PELVIC and FEMORAL SHAFT FRACTUREs

in children

What are the differences from adults ?

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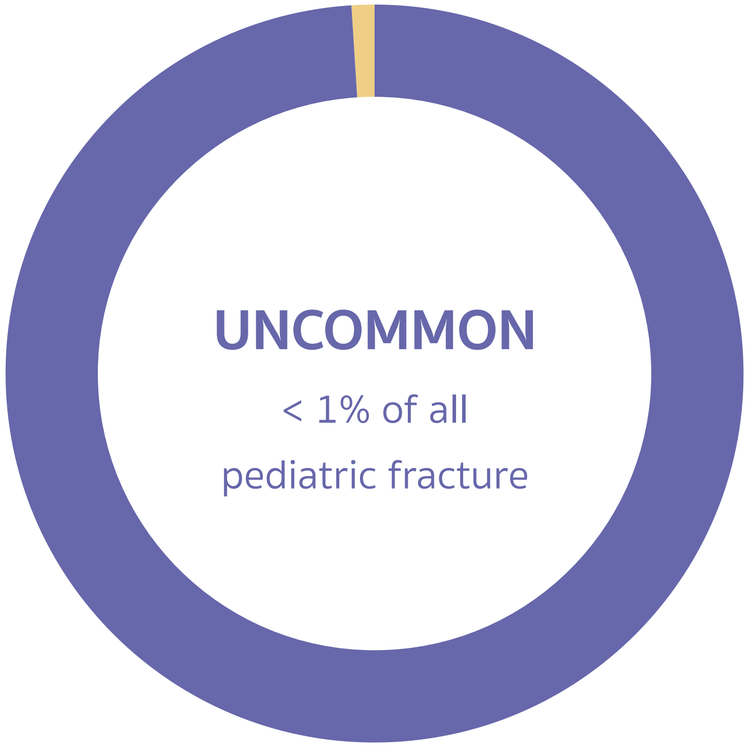
PELVIS

FEMUR

PELVIS

- General aspect
- Classification
- Treatment

1 General aspect: Epidemiology



Motor vehicle accident
= the most common causes of injury

Adults were twice as likely to suffer from pelvic fractures as children (9.6% vs 2.1%)

Demetriades D et al., 2003

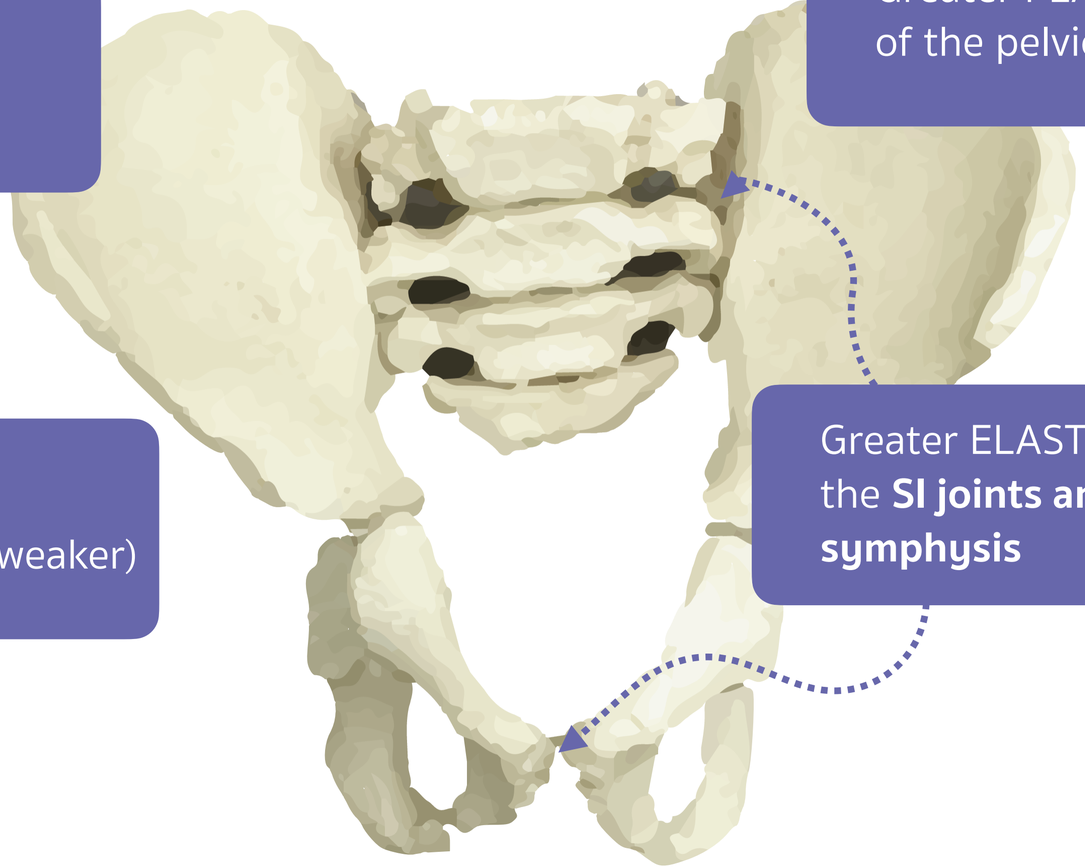
Fall from motorized vehicles, fall from heights, equestrian accidents, sporting activities

Avulsion apophyses

1 Child Pelvis vs Adult Pelvis

Thicker and stronger of periosteum

Greater PLASTICITY of the pelvic bones

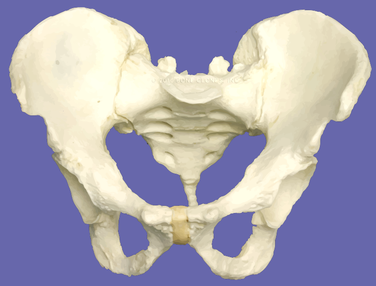


Greater ELASTICITY at the **SI joints and symphysis**

Presence of ‘Apophyses’ (weaker)

FORCE (a N)

FORCE (a N)



FRACTURE

(May be) **NO FRACTURE**

BUT, might need

FORCE **(a + b N)**

to make fracture

1 Associated Injuries

2% - 12% mortality rate

RW 2020, Hermans et al., 2017

NOT about the fractures,

Associated injuries are Causes of morbidity and mortality

Original Clinical Article

JOURNAL OF CHILDREN'S ORTHOPAEDICS

Paediatric pelvic fractures: how do they differ from adults?

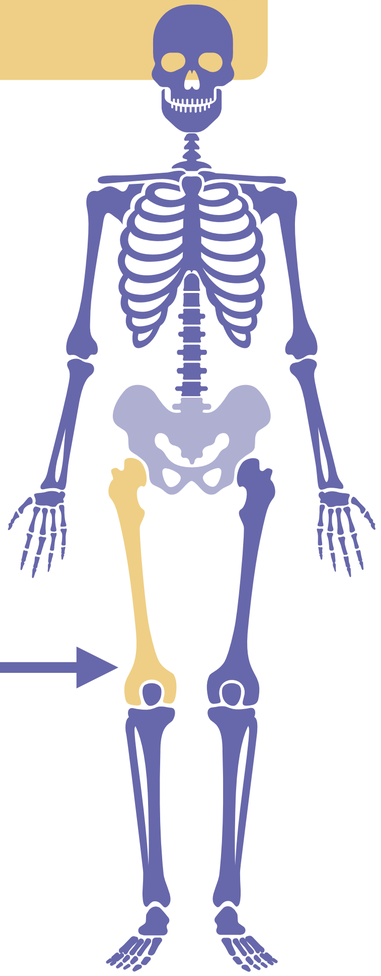
Hermans E et al., 2017

Table 3. Concomitant injuries

AIS region	Children (n = 51)	Adults (n = 268)	p-value
Head/neck	22 (43%)	85 (32%)	0.11
Face	4 (8%)	8 (3%)	0.09
Chest	12 (24%)	158 (60%)	< **0.01**
Abdomen	19 (37%)	85 (32%)	0.43
Extremities	39 (76%)	142 (53%)	< **0.01**

FEMORAL FRACTURES

The most frequent associated injuries



2

Adult Classification

PELVIS

Tile & Pennal

OTA /AO

Young & Burgess

1. **LC**
   - LC I
   - LC II
   - LC III
2. **APC**
   - APC I
   - APC II
   - APC III
3. **VS type**
4. **CM type**

ACETABULUM

Letournel

- Elementary fracture patterns
- Associated fracture patterns

Pediatric Classification

PELVIS

Torode & Zeig (Modified)

1. Avulsion fractures
2. Iliac wing fractures
3. Stable ring disruptions
4. Unstable ring disruptions

Silber & Flynn
JPO, 2002

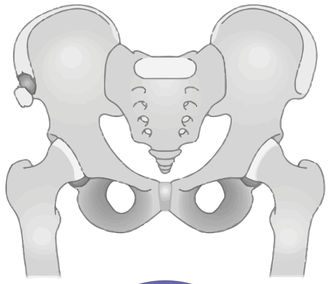
- Immature pelvis
- Mature pelvis

ACETABULUM

Bucholz (Salter-Harris based)

‘Prognosis of a Triradiate cartilage injury’

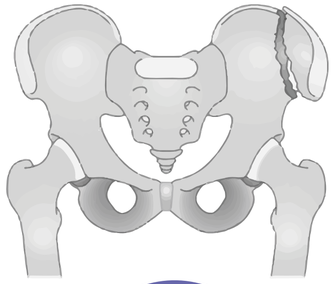
The Modified Torode and Zieg Classification



Torode I

Avulsion fracture

- Avulsion of the bony elements of the pelvis
- Separation through or adjacent to the cartilaginous growth plate



Torode II

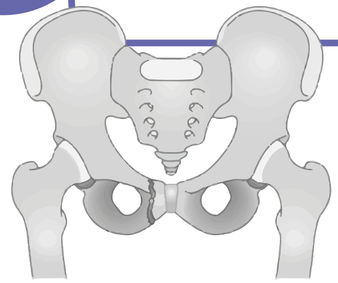
Iliac wing fracture

- Direct lateral force against the pelvis
- Disruption of the iliac apophysis
- An infolding fracture of the wing of the ilium

Torode III-A

Simple anterior ring fracture

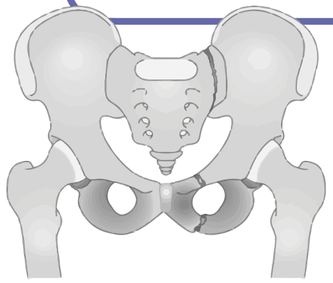
- Stable anterior wing fracture
- Pubic rami
- Pubic symphysis



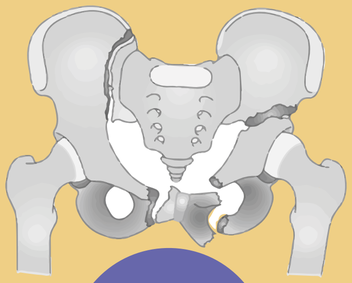
Torode III-B

Stable anterior and posterior ring fractures

- 'New group'
- Involve anterior and posterior



UNSTABLE

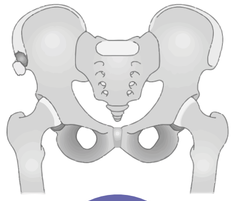


Torode IV

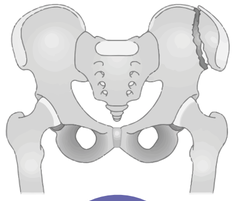
UNSTABLE ring disruption

- Ring disruption
  - Double anterior
  - Anterior & posterior
- +/- Hip dislocation
- Combined pelvic and acetabular fractures

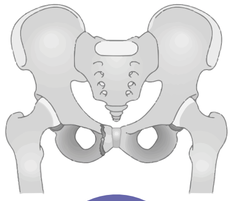
Usually need surgical treatment



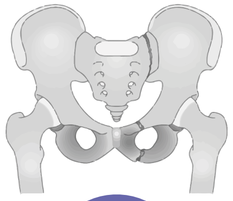
Torode I



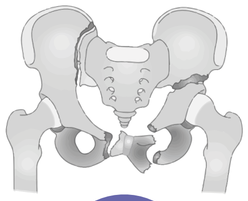
Torode II



Torode III-A



Torode III-B



Torode IV

‘Stable’ type VARIATIONs

Fractures of the Sacrum

- Types
  - Spinal-type : +/- neuro deficit
  - Alar-type:

Stable and (usually) conse

Fractures of coccyx and pelv

Stable and (usually)

VARIATIONs

Fractures near/through SI joint

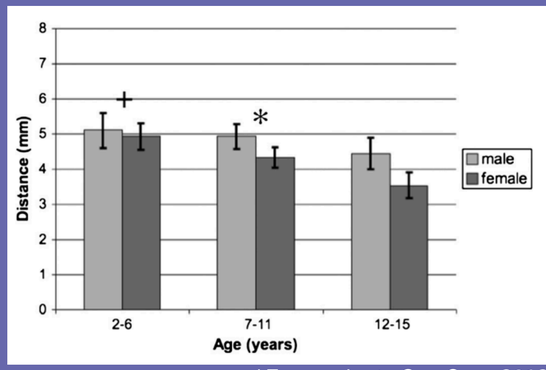
- Resemble type IIIB
- Cannot separate from SI joint disruptions

Stable and (usually) conservative

Widening of the symphysis pubis

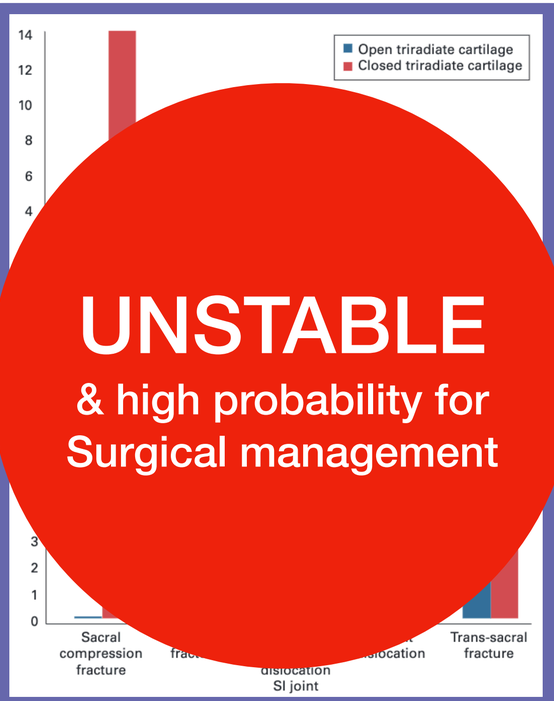
- Pain, FABER sign
- Instability:
  - Diastesis >= 2.5 cm
  - Rotational deformity > 15 degrees

UNSTABLE



J Trauma Acute Care Surg. 2012

UNSTABLE —> SURGERY



Bone Joint J. 2015

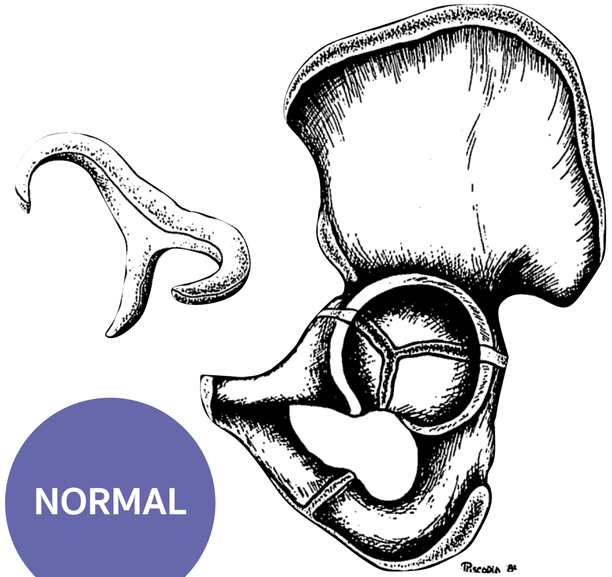
STABLE

high probability for Conservative management

UNSTABLE

& high probability for Surgical management

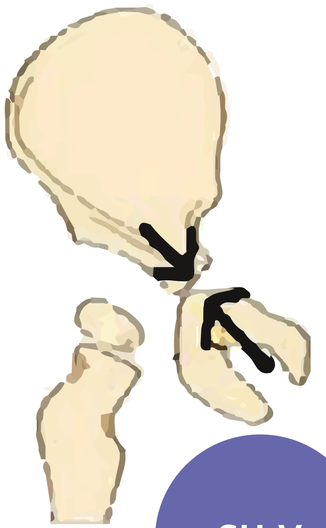
Acetabular Fractures: Salter-Harris based



NORMAL

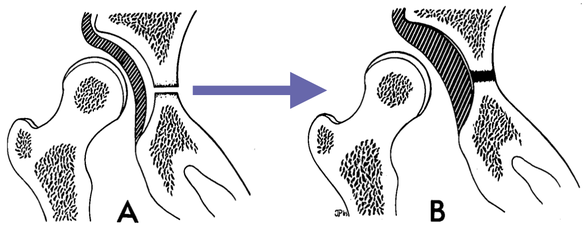
SH-I

SH-II



SH-V

<u>Premature closure of the triradiate cartilage</u> —> proliferation of the articular cartilage —> thickening of the acetabular floor —> a small acetabulum with lateral subluxation of the femoral head



<u>TREATMENTS</u>

1. Minimal displacement (< 1-2 mm): short term bedrest then PWB / spica cast in young children
2. Incongruent/unstable/more displacement: ORIF

Orthop.Traumatol-Sur., 2020
Clin. Orthop. Relat. Res., 1987

3 Management

ATLS: Treat life threatening injuries FIRST

Suggestive SIGNS of a pelvic fracture:
- High-energy trauma
- Destot's sign
- Roux's sign

RESUSCITATION

STABILIZATION
Pelvic bindier in situ

NV assessment

FRACTURE MANAGEMENT

Closed vs **Open**
Soft tissue assessment

Imaging
AP pelvis

Stability assessment
AP pelvis: stable configuration ?

→ **Repeat AP Pelvis with binder off**

Perineal assessment
- PV/PR: bleeding, palpable bony spikes
- GU injury

Complete secondary survey
- AP pelvis/inlet-outlet
- Acetabulum: Judet views
- CT scan
- Other x-rays

Multidisciplinary approach

Modified from Bristol Royal Hospital for Children (BRHC)

3 Management: Fracture Treatment

Avulsion fractures
(Torod I)

Rest, PWB (crutches) >= 2 wk
Gradual resumption of normal activities at 6 wks

Significant displacement (> 2 cm), disability —> fixation/excision

Pelvic Ring fractures
(Torod II, III(a-b), IV)

Conservative
- Torode II
- Torode III

Symptomatic Tx, protected WB, spica cast (young children)

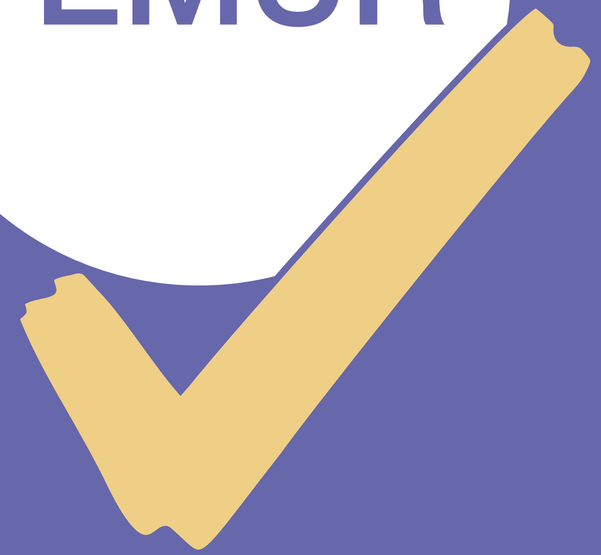
Stabilization strategies
Torode IV (UNSTABLE)
Displacement > 1 cm

Initial Mx
- Pelvic binder
- External fixation

Definite Mx
- External fixation
- ORIF
- +/- consult adult traumatologist

PELVIS

FEMUR



1

Adult Classification

AO/OTA

Pediatric Classification

Anatomical

↓

Length stable / unstable

AO/OTA

1

Adult Consideration

Configuration
AO classification

Open / closed /
NV injury / lung problem

Body weight

Pediatric Consideration

Age

Configuration:
length stable / length unstable

Open / closed /
NV injury / lung problem

Body weight

2 Problems and Solutions

PROBLEMS

- **Initial**: fracture, shortening, deformity, wound, etc.
- **Long term**: malunion, LLD, growth disturbance

ADULT

- No growth disturbance problem
- No indication for conservative treatment
- No cast is needed

*** exceptional: the very specific condition ****

SOLUTIONS

- **Initial**:
  - Realignment
  - Traction
  - Reduction
  - Fixation: TEN, plate, Ext fix
  - Maintain fixation: hip spica, pantaloon
- **Long term**:
  - Corrective osteotomy for malunion
  - Lengthening, shortening, epiphysiodesis for LLD

น้ำเชี่ยว

ล่องแก่ง

Whitewater Rafting Levels of Difficulty

Whitewater Rafting Levels of Difficulty

All rivers are rated on a "class" scale to help you determine the size and technicality of the whitewater.

- *Class I Rapids - Understand What Makes a Rapid*
- *Class II Rapids - Fun and Splashy All Day Long*
- *Class III Rapids - Maybe the Most Fun Classification?*
- *Class IV Rapids - Thrills at the Price of Skills*
- *Class V Rapids - No Guts No Glory, and Oh it's Glorious!*
- *Class VI Rapids - Just Don't*

Class 1

Rapids are easy

Rapids = แก่ง

Class 2

Rapids are novice

Novice = low level, for beginner

Class 3

Rapids are intermediate

Class 4

Rapids are advanced

Class 5

Rapids are expert

Class 1 Rapids are easy	Class 2 Rapids are novice	Class 3 Rapids are intermediate	Class 4 Rapids are advanced	Class 5 Rapids are expert
มันน่าจะหายเองได้ **อย่า “เยอะ"**	ทรงนี้ **ไม่ต้องผ่าหรอก** **แต่ๆ ต้องประคองไว้ดีๆ**	**ผ่า ดีกว่า ไม่ผ่า** ใช้ “Load-sharing implant” ไม่ต้อง rigid มากก็ได้ เดี๋ยวมันก็ติด	**ผ่า แน่นอน** และต้อง “rigid” fixation	**Limb at risk, DCO, staged treatment**
เด็กทารก: < 4 year: Insuff Fx (CP)	· ≤ 4y, short ≤ 2 cm · ≤ 5 yr, short ≤ 3 cm	· 4-5, short > 3 cm · 5-12 y + length stable	· 5-9 length unstable · 9-14 (unstable length, high BMI) · > 14 year	· Mangled limb · Limb at risk

MUST Sx

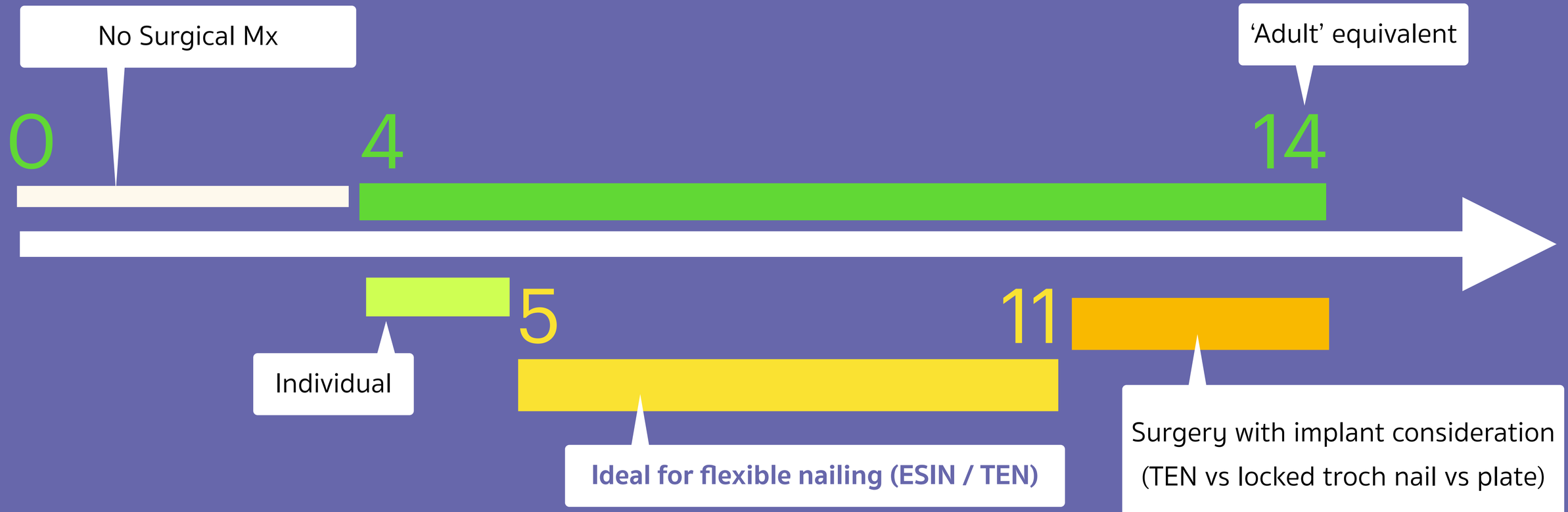
- Mangled limb
- > 14 ปี

No Sx

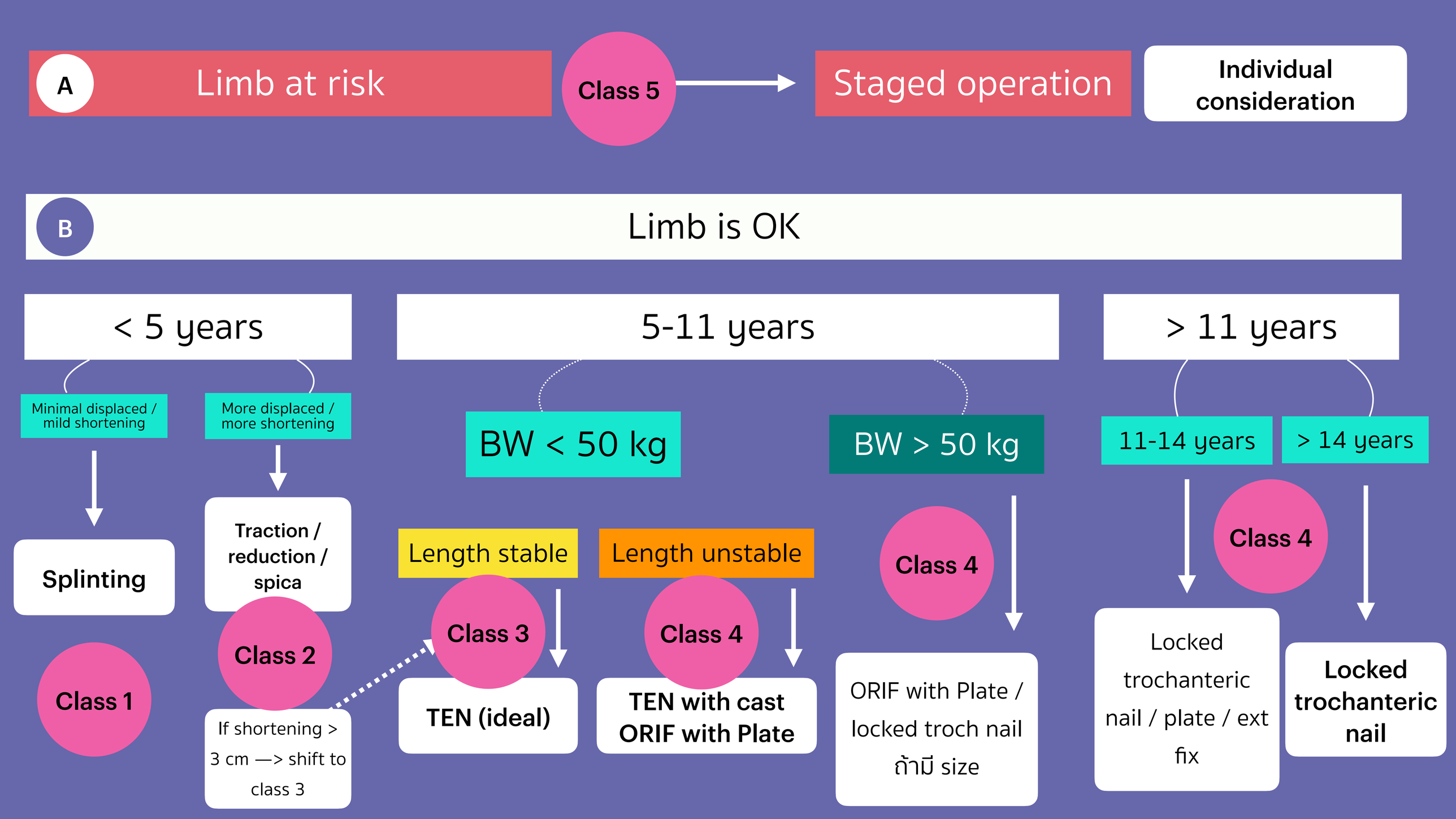
- Infant and ≤ 4 years
- U/D problems, specific conditions

Gray zone is 5-14 years, but favors to surgery.

Surgical Management: Decision making



*** exclude mangled limb, open Fx, NV injury ***

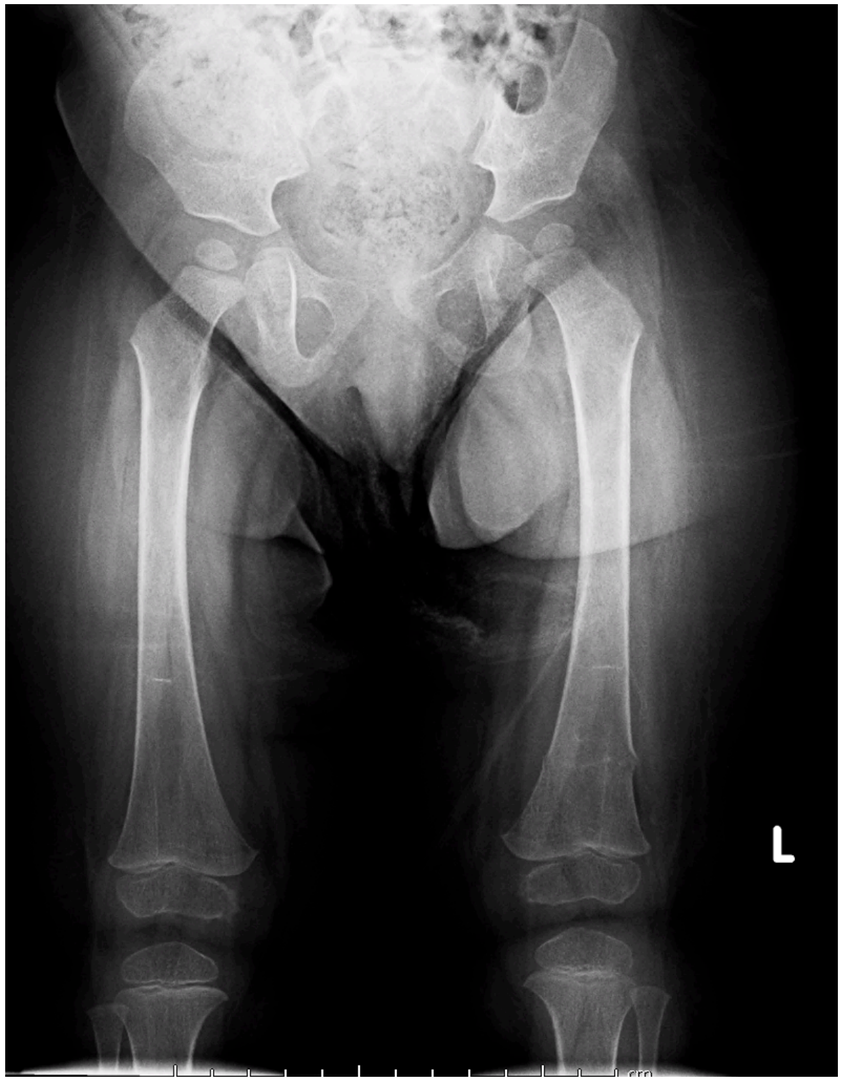

A
Limb at risk
Class 5
Staged operation
Individual consideration
B
Limb is OK
< 5 years
5-11 years
> 11 years
Minimal displaced / mild shortening
More displaced / more shortening
Splinting
Class 1
Traction / reduction / spica
Class 2
If shortening > 3 cm —> shift to class 3
BW < 50 kg
BW > 50 kg
Length stable
Length unstable
Class 3
TEN (ideal)
Class 4
TEN with cast
ORIF with Plate
Class 4
ORIF with Plate / locked troch nail ถ้ามี size
11-14 years
> 14 years
Class 4
Locked trochanteric nail / plate / ext fix
Locked trochanteric nail

1 A 14-year-old boy

Class 1 Rapids are **easy**	Class 2 Rapids are **novice**	Class 3 Rapids are **intermediate**	Class 4 Rapids are **advanced**	Class 5 Rapids are **expert**
มันน่าจะหายเองได้ **อย่า "เยอะ"**	ทรงนี้ **ไม่ต้องผ่าหรอก** **แต่ๆ ต้องประคองไว้ดีๆ**	**ผ่า ดีกว่า ไม่ผ่า** ใช้ "Load-sharing implant" ไม่ต้อง rigid มากก็ได้ เดี๋ยวมันก็ติด	**ผ่า แน่นอน** และต้อง "rigid" fixation	**Limb at risk, DCO, staged treatment**

Class 4
Rapids are
advanced

2 เด็กหญิง 1.5 ขวบ



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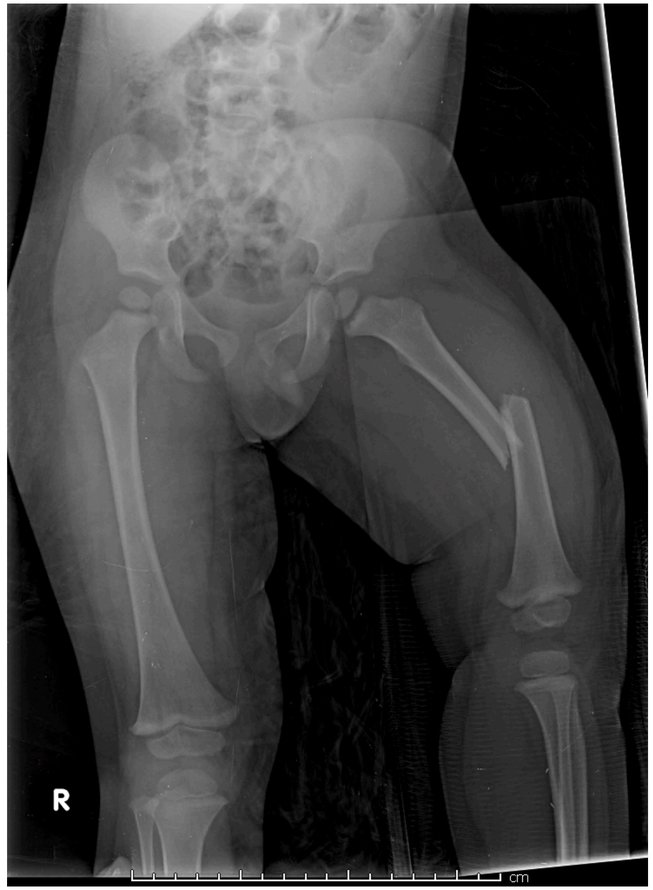
Class 1

Rapids are easy

Just splinting

3 A 2-year-old boy

Class 1 Rapids are **easy**	Class 2 Rapids are **novice**	Class 3 Rapids are **intermediate**	Class 4 Rapids are **advanced**	Class 5 Rapids are **expert**
มันน่าจะหายเองได้ **อย่า "เยอะ"**	ทรงนี้ **ไม่ต้องผ่าหรอก** **แต่ๆ ต้องประคองไว้ดีๆ**	**ผ่า ดีกว่า ไม่ผ่า** ใช้ "Load-sharing implant" ไม่ต้อง rigid มากก็ได้ เดี๋ยวมันก็ติด	**ผ่า แน่นอน** และต้อง "rigid" fixation	**Limb at risk, DCO, staged treatment**

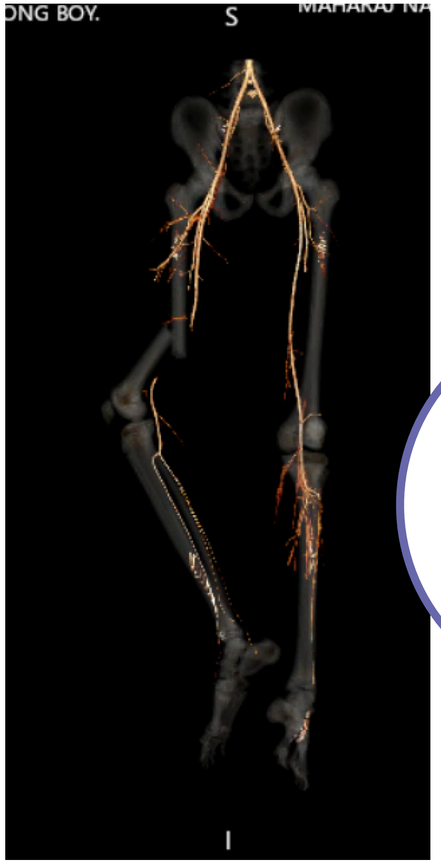


Class 2
Rapids are novice

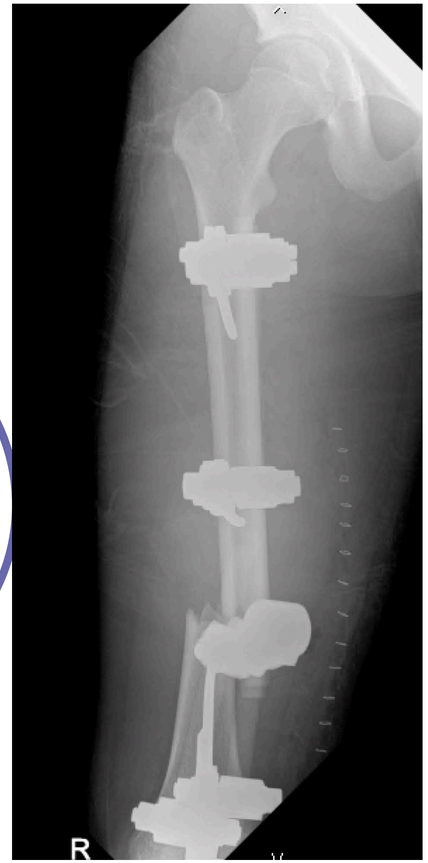
Traction
Reduction
Hip spica

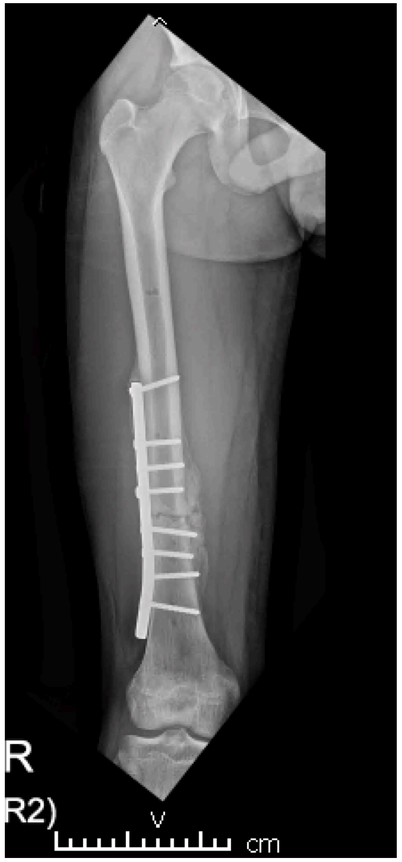
4 A 12-year-old boy

Class 1	Class 2	Class 3	Class 4	Class 5
Rapids are **easy**	Rapids are **novice**	Rapids are **intermediate**	Rapids are **advanced**	Rapids are **expert**
มันน่าจะหายเองได้ **อย่า "เยอะ"**	ทรงนี้ **ไม่ต้องผ่าหรอก แต่ๆ ต้องประคองไว้ดีๆ**	**ผ่า ดีกว่า ไม่ผ่า** ใช้ "Load-sharing implant" ไม่ต้อง rigid มากก็ได้ เดี๋ยวมันก็ติด	**ผ่า แน่นอน** และต้อง "rigid" fixation	**Limb at risk, DCO, staged treatment**



Class 5
Rapids are
expert





Staged operation

5 A 9-year-old girl

Class 1 Rapids are **easy**	Class 2 Rapids are **novice**	Class 3 Rapids are **intermediate**	Class 4 Rapids are **advanced**	Class 5 Rapids are **expert**
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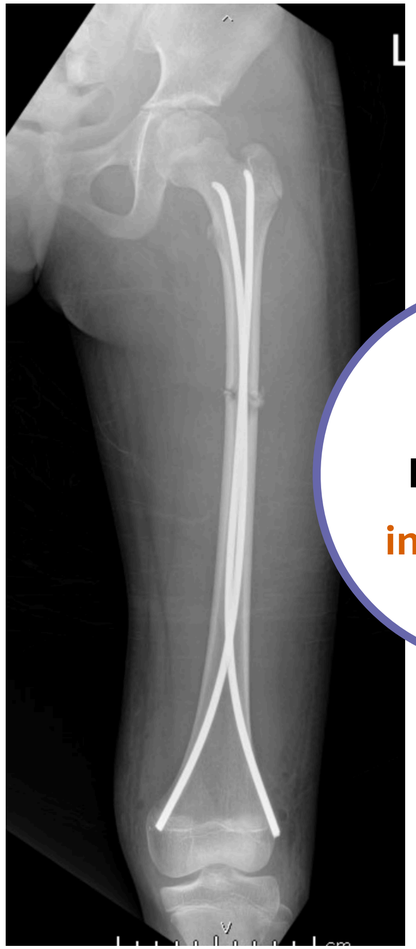

Class 3
Rapids are
intermediate

Elastic nailing

3 A 10-year-old boy

BW = 90 kg

Class 1
Rapids are easy

มันน่าจะหายเองได้
อย่า “เยอะ”

Class 2
Rapids are novice

ทรงนี้
ไม่ต้องผ่าหรอก
แต่ๆ ต้องประคองไว้ดีๆ

Class 3
Rapids are
intermediate

ผ่า ดีกว่า ไม่ผ่า
ใช้ “Load-sharing implant” ไม่ต้อง rigid มากก็ได้ เดี๋ยวมันก็ติด

Class 4
Rapids are
advanced

ผ่า แน่นอน และต้อง “rigid” fixation

Class 5
Rapids are
expert

Limb at risk, DCO, staged treatment

Class 4
Rapids are
advanced