

# Non Accidental Injury (NIA) (Battered Child Syndrome)

Michel Bach Hellfritzsch

Overlæge

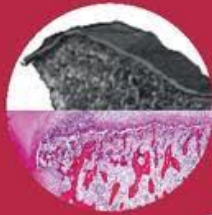
Røntgen og Skanning

Aarhus Universitetshospital

THIRD EDITION

# Diagnostic Imaging of Child Abuse

EDITED BY **Paul K. Kleinman**



CAMBRIDGE

Medicine

# Indledning

# Villadsen et al. 2014

Procentvis fordeling af lægernes svar med hensyn til, hvilke frakturer de fandt typiske for *battered child syndrome* hos børn under 18 måneder.

	<u>Femurfraktur</u>			<u>Corner-fraktur</u>			<u>Collum costae-fraktur</u>		
	ja	nej	ved ikke	ja	nej	ved ikke	ja	nej	ved ikke
Speciallæge (n = 11)	82	0	18	18	37	46	54,5	18	27,5
Reservelæge (n = 8)	50	37,5	12,5	37,5	25	37,5	75	25	0



# Villadsen et al. 2014

- ◆ Vores undersøgelse viser, at to tredjedele af de deltagende læger angav at have tilstrækkelig faglig viden om BCS.
- ◆ To tredjedele af speciallægerne og halvdelen af reservelægerne ville underrette til sociale myndigheder eller en pædiatrisk afdeling alene på mistanken.
- ◆ På den baggrund kan manglende faglig viden om BCS kombineret med tilbageholdenhed, hvad angår underretning, være en mulig årsag til de få underretninger af BCS, som anført herover.

# Villadsen et al. 2014

Det faglige vidensniveau hos behandlende læger uanset anciennitet på udvalgte skadestuer/akutmodtagelser er med denne undersøgelse fundet at være utilfredsstillende.

# Standards for radiological investigations of suspected non-accidental injury 2008

## Enkelt punkter:

- ◇ Op til 55% af mishandlede børn med dødelig udgang har været i kontakt med sundhedsvæsenet inden for den seneste måned.
- ◇ Det præmobile barn er mindre udsat for hændelige uheld, og jo mindre det er, jo mere sandsynligt er det at frakturen er påført.
- ◇ Svære skader kan også omfatte thorax, abdomen og/eller hjernen (Non Accidental Head Injury - NAHI)
- ◇ Radiologen har ansvar for at tage øjeblikkelig kontakt til henvisende læge angående abnorme fund

# Serviceoven § 153

Personer, der udøver offentlig tjeneste eller offentligt hverv, skal underrette kommunalbestyrelsen, hvis de under udøvelsen af tjenesten eller hvervet får kendskab til eller grund til at antage,

1. at et barn eller en ung under 18 år kan have behov for særlig støtte,
2. at et barn umiddelbart efter fødslen kan få behov for særlig støtte på grund af de vordende forældres forhold,
3. at et barn eller en ung under 18 år kan have behov for særlig støtte på grund af barnets eller den unges ulovlige skolefravær eller undladelse af at opfylde undervisningspligten, eller
4. at et barn eller en ung under 18 år har været udsat for overgreb.

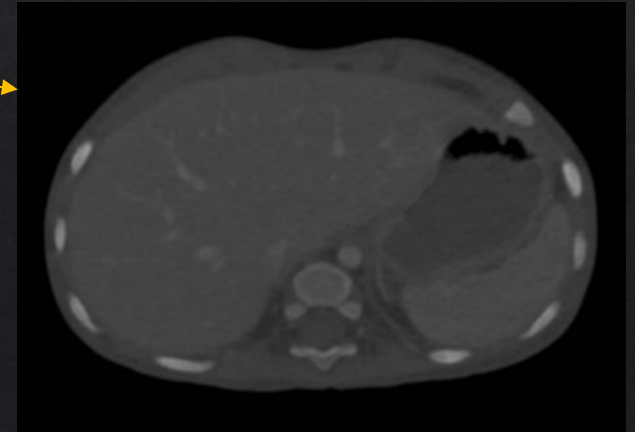
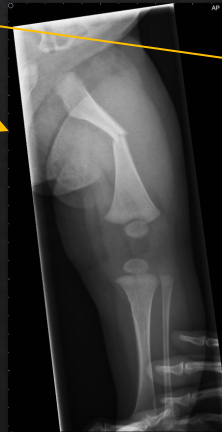
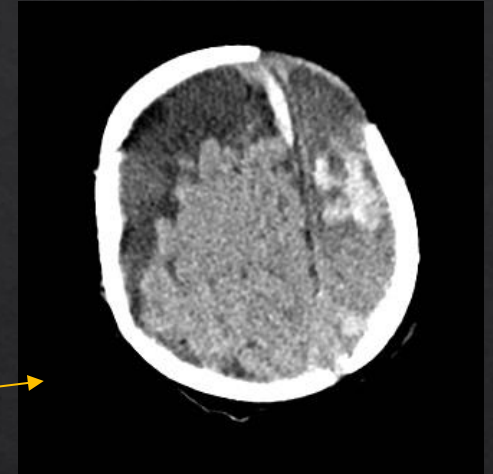
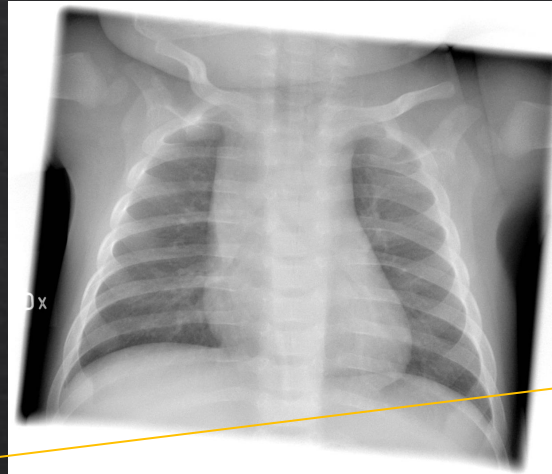
Se eksempelvis:

<https://paediatri.dk/socialpaediatri-vej1>



# Radiologens rolle

Tilfældige fund  
Udredning



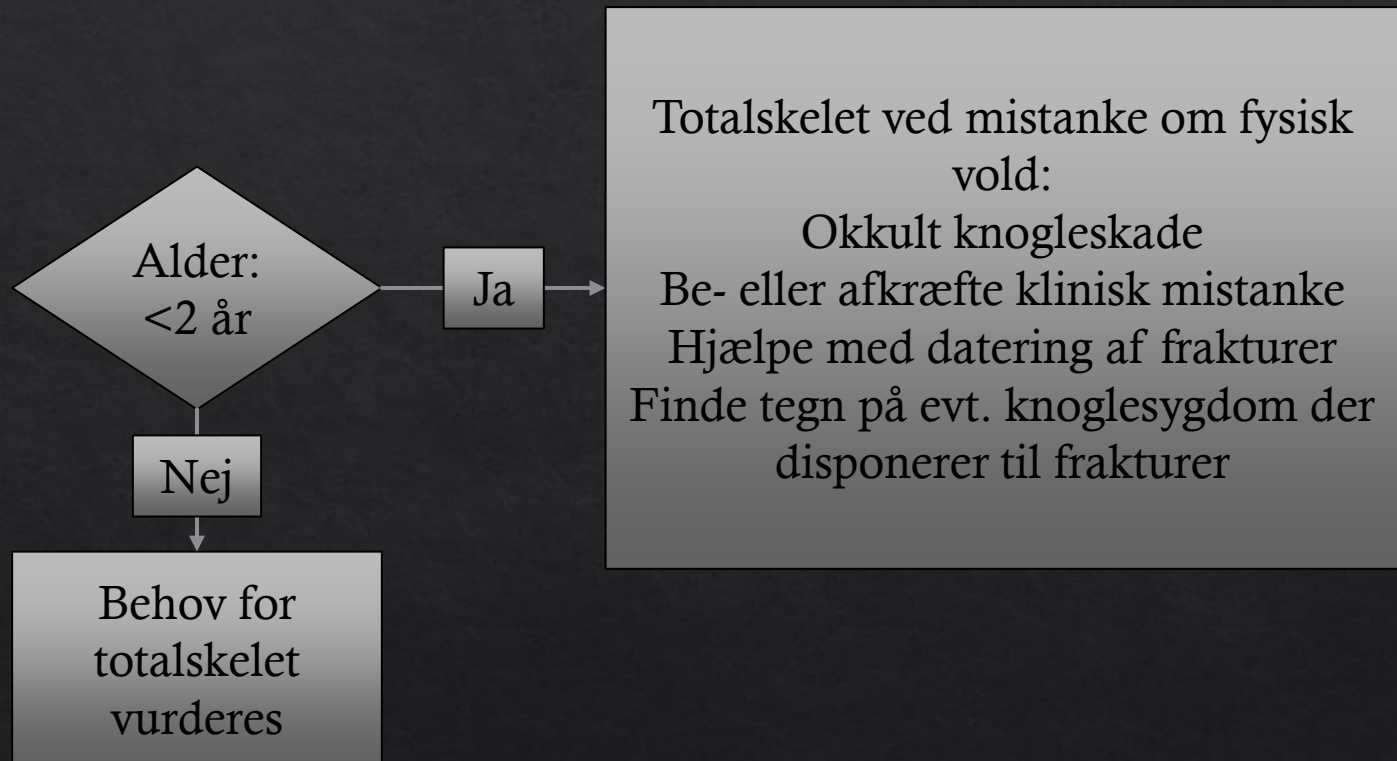


Udredning

# Udredning

- ◇ Klinisk undersøgelse
- ◇ Rtg. af totalskelet
  - ◇ Henvisning fra specialæge i pædiatri
  - ◇ Første radiologiske undersøgelse - med mindre der klinisk er indikation for anden undersøgelse
- ◇ CT thorax og abdomen hvis klinisk indiceret
  - ◇ udføres på samme måde som ved hændeligt uheld.
- ◇ Neuroradiologi
  - ◇ Encephalopatiske tegn, fokale neurologiske udfald eller retinablødning
  - ◇ Børn under 1 år med tegn på fysisk vold
  - ◇ CT cerebrum
  - ◇ MR cerebrum

# Udredning



# Rtg. af totalskelet

## ◇ Kranium

- ◇ AP og lateral (Hvis der ikke udføres CT skanning)

## ◇ Thorax

- ◇ AP inkl. klavikler
- ◇ Skråoptagelser af thorax (costae)

## ◇ Abdomen/bækken

- ◇ AP

## ◇ Columna

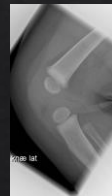
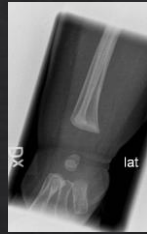
- ◇ Lateral
- ◇ AP på thorax og bækken

## ◇ Ekstremiteter

- ◇ AP af begge humeri
- ◇ AP af begge anbrachii
- ◇ PA af begge hænder
- ◇ AP af begge femora
- ◇ AP af begge crurae
- ◇ DP af begge fødder
- ◇ Evt. suppl. sideoptagelser af albue, håndled, knæ og ankel



# Total skelet



Ved behov evt.  
supplerende  
projektioner





Subperiostal knoglenydannelse og callus ses på konventionel røntgen først efter 9-10 dage.

Oestreich and Caré



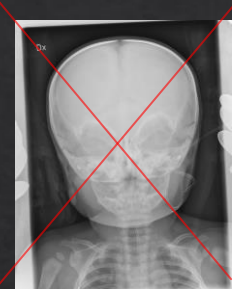
Primær undersøgelse



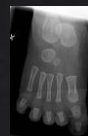
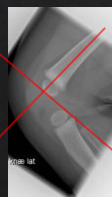
14-dages kontrol

Klassisk metafysær læsion (CLM) ved primær undersøgelse og ved 14-dages kontrol

Total skelet  
2 ugers kontrol



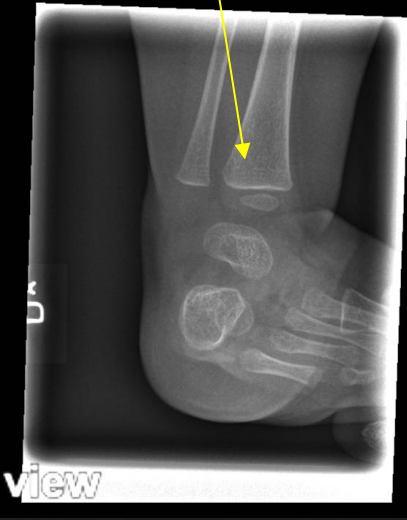
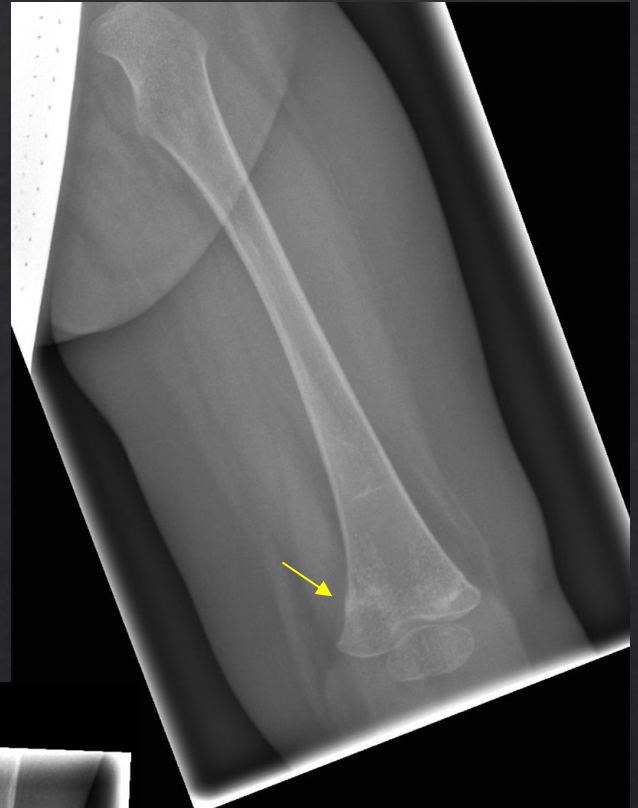
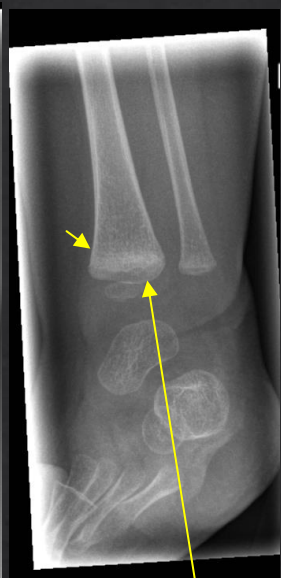
Samt evt.  
områder der skal  
kontrolleres



Andre  
modaliteter: CT

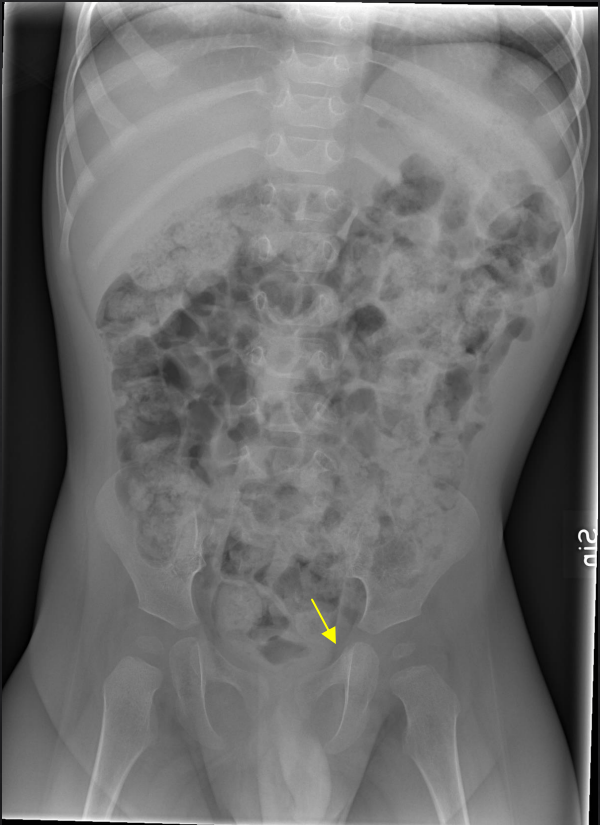
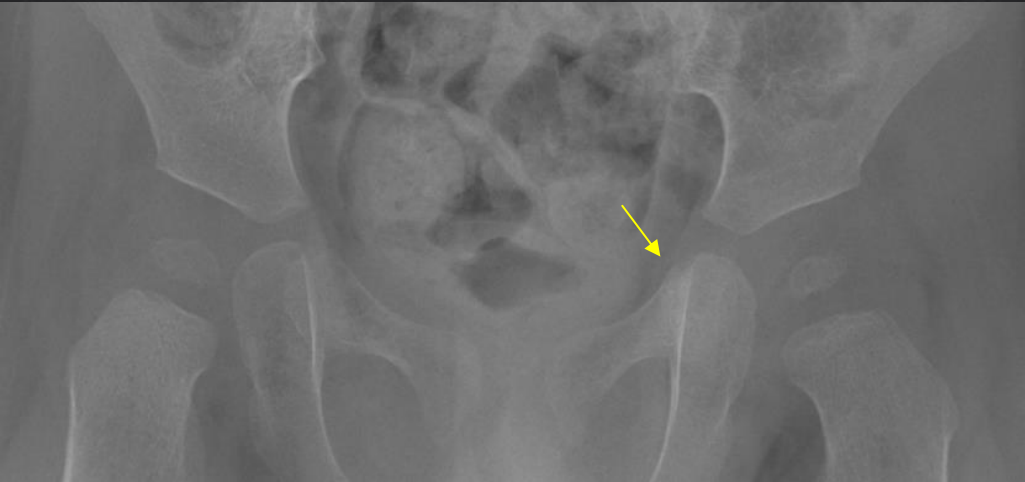
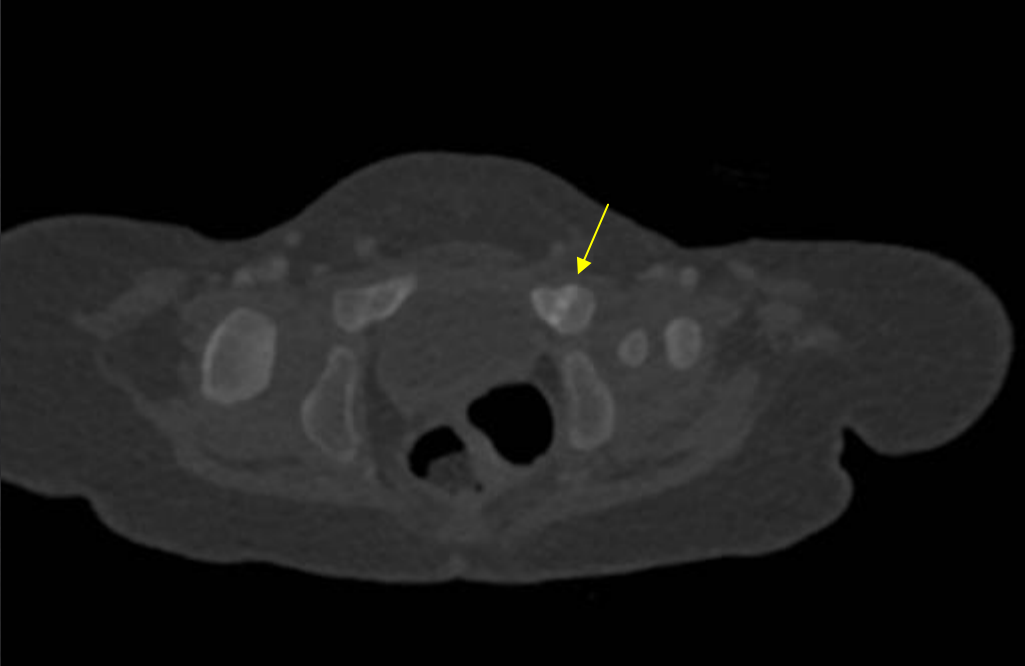
1 år gammel barn senere undersøgt  
med CT (obs. abdominal læsion)

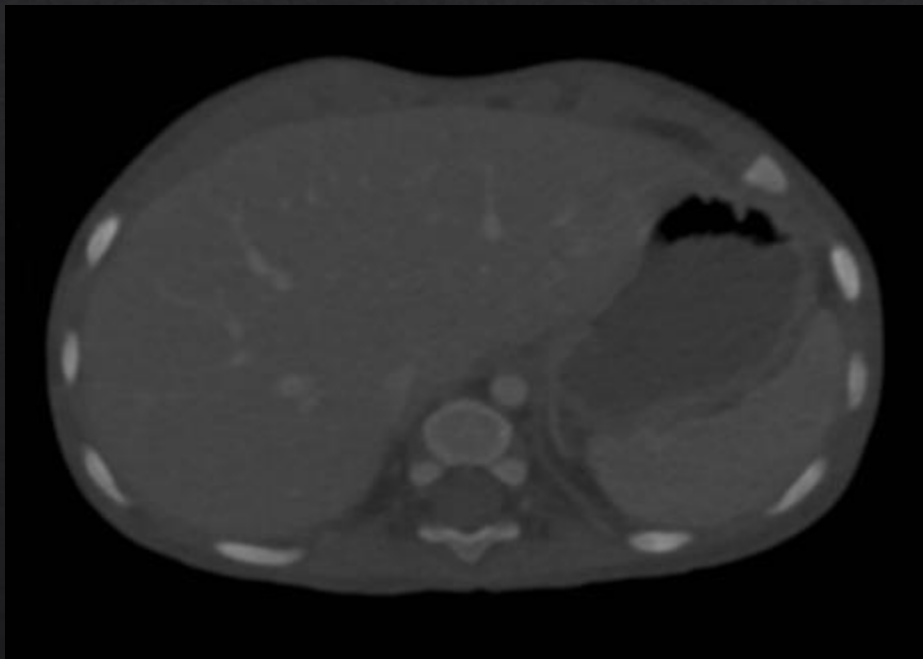
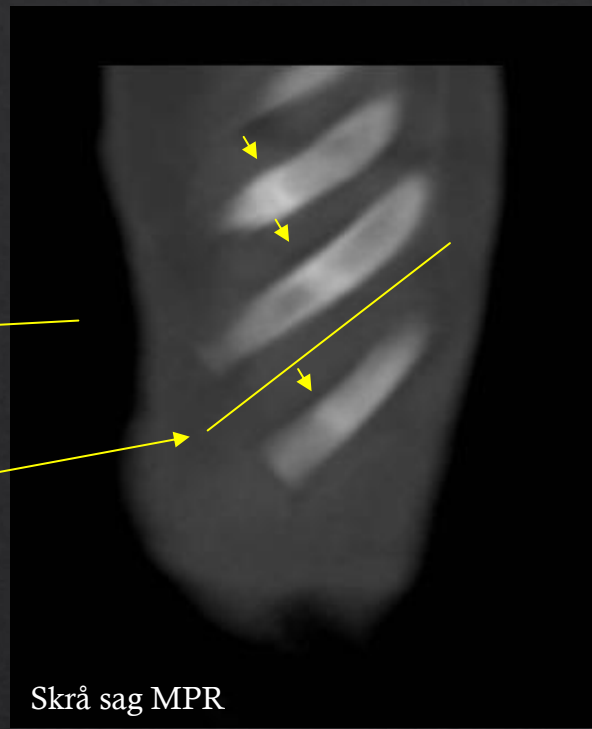
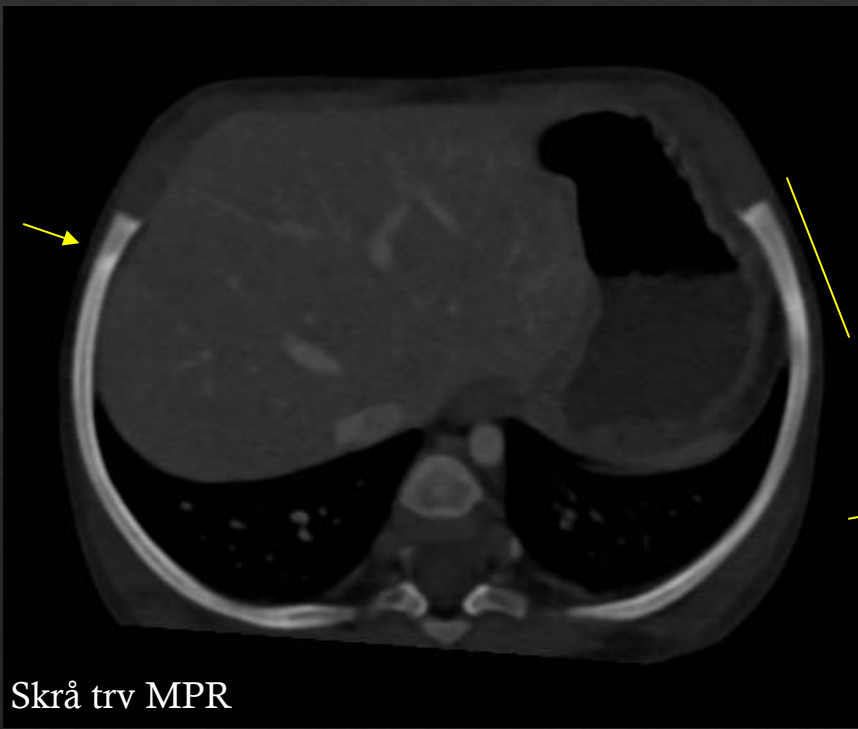




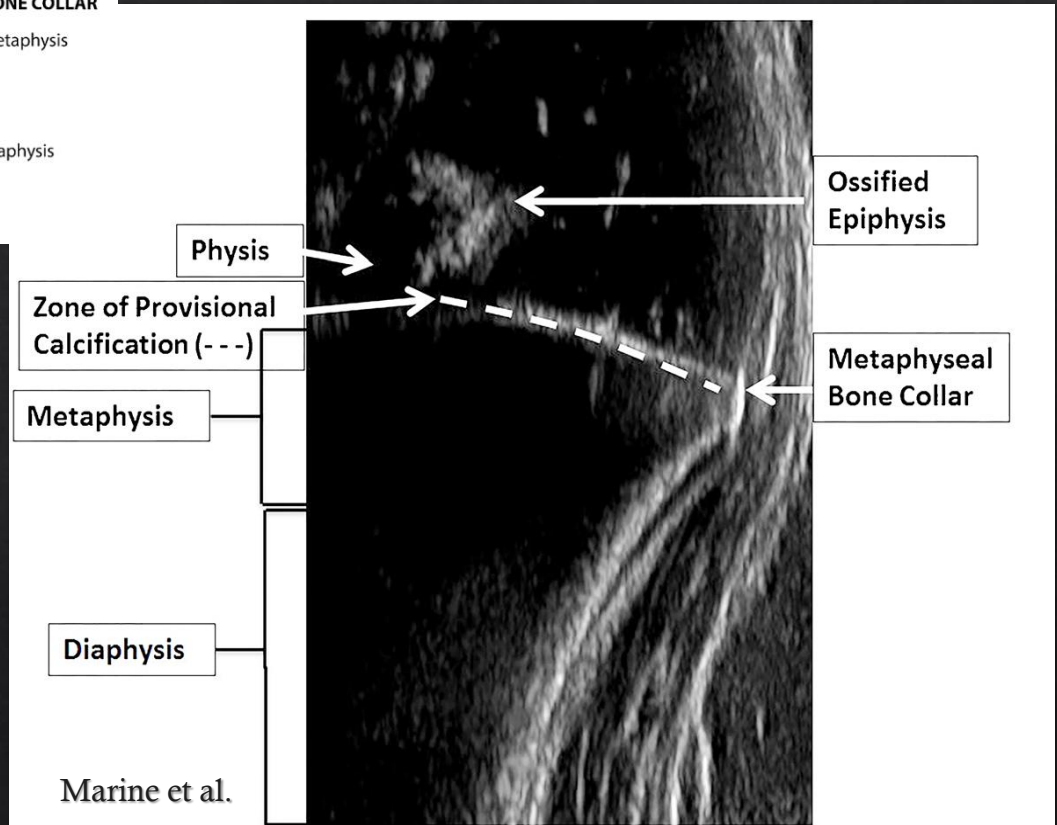
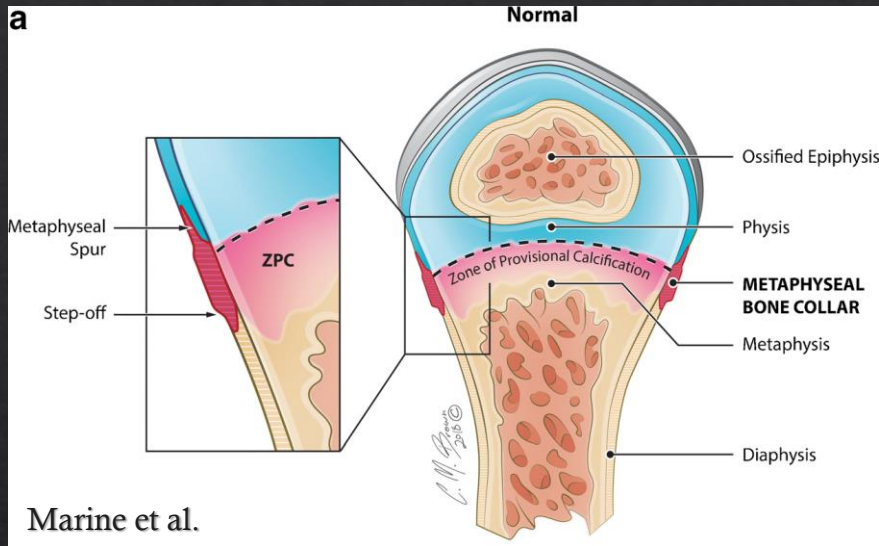
ni2

view

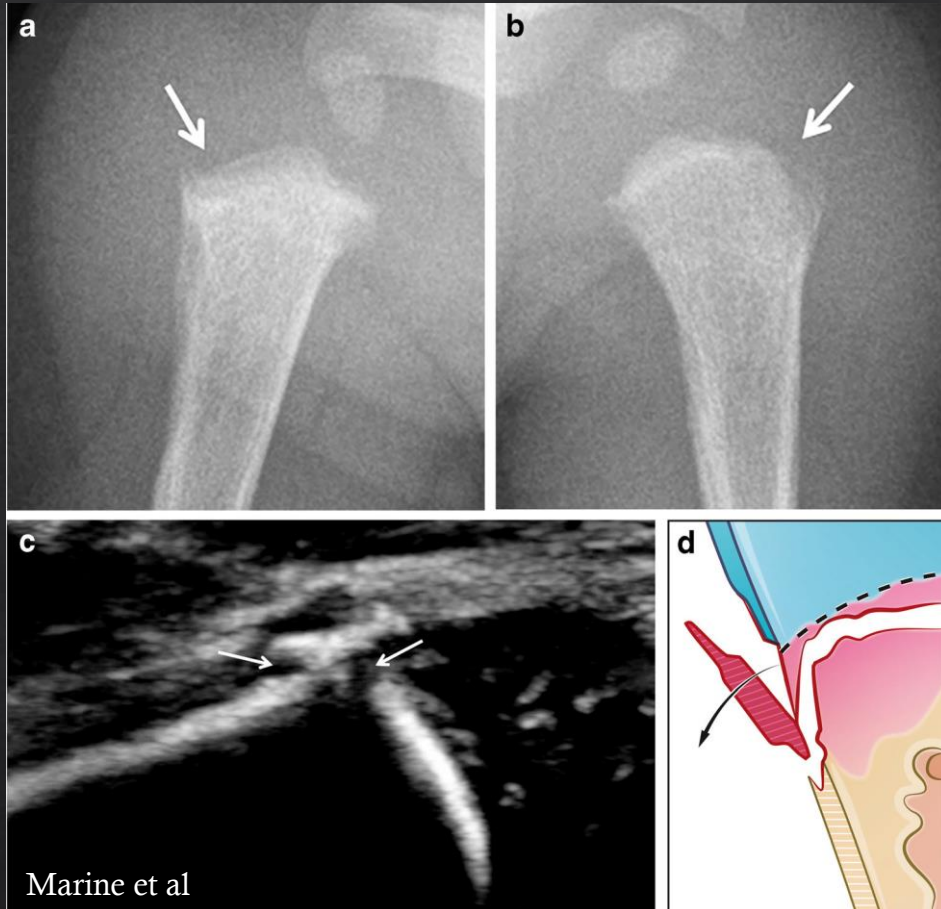




# Andre modaliteter: UL







# Fraktur oversigt

# Specificity of injuries for child abuse

## ◇ **High specificity (highest specificity in infants)**

- ◇ Classic metaphyseal lesions (CML)
- ◇ Rib fractures especially posteromedial
- ◇ Scapular fractures
- ◇ Sternal fractures
- ◇ Spinous process fractures

## ◇ **Moderate specificity**

- ◇ Multiple fractures, especially bilateral
- ◇ Fractures of different ages
- ◇ Epiphyseal separations
- ◇ Vertebral body fractures and subluxations
- ◇ Digital fractures
- ◇ Complex skull fractures
- ◇ Pelvic fractures

## ◇ **Common but low specificity**

- ◇ Subperiosteal new bone formation
- ◇ Clavicular fractures
- ◇ Long-bone shaft fractures
- ◇ Linear skull fractures

# Frakturtyper: Alm. frakturer

Dreng knap 3 mdr.

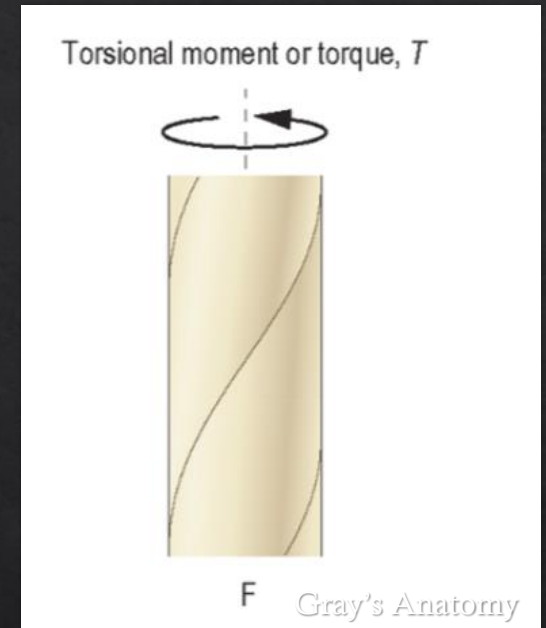




# ”Toddlers fracture”



# ”Toddlers fracture”

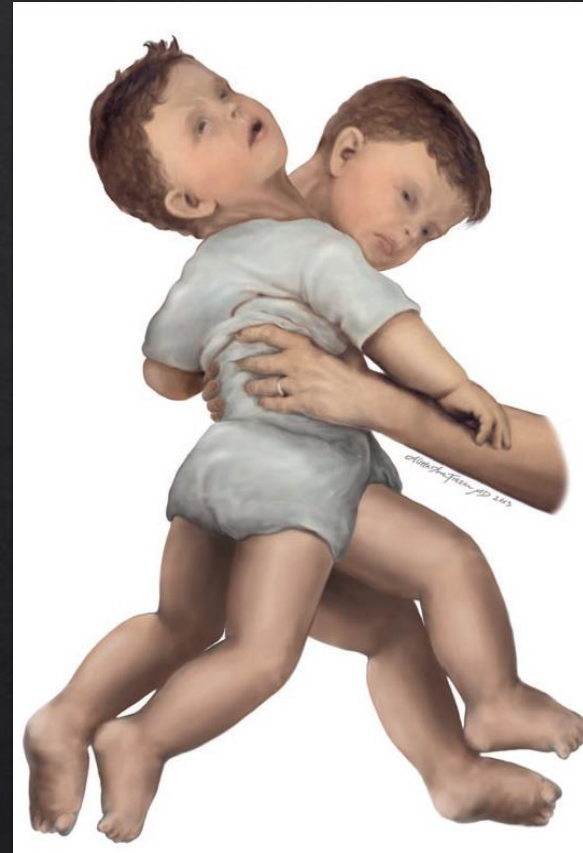
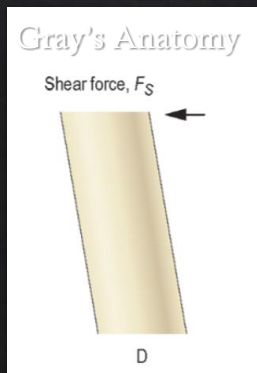


NB! ”Toddlers fracture” når barnet går selvstændigt.

# Frakturtyper: CLM

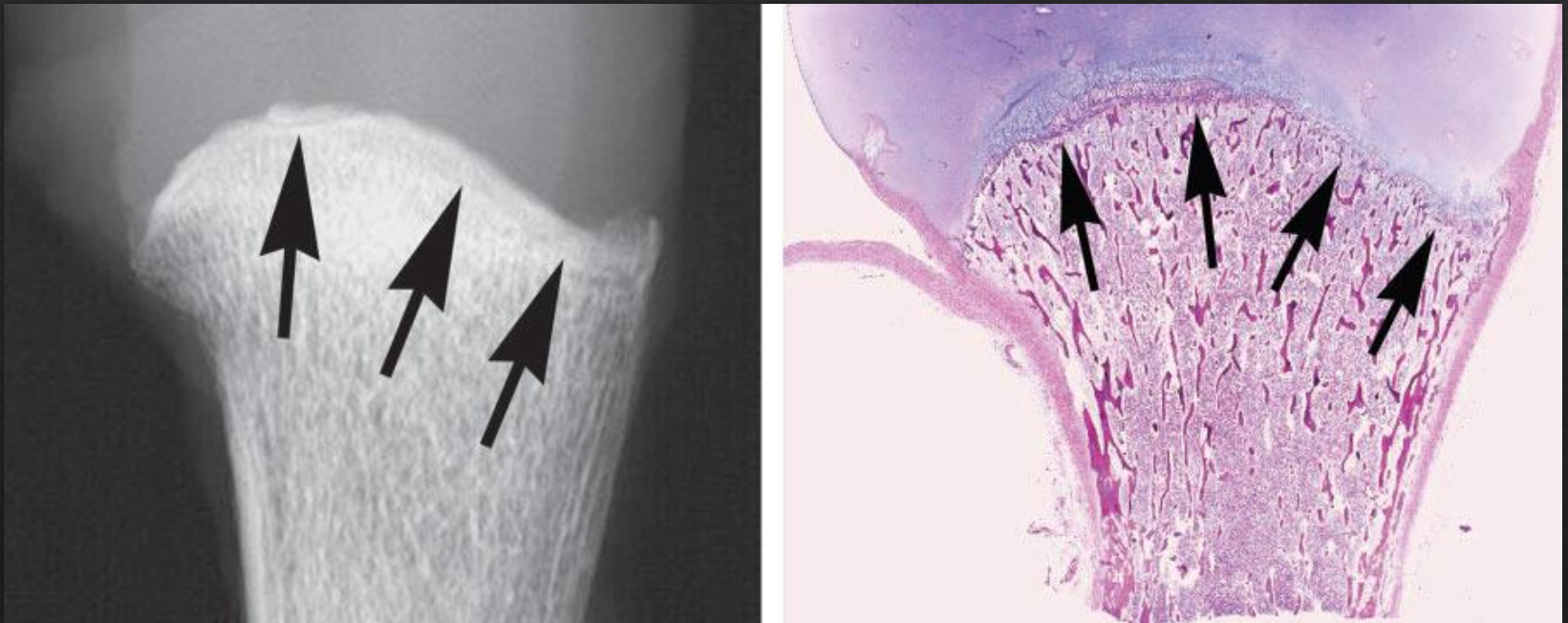
# CML: Classic metaphyseal lesion

- ◆ Hyppigste lokalisasjon:  
Distale femur -> Proximale tibia -> Proximale humerus
- ◆ Næsten udelukkende hos barn <2 år.
- ◆ Generelt ingen fraktur følger





# CML



Lonergan et al., RadioGraphics 2003; 23:811–845 (fra Paul Kleinman, MD, The Children's Hospital, Boston, Mass.).



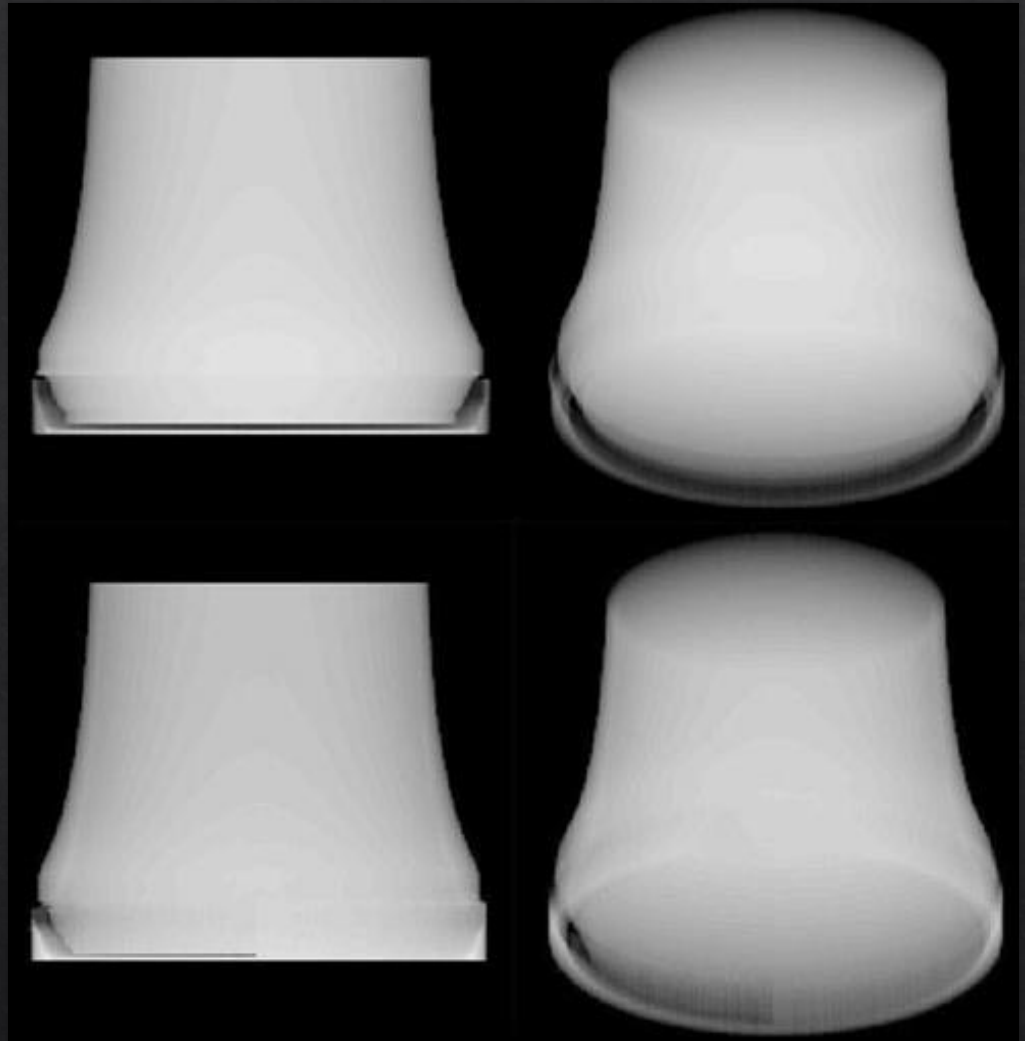
# CML: Classic metaphyseal lesion

- ◇ Corner lesion
- ◇ Bucket handle lesion



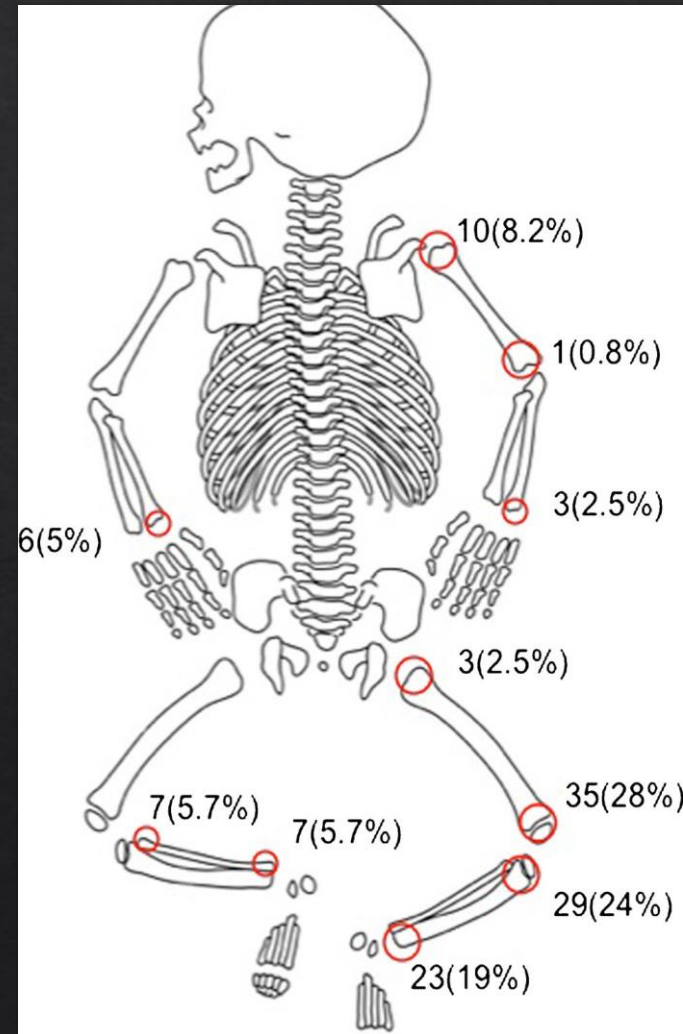
Stephen Chapman "Non-accidental Injury" in  
Imaging in pediatric skeletal trauma, Springer

CML: Corner  
lesion vs. Bucket  
handle lesion



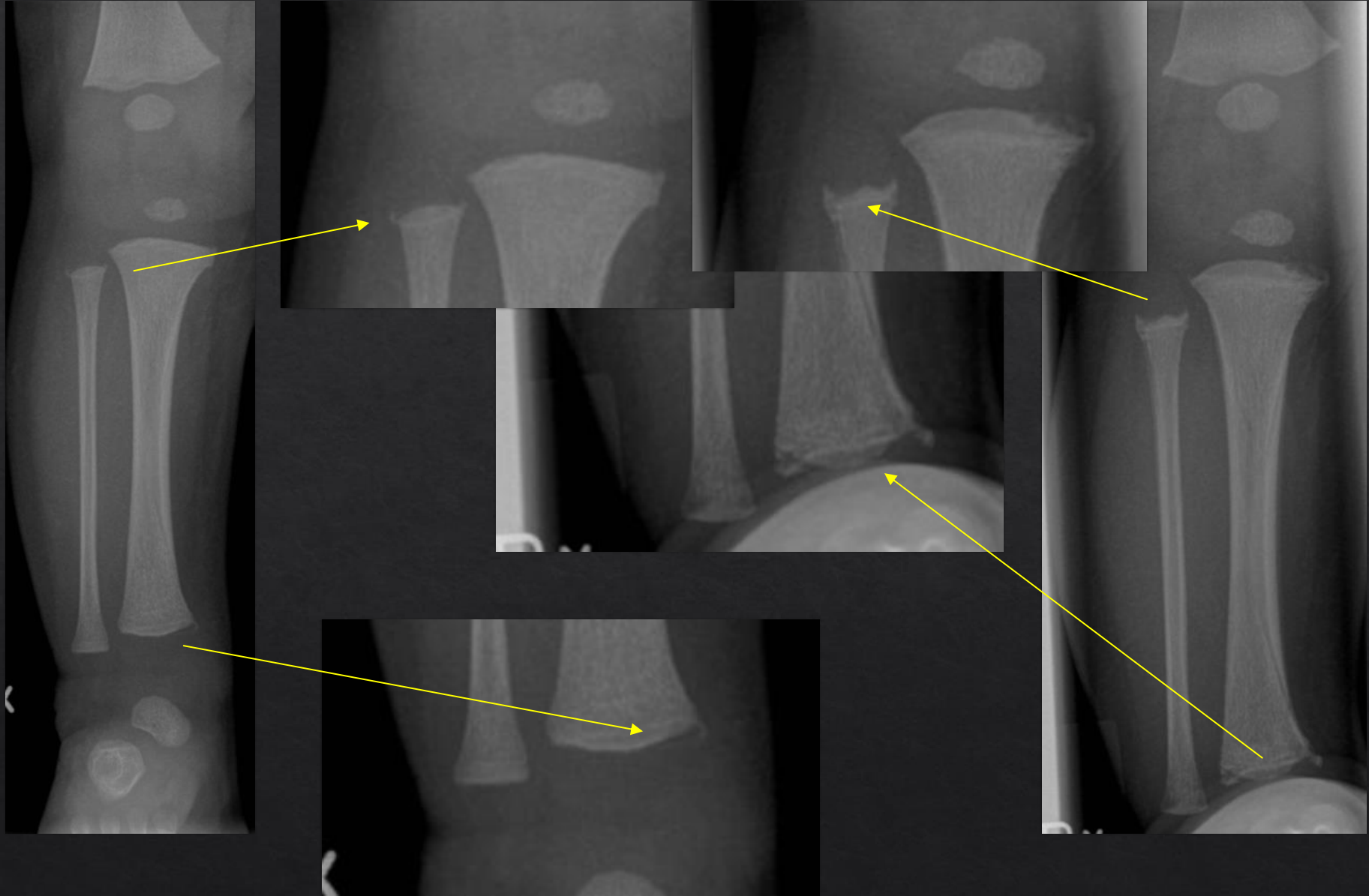
# CML: Classic metaphyseal lesion

- ◆ Hyppigste lokalisation:  
Distale femur -> Proximale tibia -> Proximale humerus



Primær undersøgelse

14-dages kontrol



# Frakturtyper: Costa frakturer

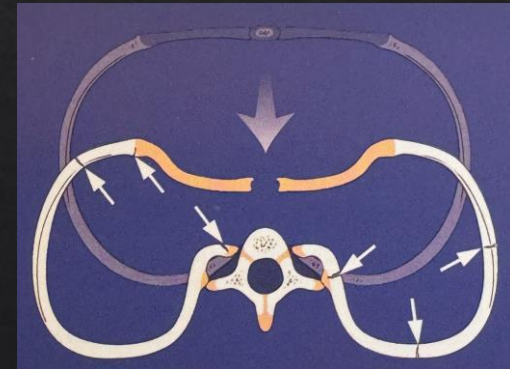


# Costa fraktur

- ◇ Specifik fraktur
- ◇ Scintigrafi eller CT bedre til at detektere disse frakturer.
- ◇ Sjælden ved fødslen
- ◇ Sjælden ved Hjerte-Lunge-Redning (HLR). Der er her tale om anteriore frakturer.

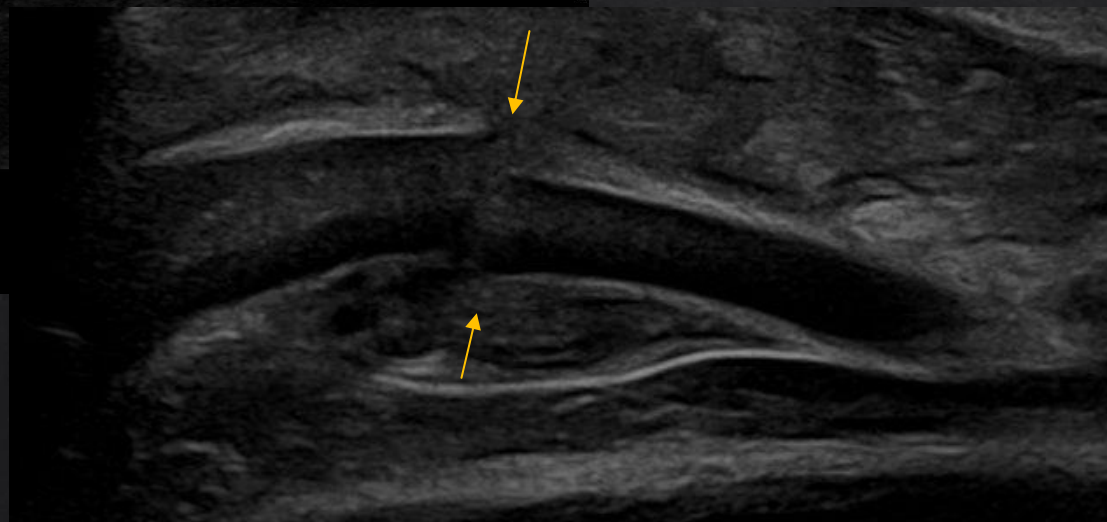
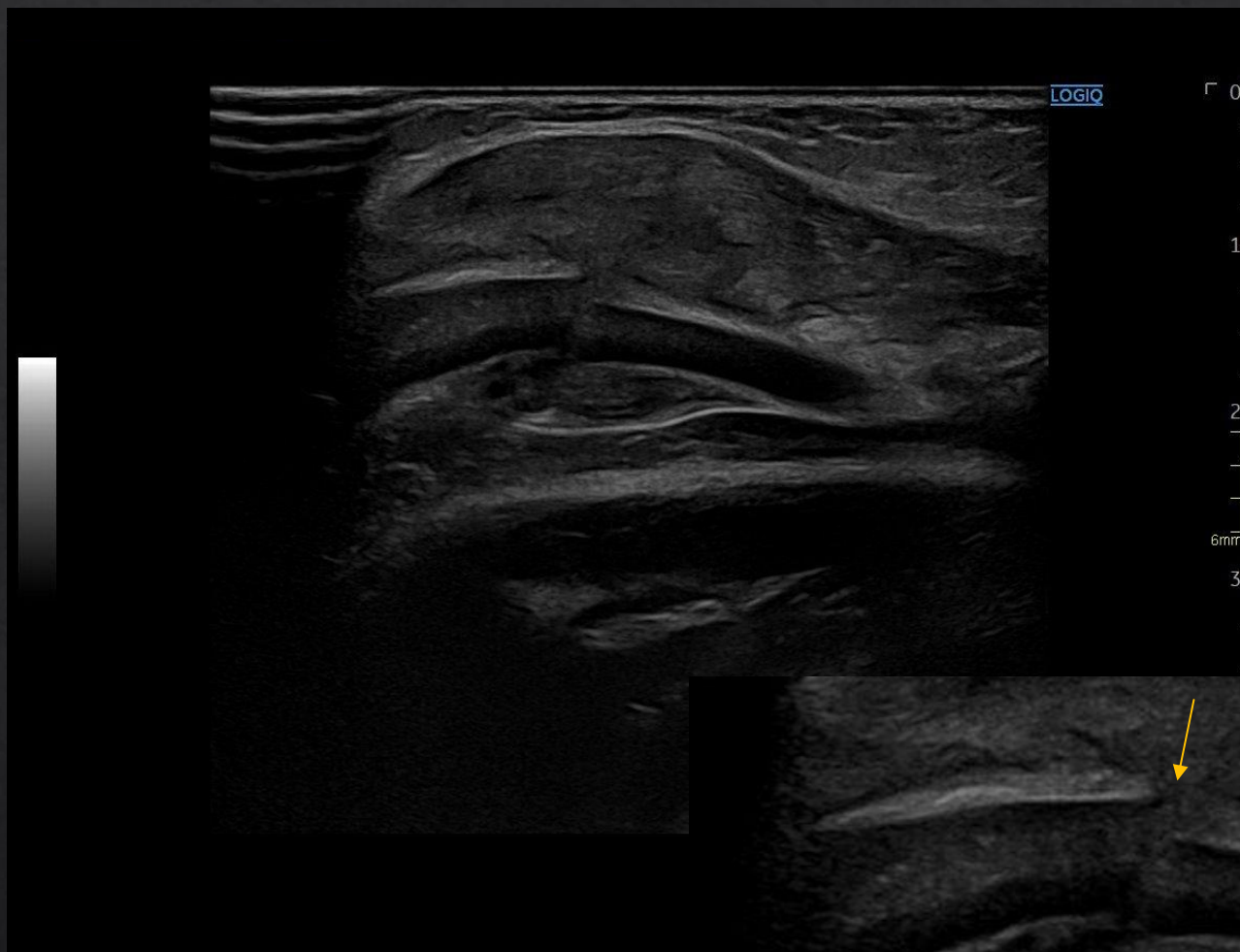


Lonergan et al., RadioGraphics 2003; 23:811–845



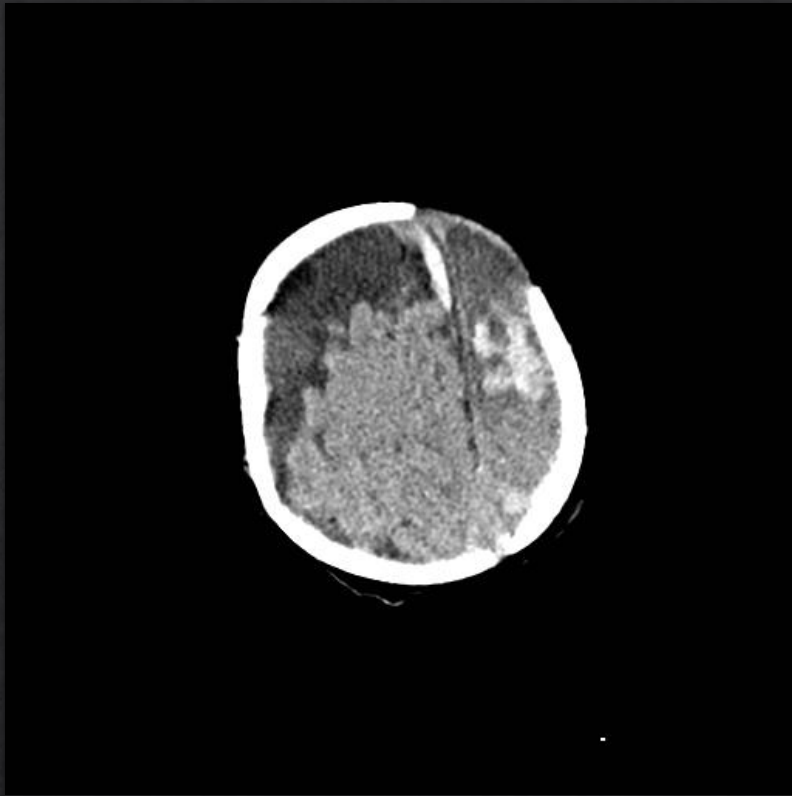
Kleinman: “Diagnostic imaging of child abuse”

# Fraktur i brusken



12 måneder gammel barn med  
brud i den bruskeede del af  
ribbenet

Anterior fraktur

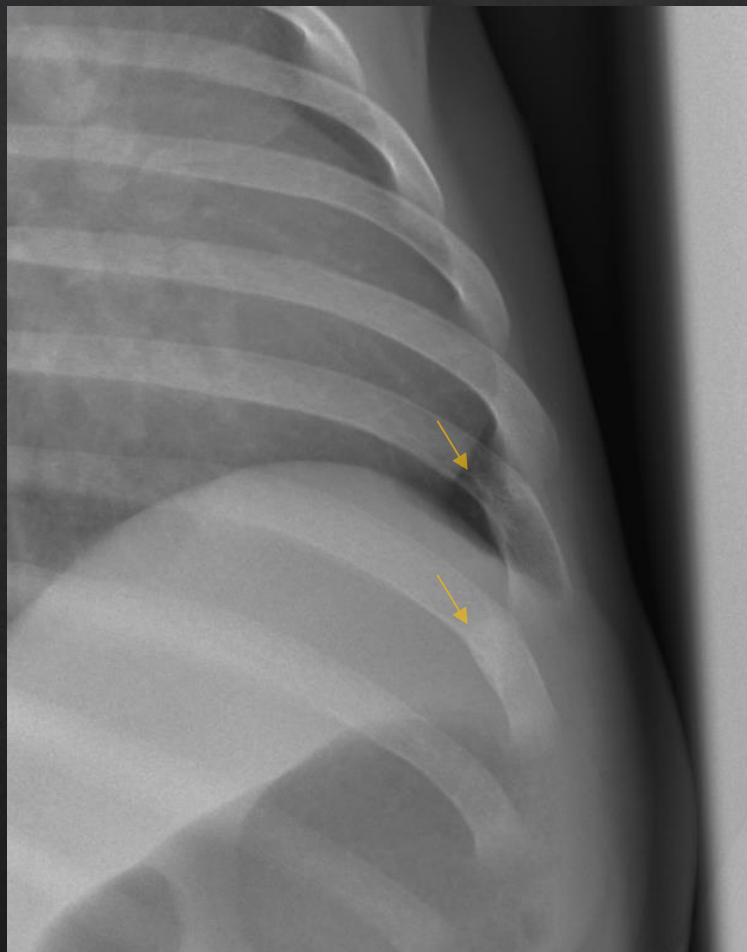
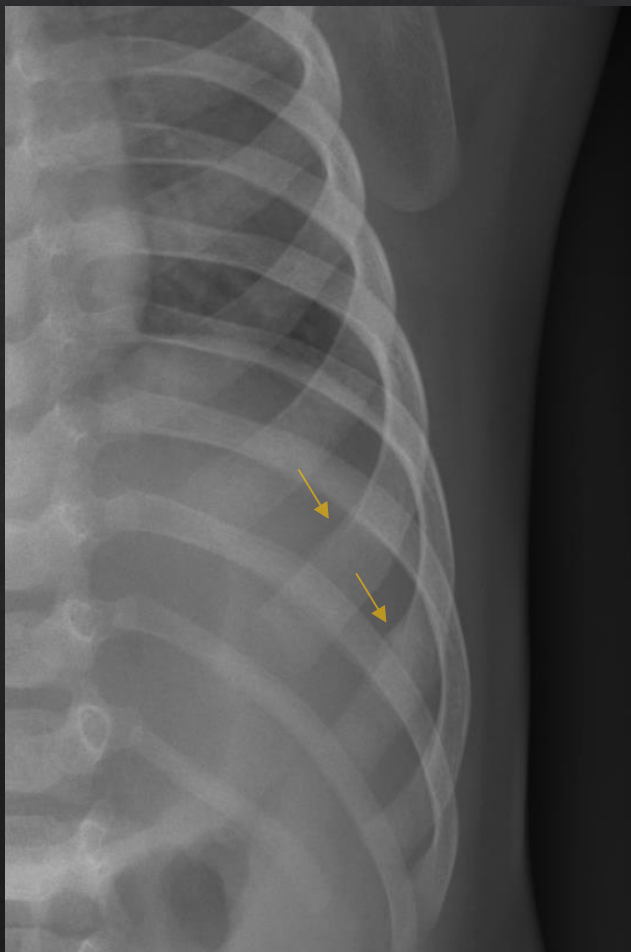


Barn 5 mdr. med hygromer



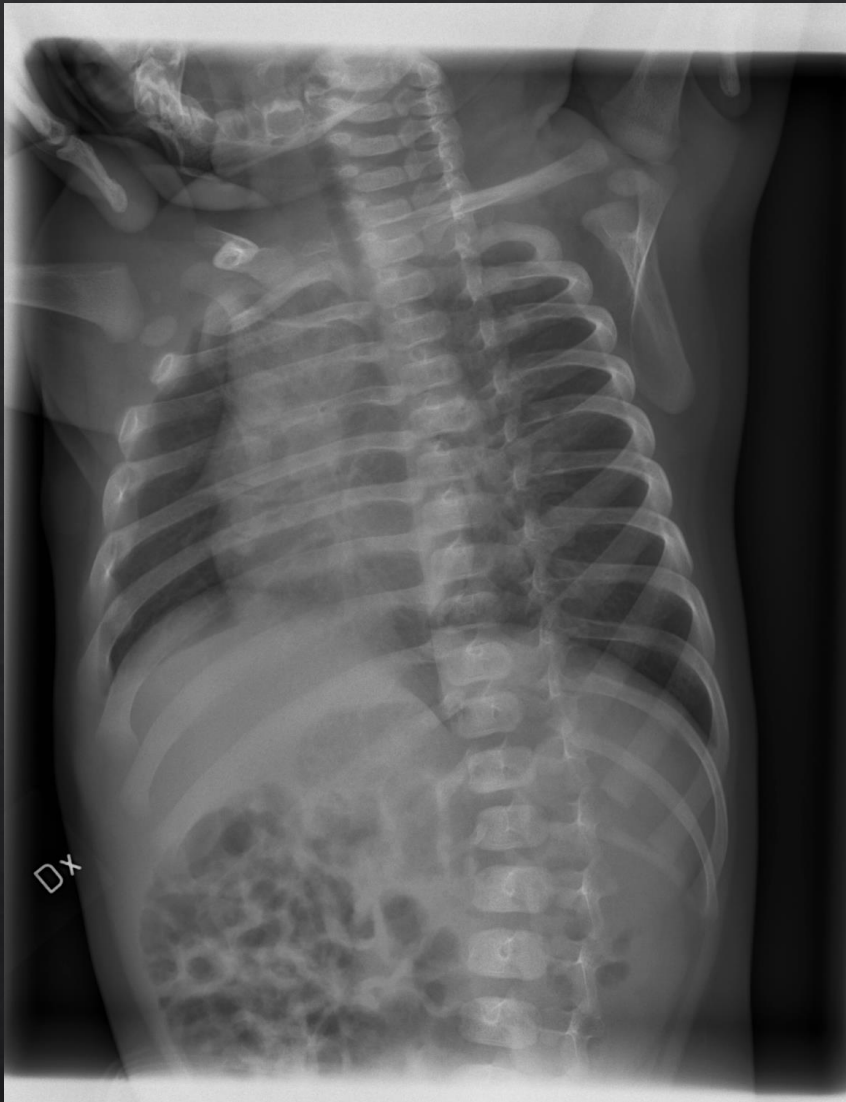






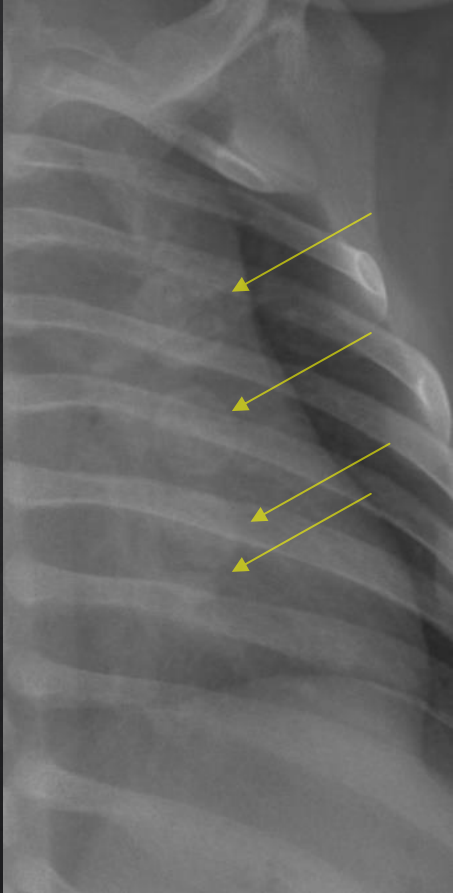
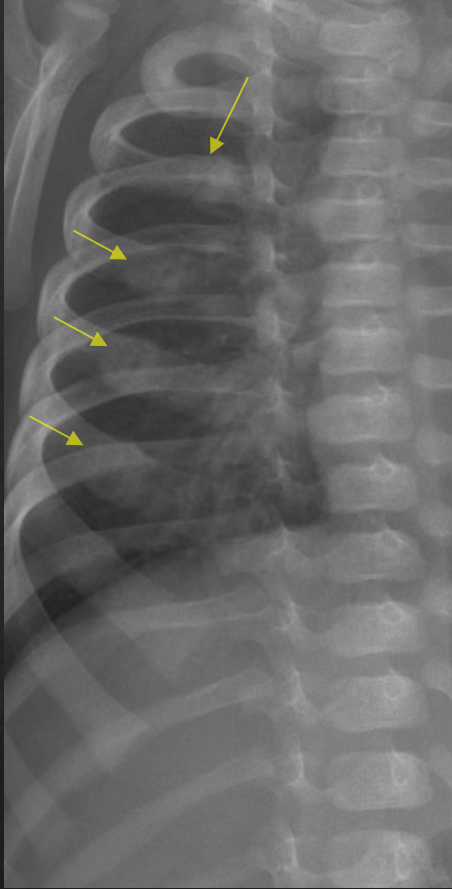
Posteriolateral fraktur



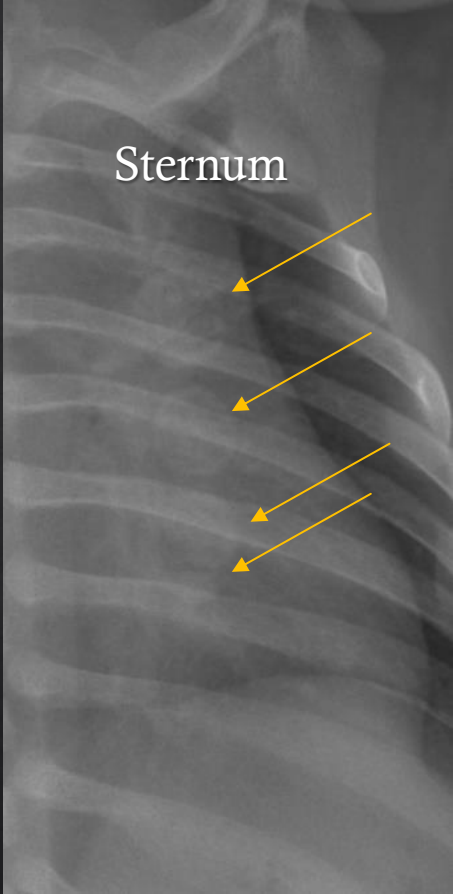
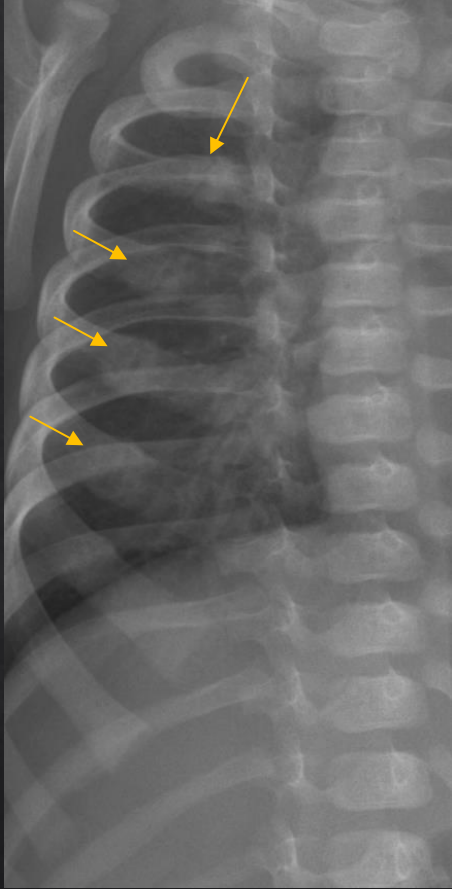


3 mdr. gammel





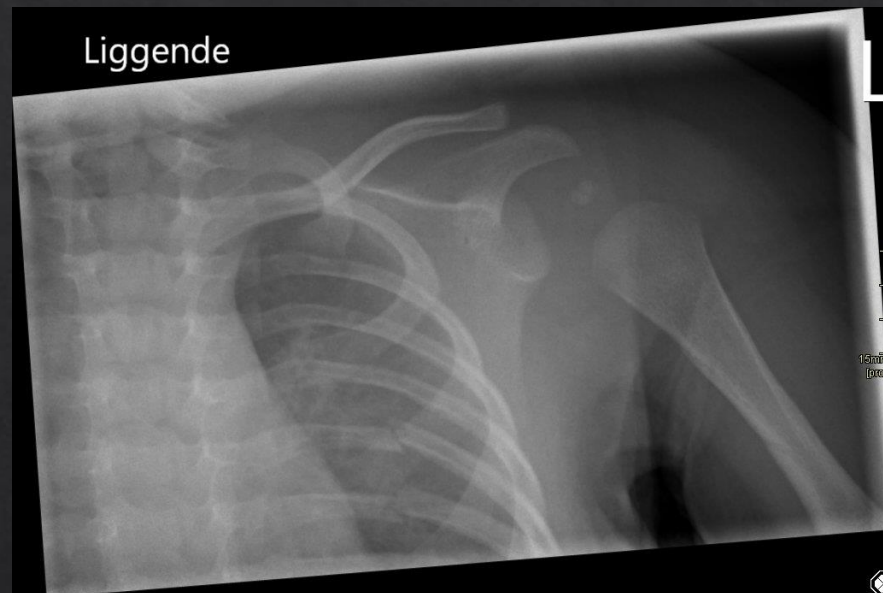
3 mdr. gammel



3 mdr. gammel

Posteriolateral fraktur med 14  
dages kontrol

Knap 4 mdr. gammel, faldet fra puslebord.



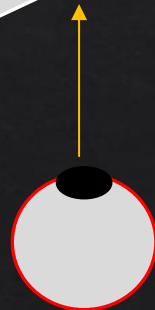
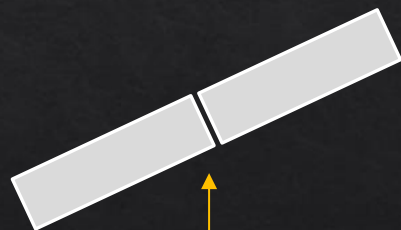
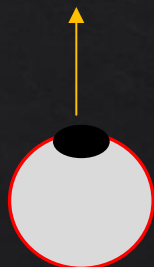
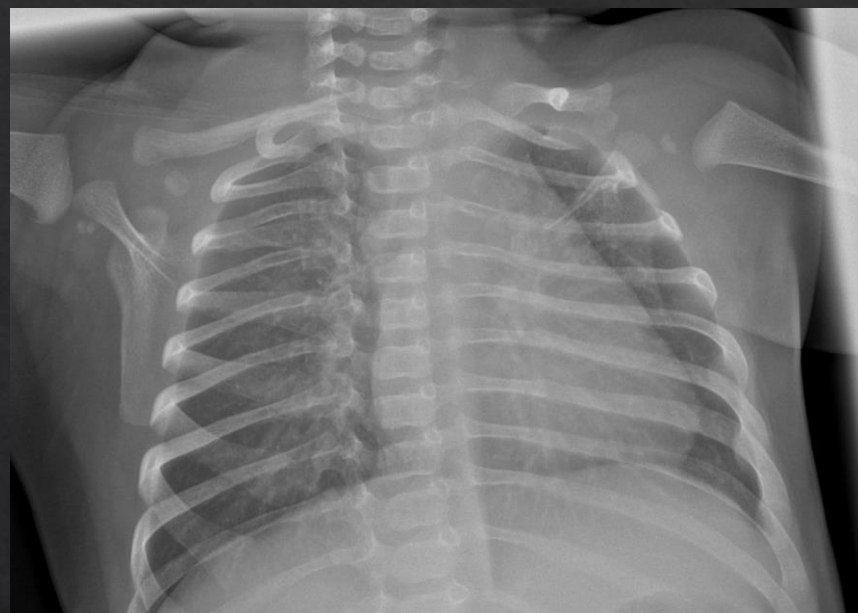
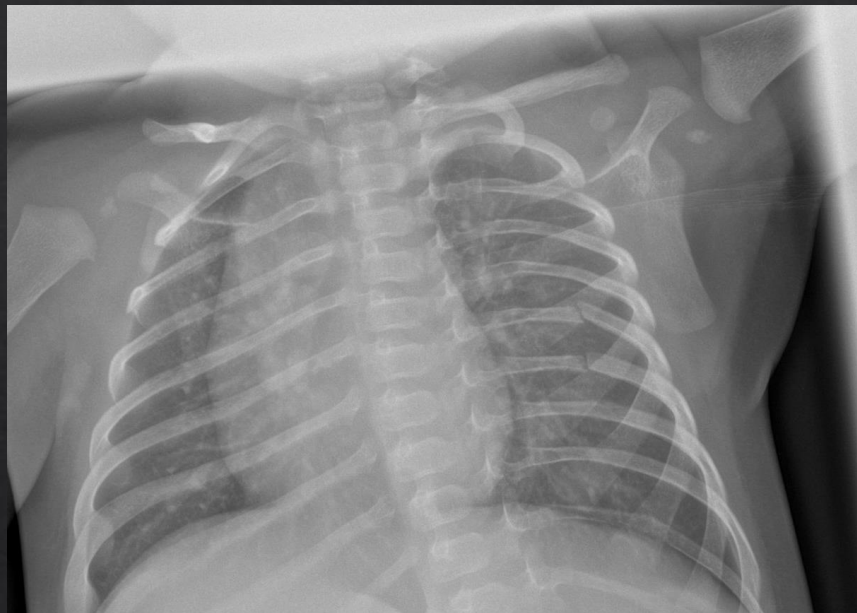


Knap 4 mdr. gammel, faldet fra puslebord.

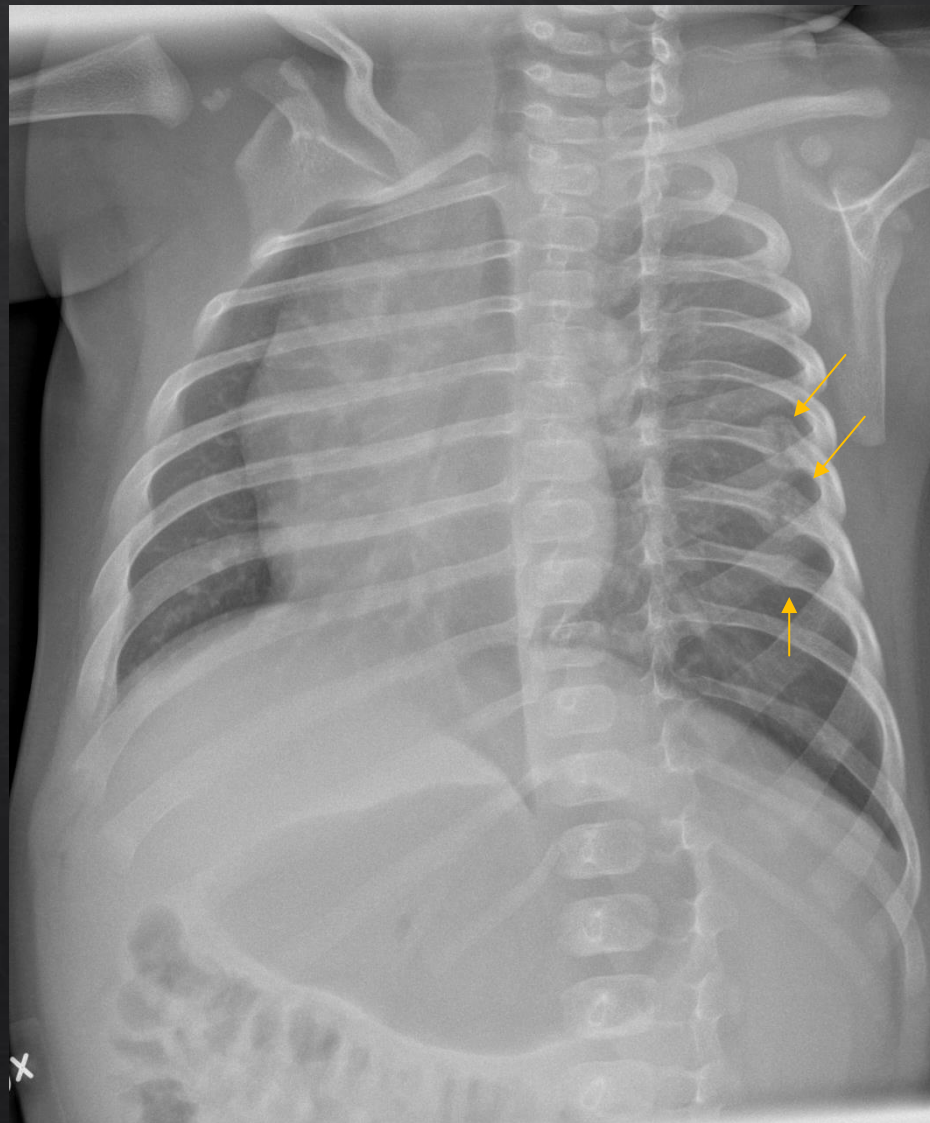




Knap 4 mdr. gammel, faldet fra puslebord.



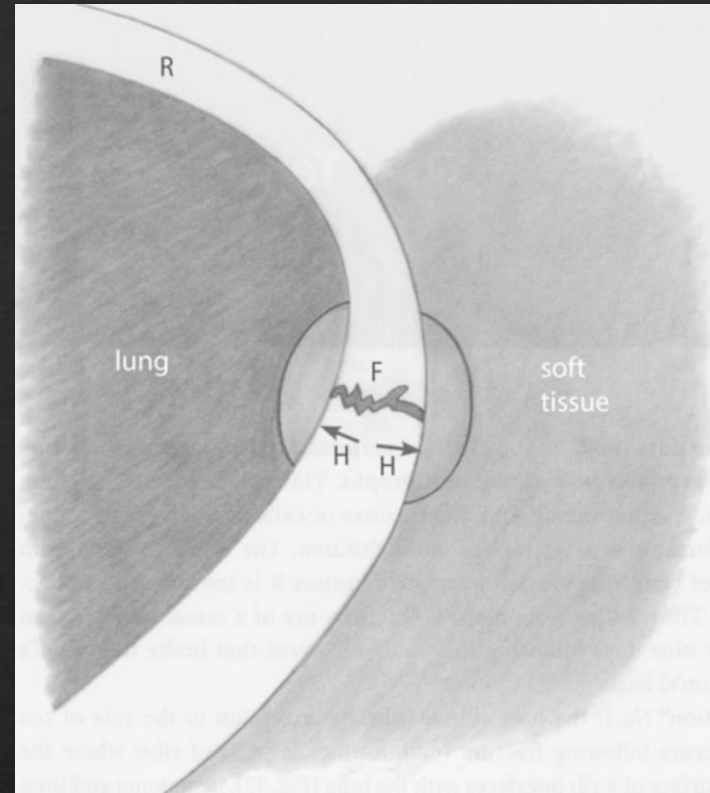
Knap 4 mdr. gammel, faldet fra puslebord.



Kontrolbilledet efter 14 dage



Oestreich and Caré



Oestreich and Caré

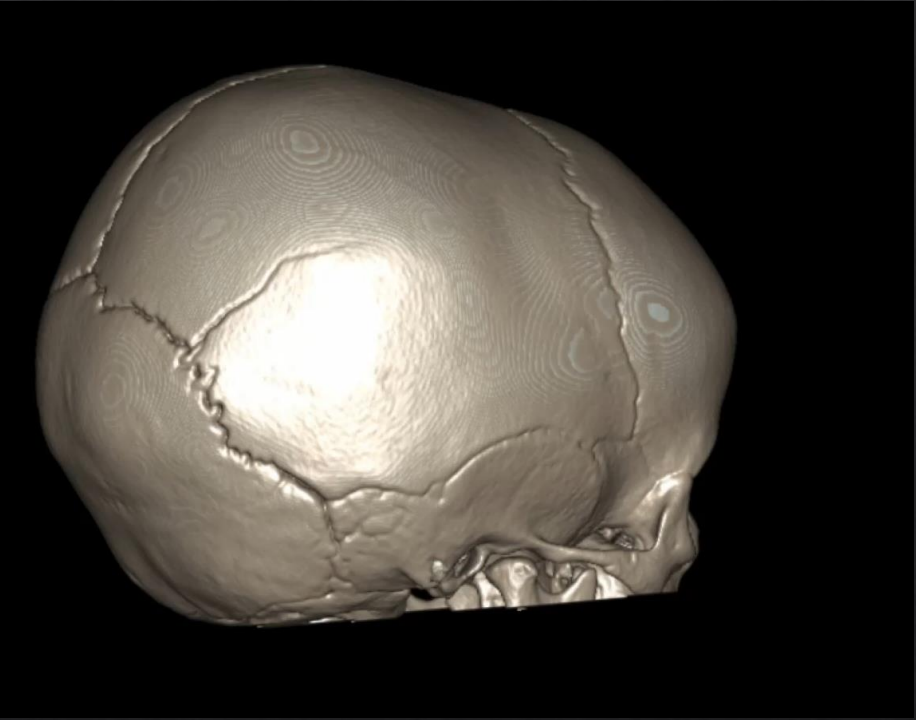
Callus væv ses på konventionel røntgen først efter 9-10 dage. På medialsiden af costae, ses hæmatomet dog, idet det afgrænses af luftholdig lungevæv.

# Frakturtyper: Kranie frakturer









# Frakturtyper: Columna frakturer

Dreng på 11 måneder med distal crus fraktur



Dreng på 11 måneder med distal crus fraktur og multiple hvirvelfrakturer

Pige 8 måneder  
til sammenligning



Dreng 13 måneder  
til sammenligning





Fraktur alder



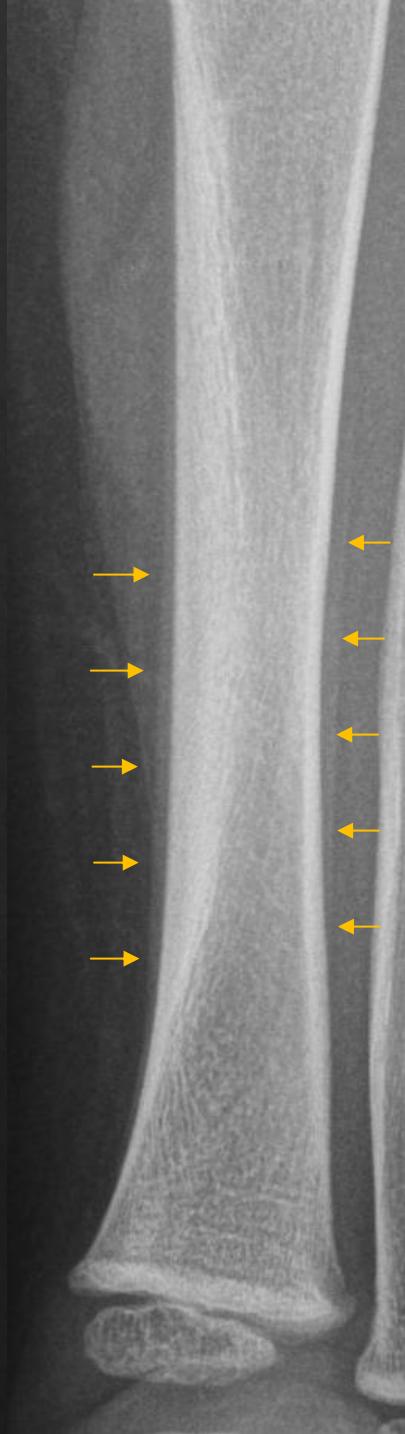
# Faser

- ◇ Fraktur
- ◇ Subperiotal knoglenydannelse (SPNBF)
- ◇ Callus
- ◇ Remodelering

# Helings tegn

- ◇ Periosteal reaction:
  - ◇ Linear and thin (not rounded) elevation and calcification of the periosteum, which is parallel to the shaft of bone, located around or adjacent to the fracture site
- ◇ Callus formation:
  - ◇ Evidence of healing as new bone is laid down which gradually calcifies and ossifies. It envelops the fracture site. This initially has a 'fluffy' edge followed by a more well demarcated dense edge which is nearly as dense as cortex
- ◇ Bridging callus:
  - ◇ Fracture line has been completely crossed by intact callus, though the fracture line may or may not remain visible
- ◇ Remodelling:
  - ◇ Loss of fracture line definition with complete bridging of the fracture gap with continuity of cortical bone

Fra Prosser et al (2012).



◇ Subperiostal knogle nydannelse (SPNBF) – tidligt stadie.

◇ Subperiostal knogle nydannelse (SPNBF) – sent stadie.



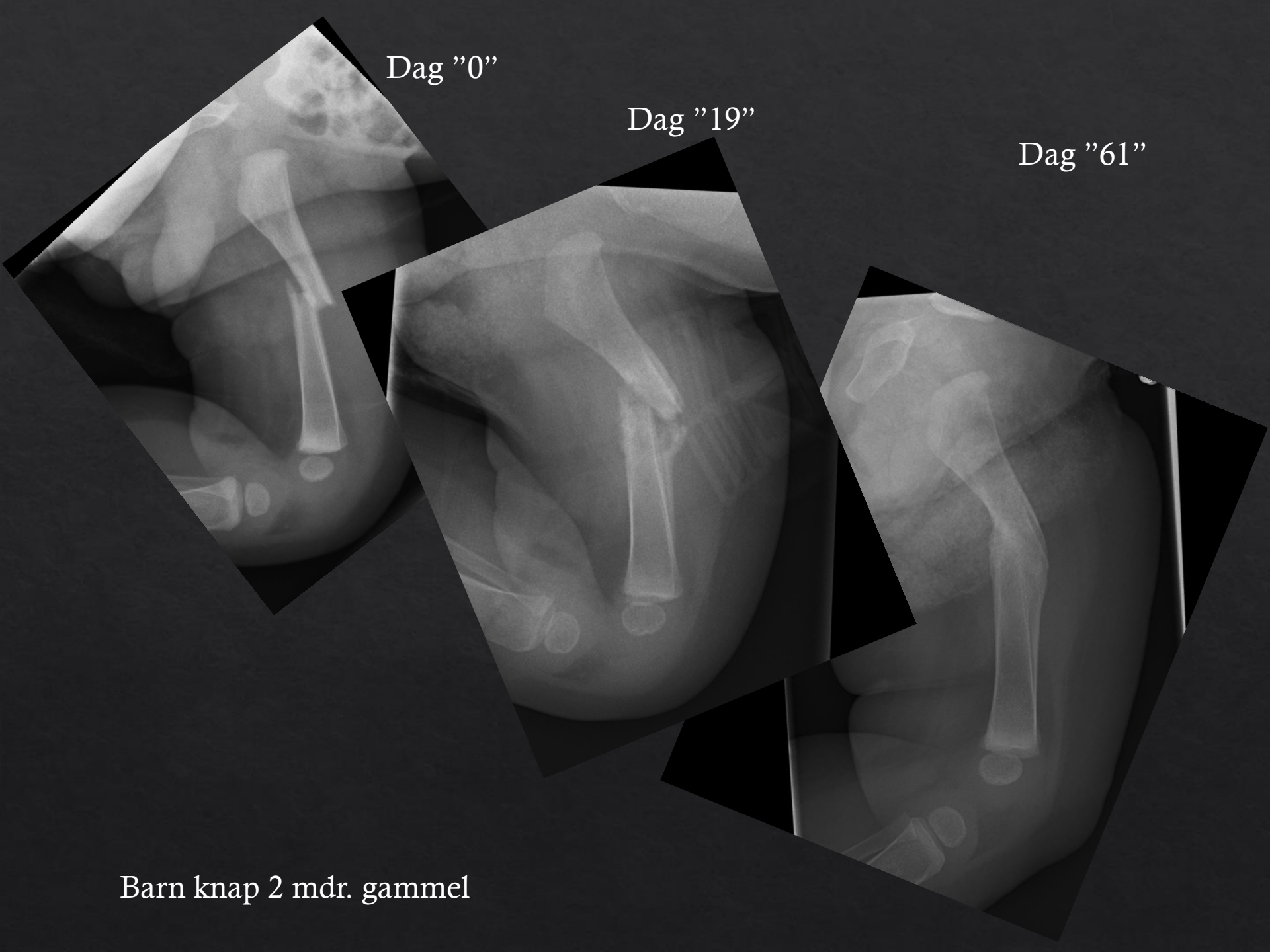


Dag "0"

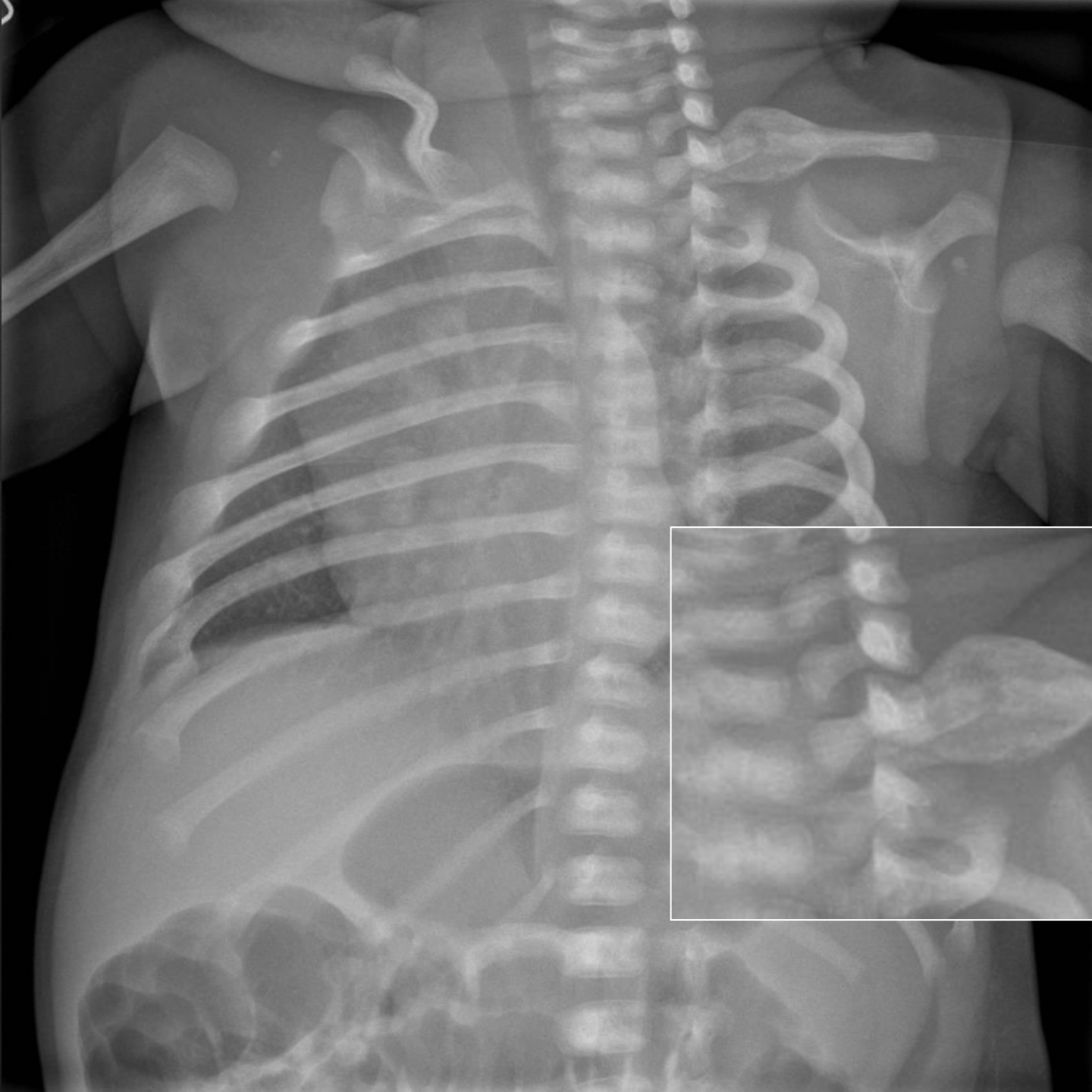
Dag "19"

Dag "61"

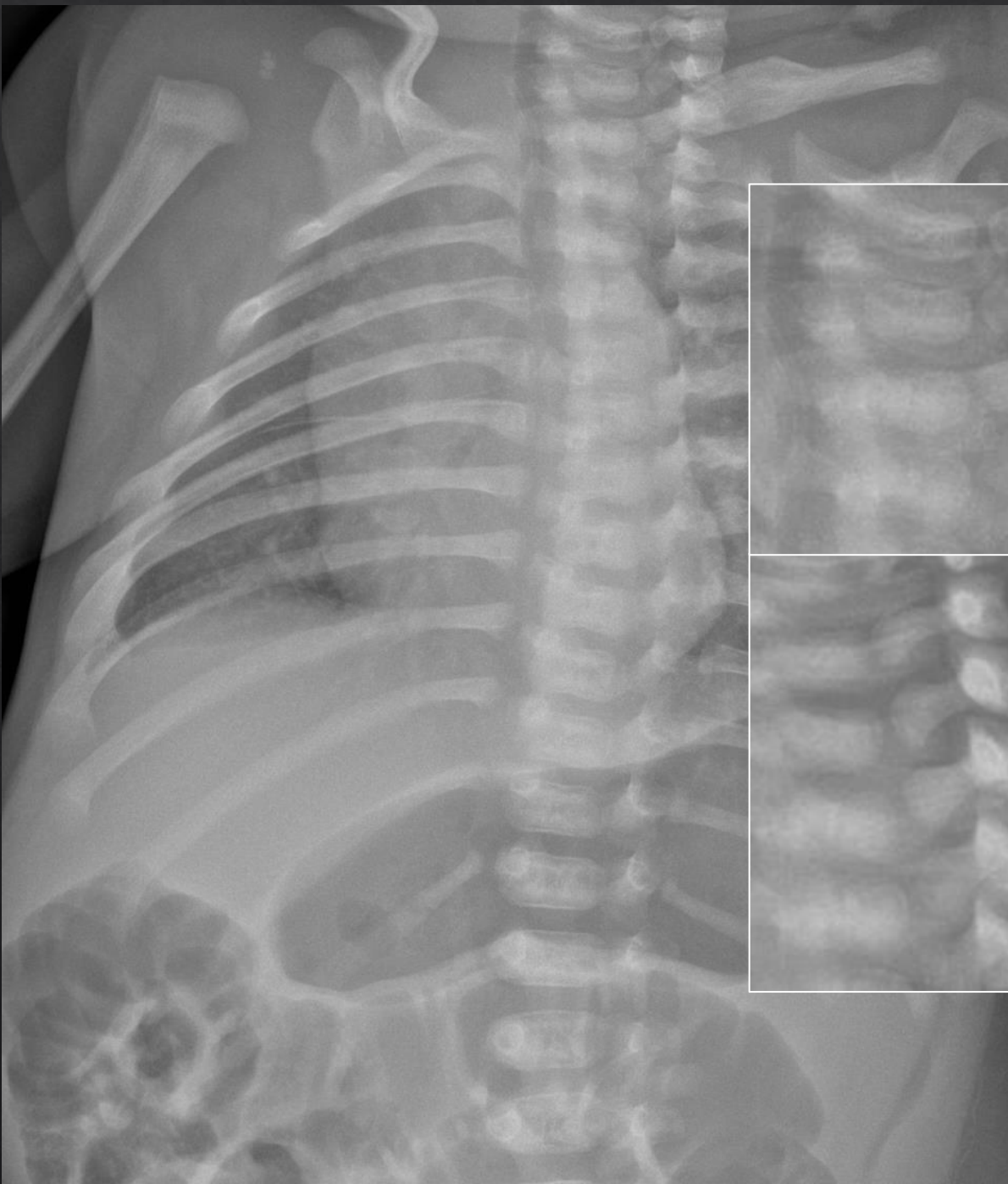
Barn knap 2 mdr. gammel



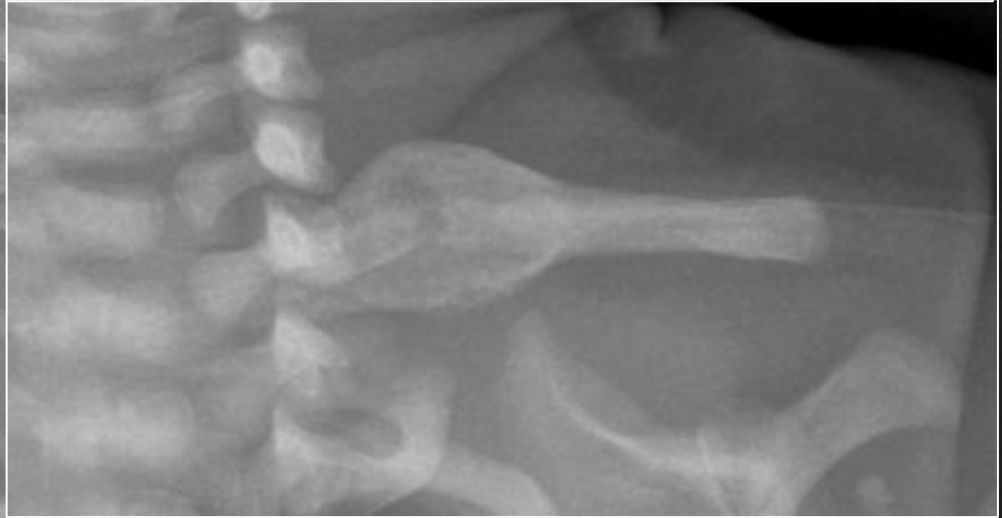
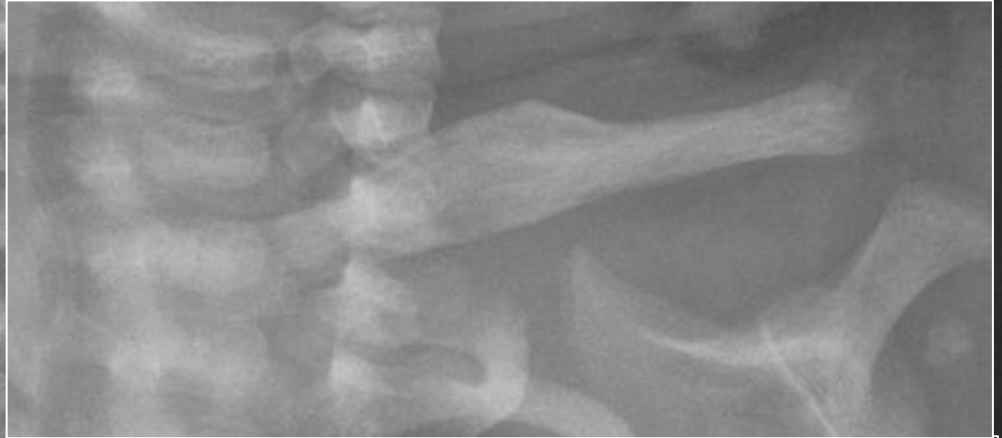




Dreng en måned gammel.



Dreng nu 1½ mdr. (14-dages kontrol undersøgelse).



Dreng en måned gammel.

# A Timetable for the Radiologic Features of Fracture Healing in Young Children

**TABLE 3: Day That Each Feature of Fracture Healing Was First Seen, Peaked, and Was Last Seen on Digital Radiography**

Feature of Fracture Healing	No. of Days Since Injury		
	First Seen <sup>a</sup>	Peak Period <sup>b</sup>	Last Seen <sup>c</sup>
Soft-tissue swelling	1	1–2	31
Periosteal reaction	5	15–35	96
Soft callus	12	22–35	66
Hard callus	19	≥22	96
Bridging	19	≥36	300
Remodeling	45	≥36	421

<sup>a</sup>The first day that reviewers agreed a feature was present.

<sup>b</sup>Time bands when agreed presence rose to its greatest level, exceeding 40%, before starting to decline again.

<sup>c</sup>Last day reviewers agreed that feature was present.

# A Timetable for the Radiologic Features of Fracture Healing in Young Children

- ◇ 228 billeder
- ◇ 82 frakturer
- ◇ 63 børn yngre end 5 år – gennemsnitsalder 4,8 år.



# “A study of radiological features of healing in long bone fractures among infants less than a year”

**Table 3** Radiological features consistent with healing phases over time (days)

		Periosteal reaction	Callus	Bridging	Remodeling
Total	Range	7–130	9–130	15–130	51–247
	Peak <sup>1</sup>	9–49	9–26	15–67	51–247
Complete	Range	9–130	9–130	15–130	51–247
	Peak	9–49	9–36	15–67	51–247
Incomplete	Range	7–52	*	*	*
	Peak	7–28			

<sup>1</sup> Peak defined as present in >40% of images

\*Lack of agreement in the majority of cases

**Table 4** Proposed timetable for dating complete fractures based on presence of radiographic features

Proposed time table for fracture dating based on radiographic features

No healing	Periosteal reaction	Callus	Bridging	Remodeling	Fracture age
+					<9 days old
	+	+	–	–	≥9–14 days old
	±	+	+	–	≥15–51 days old
	±	±	±	+	≥51 days old

\*Proposed timetable is for complete fractures, and caution should be taken using the timetable for incomplete fractures



# “A study of radiological features of healing in long bone fractures among infants less than a year”

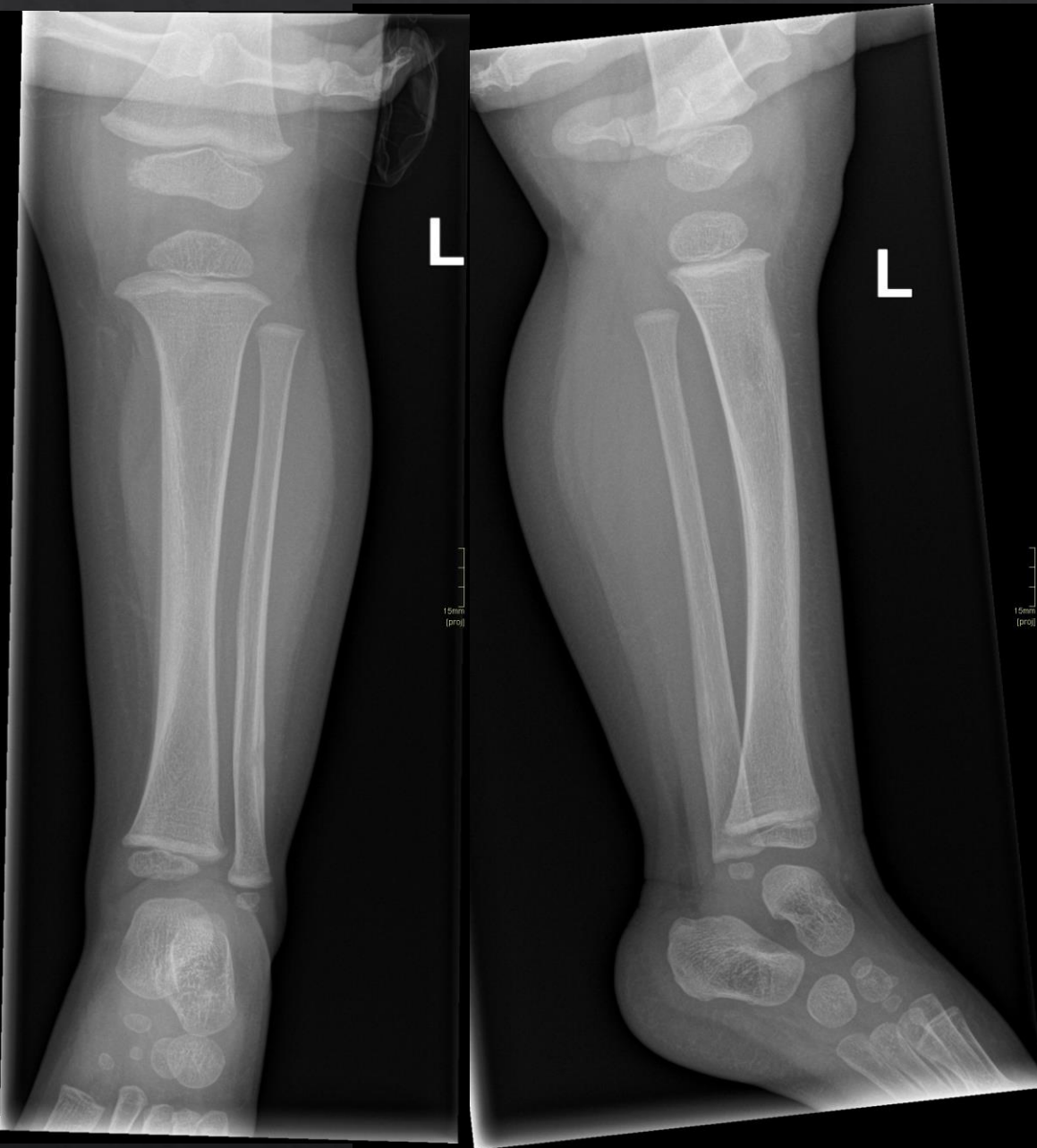
- ◇ 59 billedserier
- ◇ 40 børn < 1 år gamle.
- ◇ Tre radiologer: Periostal reaktion, callus, brodannelse, remodellering (til stede, ikke til stede, uklart)
- ◇ ”Peaked”: Til stede på mere end 40% af billederne.

# Fraktur datering

It is important to understand that radiological dating is an inexact science.

Chapman "Non-accidental Injury" in Imaging in pediatric skeletal trauma, Springer, 2008

Frakturer af  
forskellig  
alder



Dreng 9 mdr.

Oplyst at traumet er er sket for 11 dage siden.







Dag 0



Dag 17

Dreng 9 mdr.



# Differential diagnoser

Hændeligt  
uheld

Anatomiske  
normal  
varianter

Obstetrisk  
traume

Skeletal  
dysplasi og  
syndromer

Osteogenesis  
imperfectal

# Anatomiske normalvarianter

# Højresidig tibia fraktur



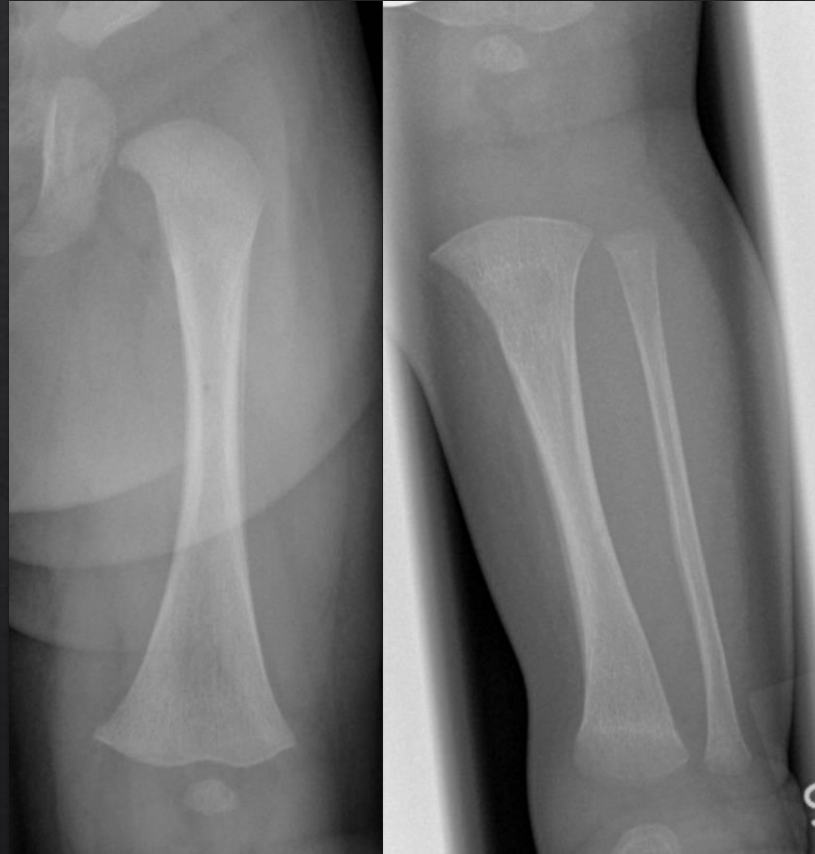
# Fysiologisk periostitis

## Fysiologisk periostitis

- Alder: 1-4 mdr. (ind imellem 6 mdr.)
- Bilateralt hos 40-70 %
- Hyppigst: Tibia > femur > humerus > ulna > radius
- < 2 mm tyk
- Diafysært

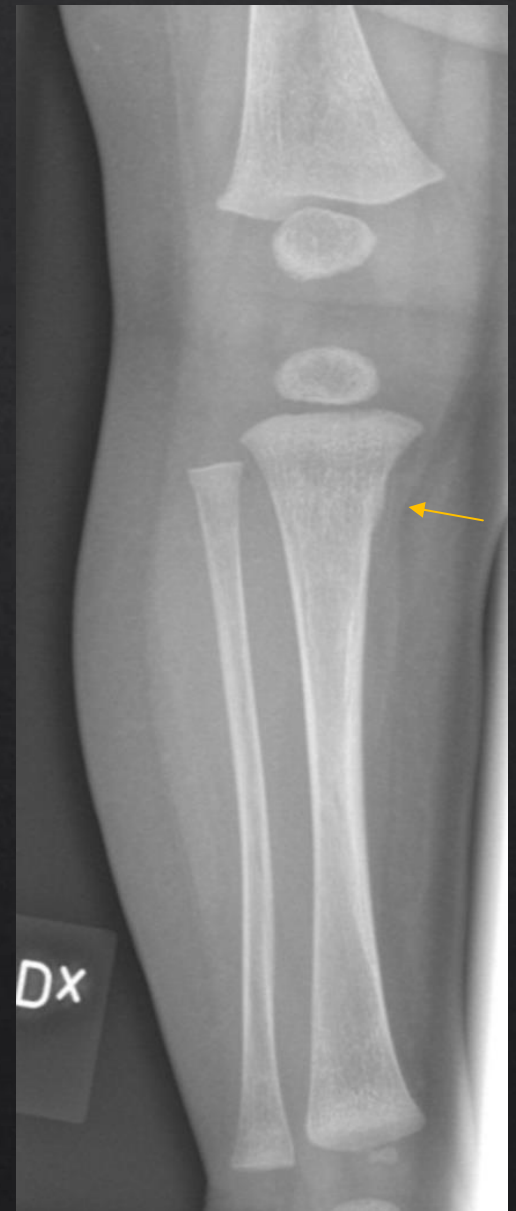
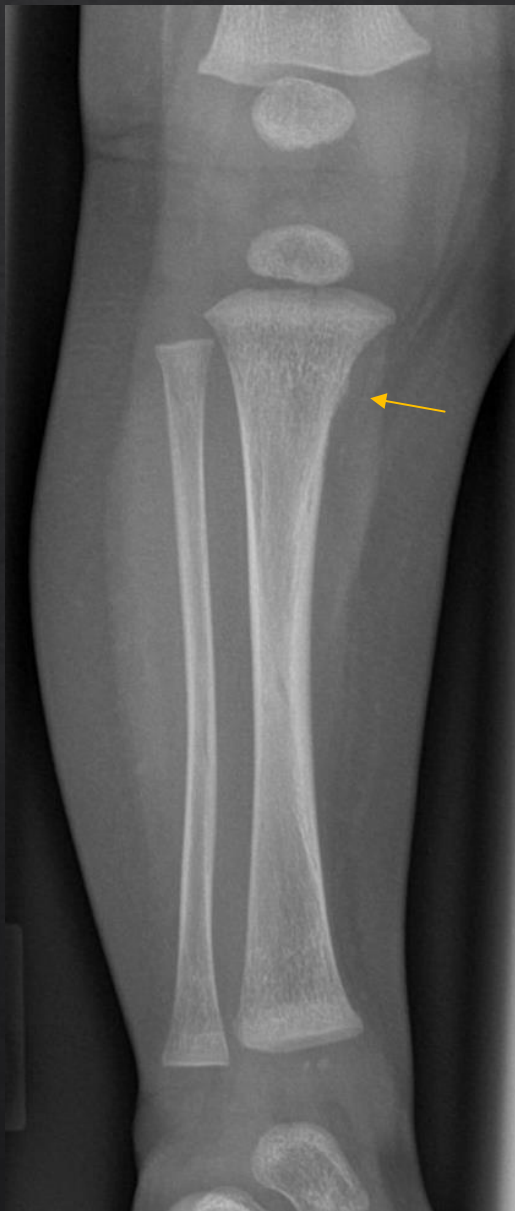
Normal fænomen med hurtig knoglenydannelse ved intramembranøs ossifikation langs periost i de lange rørknoglers diafyse.

”Pediatric Orthopedic Imaging”

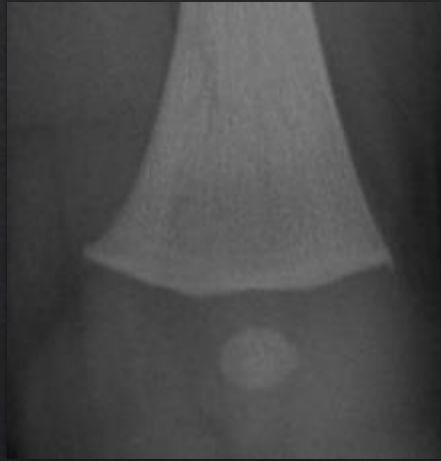


Dreng to mdr. med højresidig tibiafraktur

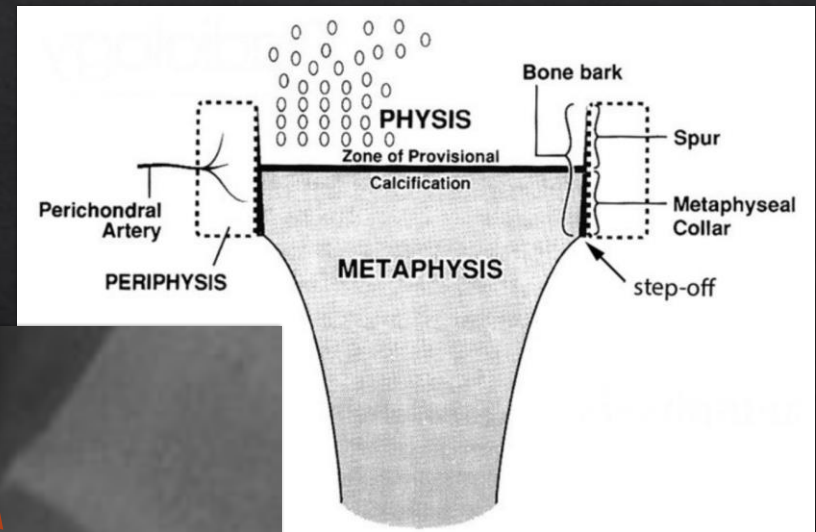




Pige på 3 mdr. Kontrolundersøgelse efter 14 dage



# Sporedannelse: Normal anatomi



Oestreich and Caré

# Metafysært "næb"

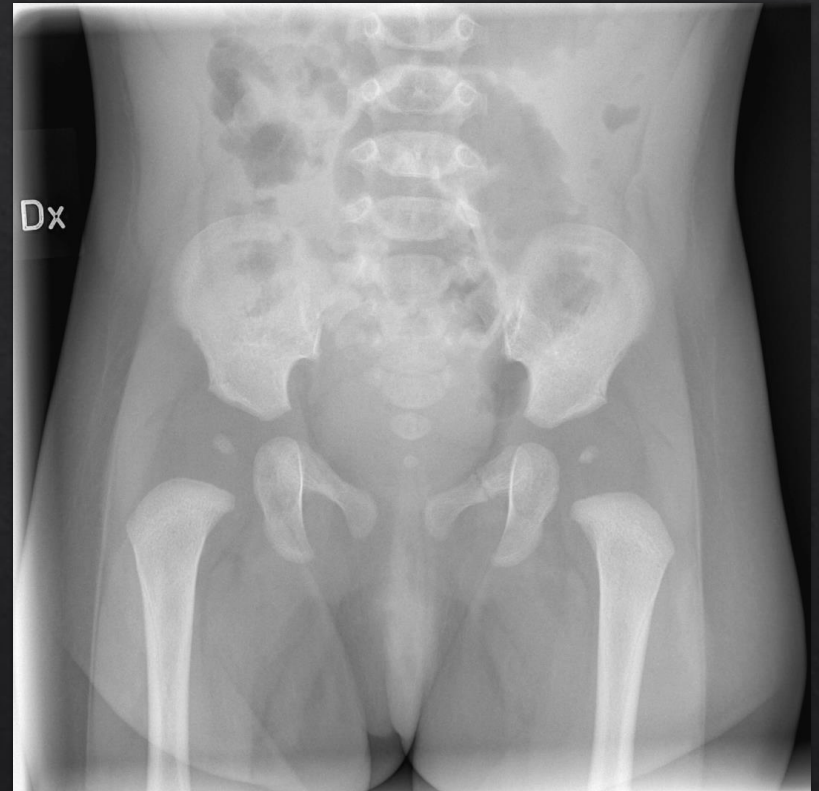




# Metafysært "næb"

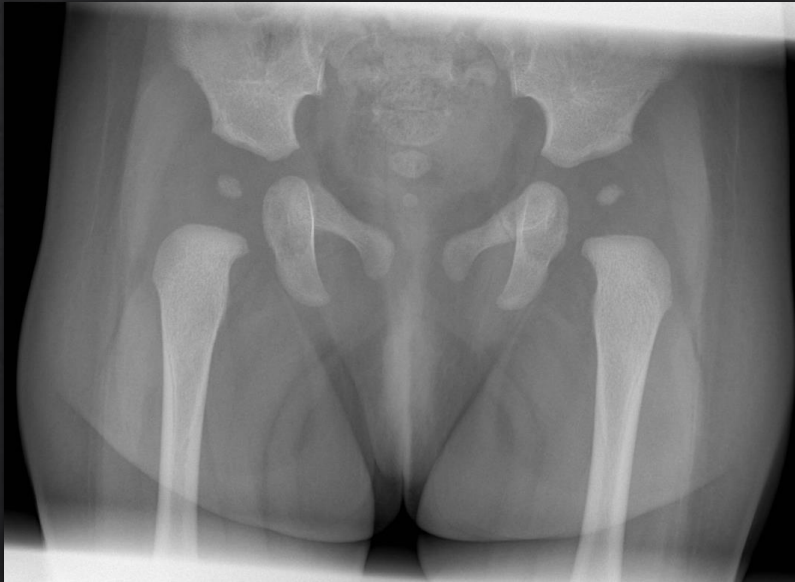


Kleinman et al. 1991



2 mdr. gammel

# Accessorisk synchondrose i ramus superior ossis pubis

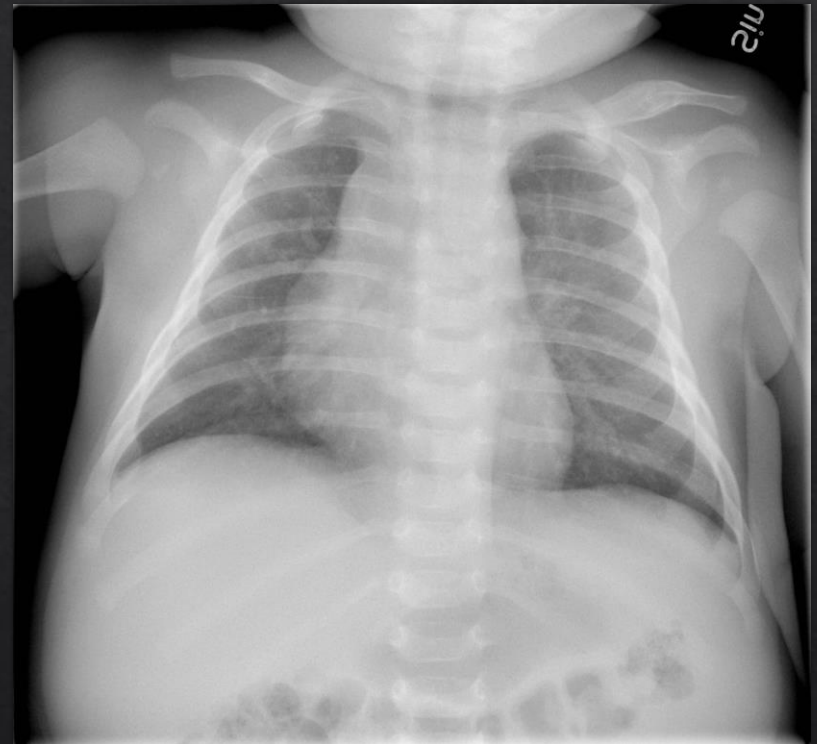


Kontrol 14 dage senere

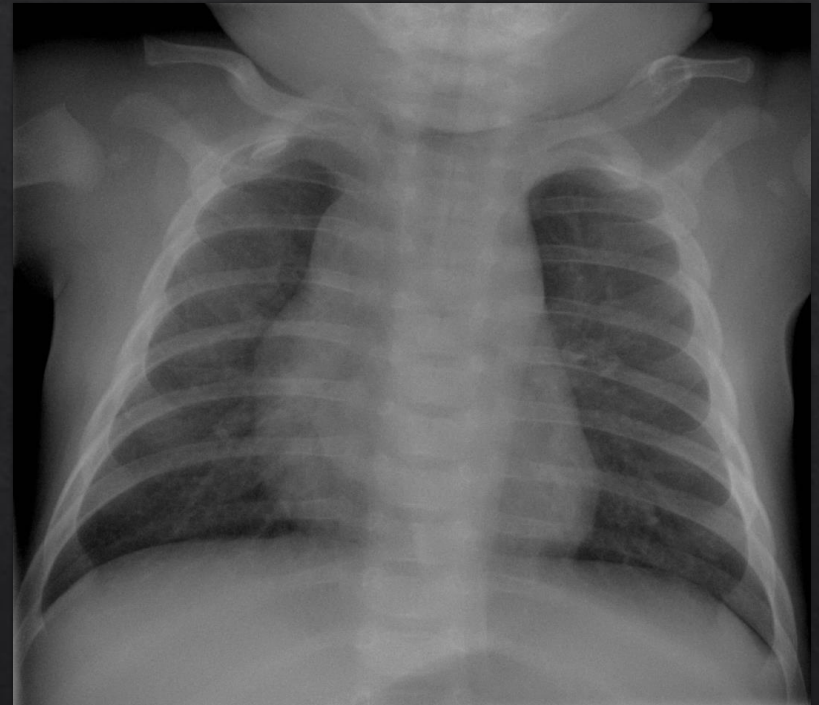
# Obstetriske frakturer



# Dreng 54 dage gammel



Dreng 54 dage gammel+14 dage



# CML?



Currarino et al. 2000

# CML?



Andet barn 6år 9 mdr.



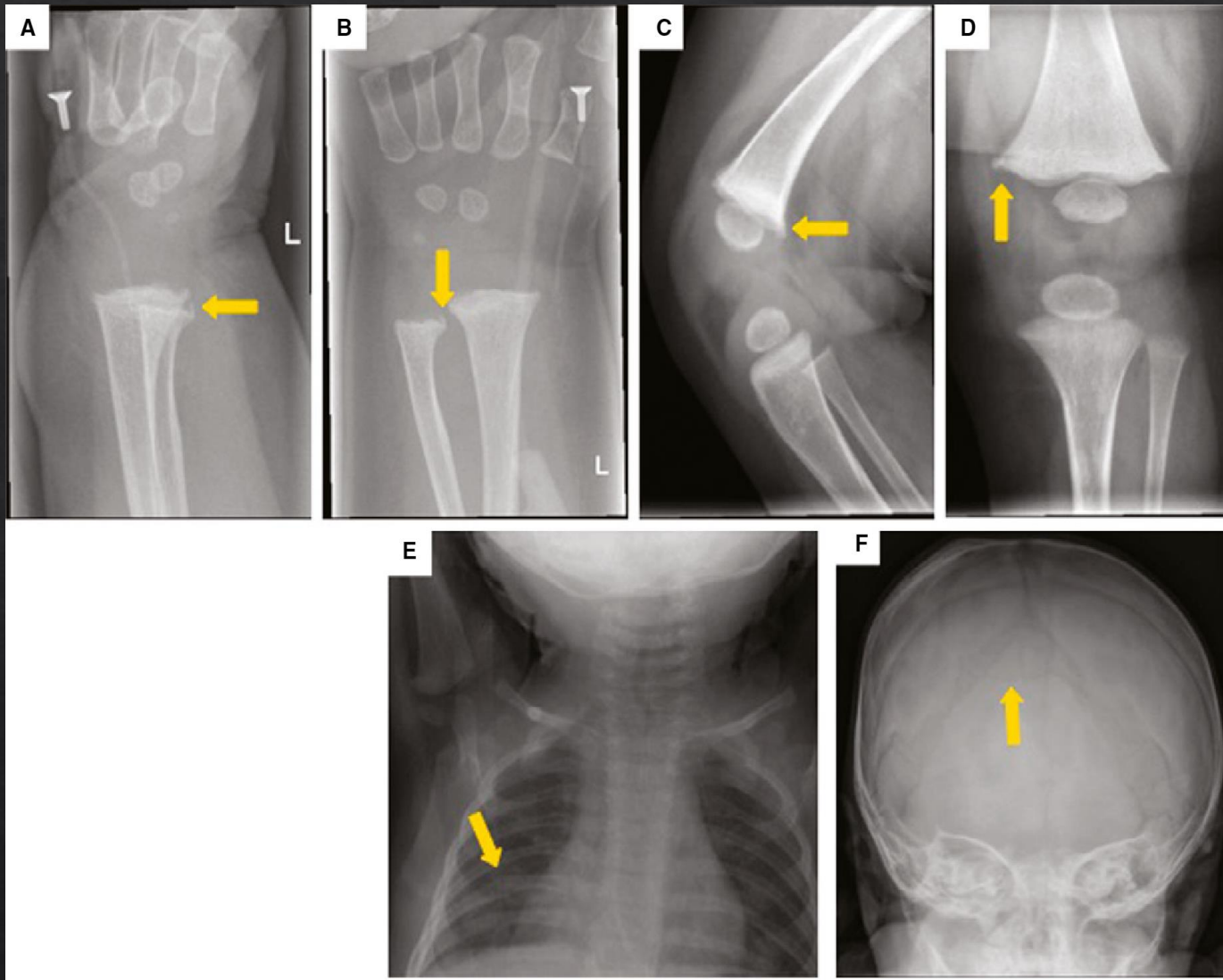


# Skeletal dysplasi og syndromer

Developmental coxa vara associated with spondylometaphyseal dysplasia (DCV/SMD): “SMD-Corner Fracture Type” (DCV/SMD-CF)



# Menkes Syndrome/Kinky Hair Disease



# Litteratur



# Litteratur

- ◇ Barber et al.: "The yield of high-detail radiographic skeletal surveys in suspected infant abuse", *Pediatr Radiol* (2015) 45:69–80
- ◇ Ignasi et al.: "The yield of high-detail radiographic skeletal surveys in suspected infant abuse", *Pediatr Radiol* (2015) 45:69–80
- ◇ Kleinman et al.: "Normal metaphyseal radiologic variants not to be confused with findings of infant abuse", *AJR* (1991) 156:781-783
- ◇ Kleinman ed.: "Diagnostic Imaging of Child Abuse", 2015 Cambridge University Press.
- ◇ Kwon et al: "Physiologic Subperiosteal New Bone Formation: Prevalence, Distribution, and Thickness in Neonates and Infants", *AJR* 2002;179:985–988
- ◇ Lonergan et al.: "Child abuse: Radiologic-Pathologic correlations", *RadioGraphics* (2003) 23:811-845

# Litteratur

- ◇ Marine et al.: "Ultrasound findings in classic metaphyseal lesions: emphasis on the metaphyseal bone collar and zone of provisional calcification", *Pediatric Radiology* <https://doi.org/10.1007/s00247-019-04373-w>
- ◇ Oestreich et al.: "Recognizing Child Abuse in Radiology", Springer 2017
- ◇ Prosser et al."A timetable for the radiologic features of fracture healing in young children", *AJR* (2012); 198: 1014-1020.
- ◇ "The radiological investigation of suspected physical abuse in children" 2018  
The Royal College of Radiologists
- ◇ Stein-Wexler et al.: "Pediatric Orthopedic Imaging", Springer
- ◇ Tsai et al.: "High-resolution CT with histopathological correlates of the classic metaphyseal lesion of infant abuse", *Pediatr. Radiol.* (2014) 44: 124-140.
- ◇ Warner et al.:" A study of radiological features of healing in long bone fractures among infants less than a year". *Skeletal Radiol* (2017) 46:333-341