion of physeal injuries is probably much less, ranging from 1% to 12% of injuries depending on the sport
Reasons for concern

• Although 71–75% of sport related growth plate fractures were associated with growth disturbance in two studies, 27,68

• the proportion of those with poor prognosis is probably much less, ranging from 0% to 37%. 16,24,25,33,69–74
Reasons for concern

• **Type 1 and particularly type 2 Salter-Harris** acute growth plate injuries are not as innocuous as originally described.

• may occasionally be associated with **localised growth plate closure** and osseous bridging. ¹⁶,²⁴,²⁵,³³,⁶⁹–⁷⁴
Reasons for concern

• great concern that **many coaches** of children and youth sports, although

• enthusiastic and well meaning volunteers,

• **largely uninformed** about the growth and development characteristics of children and youth

• **appropriate care and prevention** of athletic and particularly growth plate injuries
Preventive measures

- **Training and skill development** should be individualised to reduce risk of acute and stress related physeal injury;

- in particular, coaches should **reduce training loads and delay skill progressions** for young athletes experiencing periods of rapid growth.

- Careful measurement of **height at three month intervals** will provide coaches with data to estimate growth rate.

- Height measurements should be taken at the **same time of day** (preferably in the morning) and should not be taken after a workout.
Preventive measures

• Coaches should use a variety of drills or activities during practice

• to avoid excessively repetitive movements that may result in overuse injury.

• Emphasis should be on quality of workouts rather than training volume.
Preventive measures

- **Periodic physical examination** should be carried out so that
  - stress related growth plate and other overuse injuries can be diagnosed at an early stage and
  - modifications made to the training programme to assist in the recovery process;
- **when indicated, radiographs** of symptomatic physeal areas should be administered to rule out stress changes.
Preventive measures

- Physical conditioning:
  - strengthening,
  - range of motion,
  - and proprioceptive exercises,
  - may help to reduce both acute and chronic physeal injury.
Preventive measures

- **Trained personnel** such as certified athletic trainers should supervise injury rehabilitation and return to practice.

- **Periodisation of training** may also help to reduce stress related physeal injuries and prevent overtraining.

- This technique involves the systematic **cycling of training loads** over set periods of time with well defined rest periods.
Preventive measures

• When **acute epiphyseal fracture involves a joint**, it is recommended that the child not participate in contact sports for at least **four to six months** to prevent reinjury.

• **Long term follow up** is usually necessary to monitor the child’s recuperation and growth.

• Evaluation includes **x-ray examination of matching limbs** at three to six month intervals for at least **two years**
Preventive measures

• For collision sports:

  • maturity,

  • fitness levels,

  • achievement and skill in the sport

• should be considered as possible criteria for equalising competition among chronological age peers

• and preventing unnecessary acute physeal and other injuries.¹⁵⁴–¹⁵⁶
Take home message

• Severe pain around a joint, whether of
  • sudden or gradual onset,
  • significant growth plate changes,
    • examination by a doctor,
    • prompt treatment,
  • specific recommendations about return to activity.
Take home message

- A child should never be allowed or expected to "work through the pain."
Thank you!