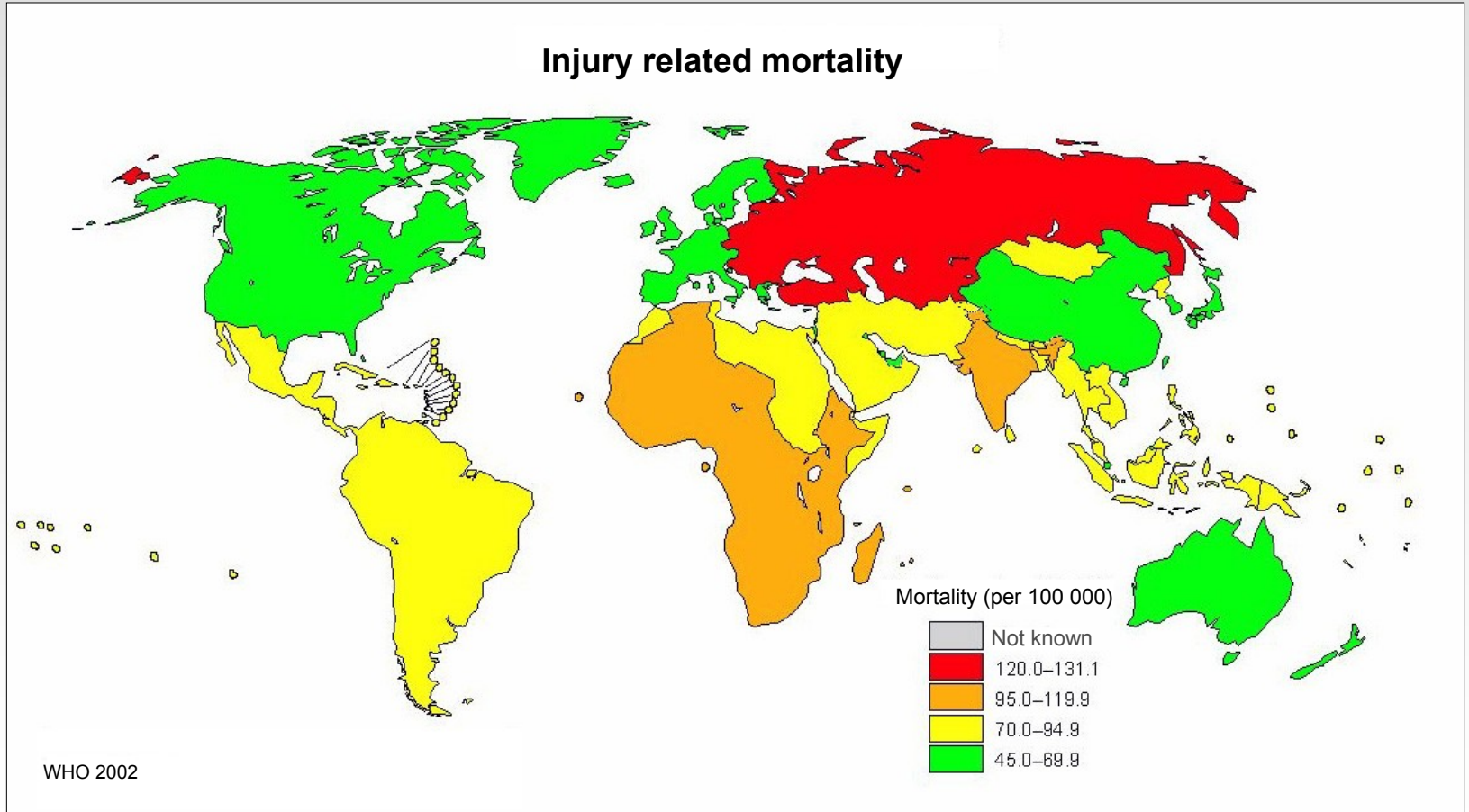


Craniocerebral injuries in pediatric patients

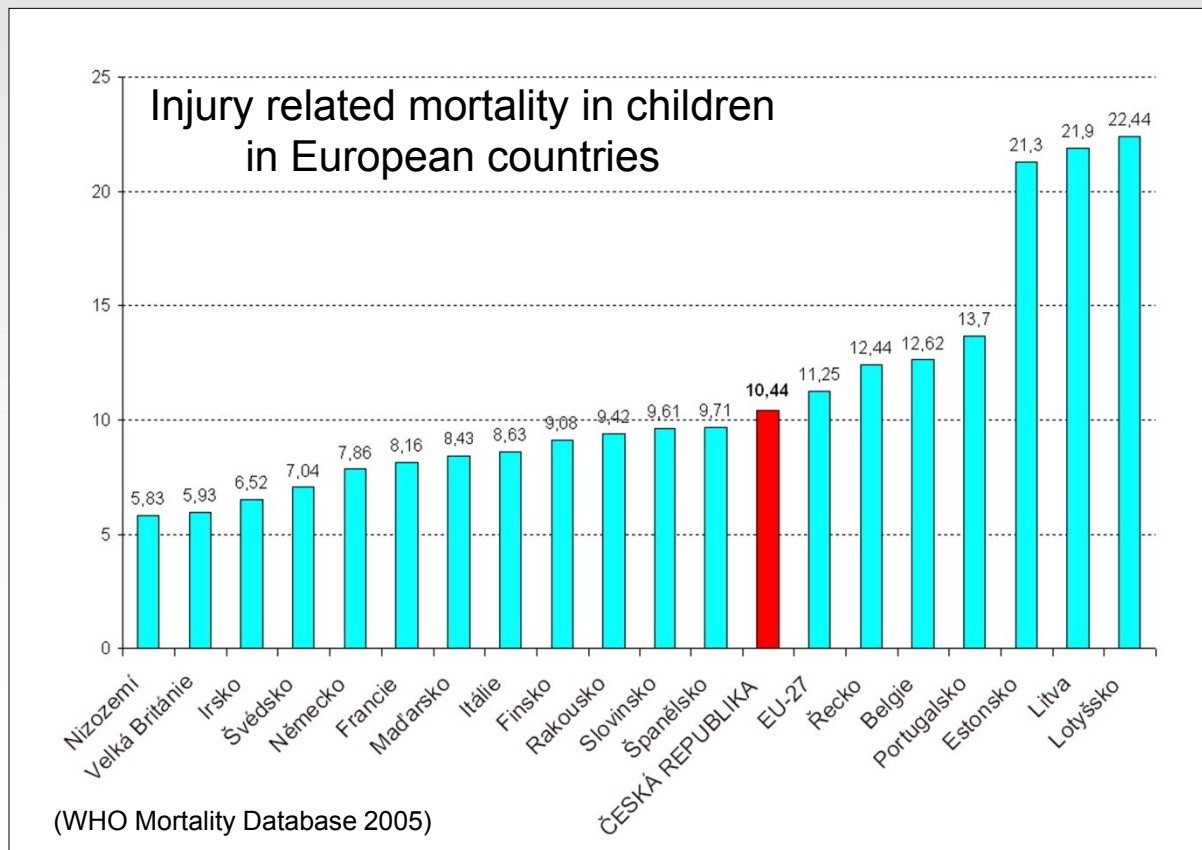
Eva Brichtova, MD., Ph.D.,

Pediatric injuries – global problem



Pediatric injuries in Czech republic

- the most common cause of death in children under 14 years
- craniocerebral injuries represent the most serious injuries with possibly lifelong consequences



Pediatric Traumatology Center, Faculty Hospital Brno

(ISO 9001/2000 certified)

7000 injuries/year

400 head injuries/year

88% - cerebral concussion and superficial head injury



Factors determining the specificity of craniocerebral injuries (CCI) in children under 2 years of age

The immaturity of the nervous system

- ongoing myelination
- proliferation of glial cells
- integration of the blood-brain barrier

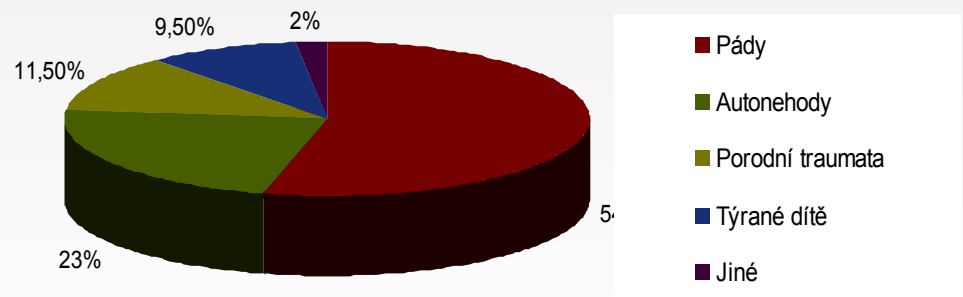
Physical properties of the skull

- thinner and more flexible skull
- persisting cranial sutures
- smoother topography of the skull base



The aetiology of craniocerebral injuries in children under 2 years of age

- Crashes** (from the changing table or stroller, walking)
- Car accident** (unrestrained in a car seat)
- Birth trauma** (instrumentation using birth)
- Child abuse** („shaken baby“)



**Patients hospitalized with severe CCI
in the Faculty Hospital Brno**

**Specifics of the CCI in children
under 2 years of age**

Injuries to scalp

Haemostasis should be very careful due to increased risk of hemorrhagic shock

Patients weighing 5 kg - 400ml blood volume

100 ml blood loss = 25% blood volume!

Hypovolemic shock



**Specifics of the CCI in children
under 2 years of age**

Cephalhaematoma

Subperiosteal bleeding due to perinatal injury

Increased pressure on the neonatal head passing through the birth canal

The incidence in newborns from 0.2% to 3.0%

Using birth instrumentation (forceps birth, vacuumextractor)

Predominantly parietal location



**Specifics of the CCI in children
under 2 years of age**

Cephalhaematoma

More than 80% of cephalhaematomas spontaneously resorb within 3 weeks

In the absence of spontaneous and rapid absorption, calcification and ossification of the cephalhaematoma surface create bone crest, which distorts the shape of the head

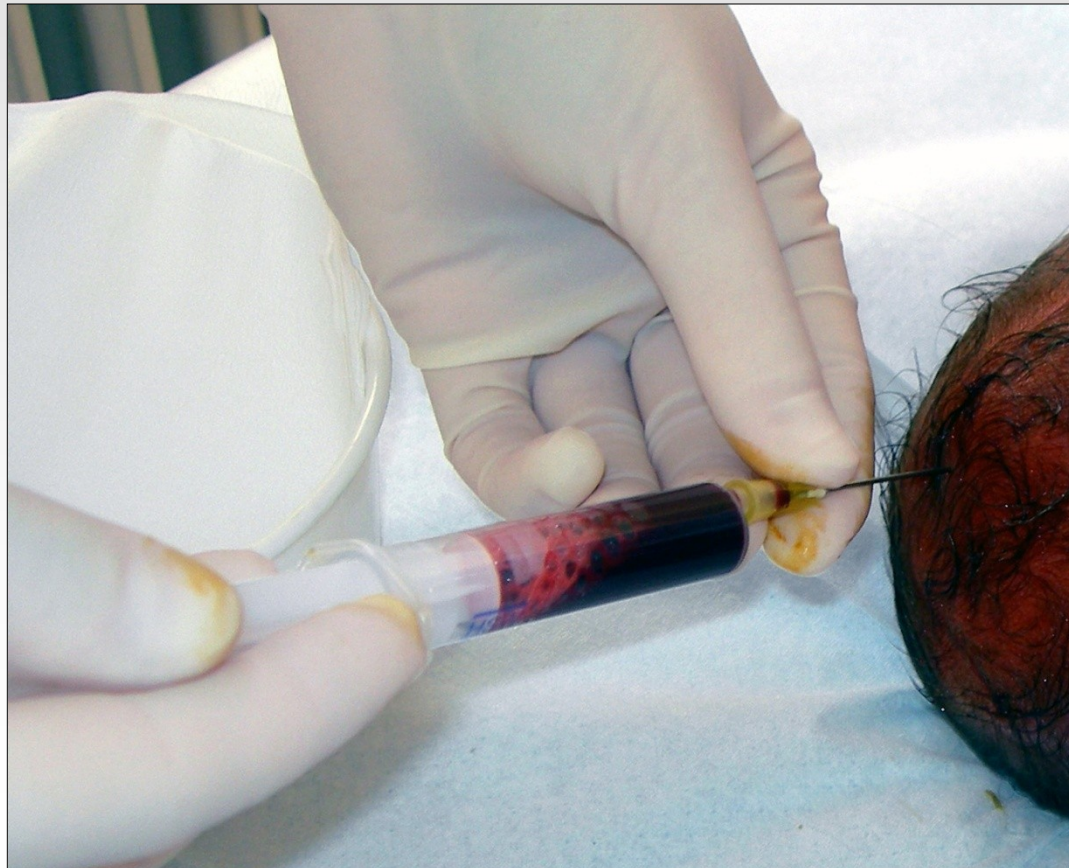
Calvarial bones resorbtion under the ossificated cephalhaematoma



**Specifics of the CCI in children
under 2 years of age**

Cephalhaematoma

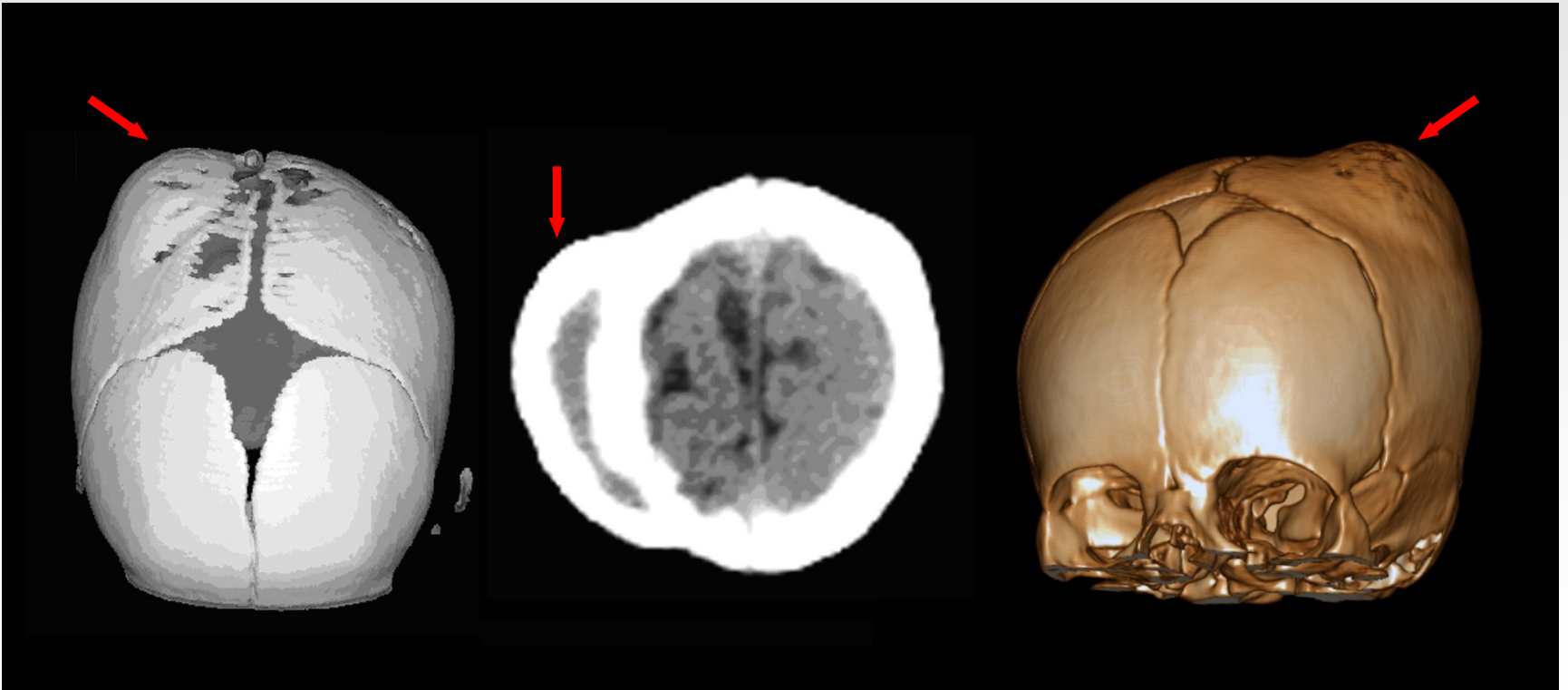
Cephalhaematoma treatment - puncture



**Specifics of the CCI in children
under 2 years of age**

Cephalhaematoma

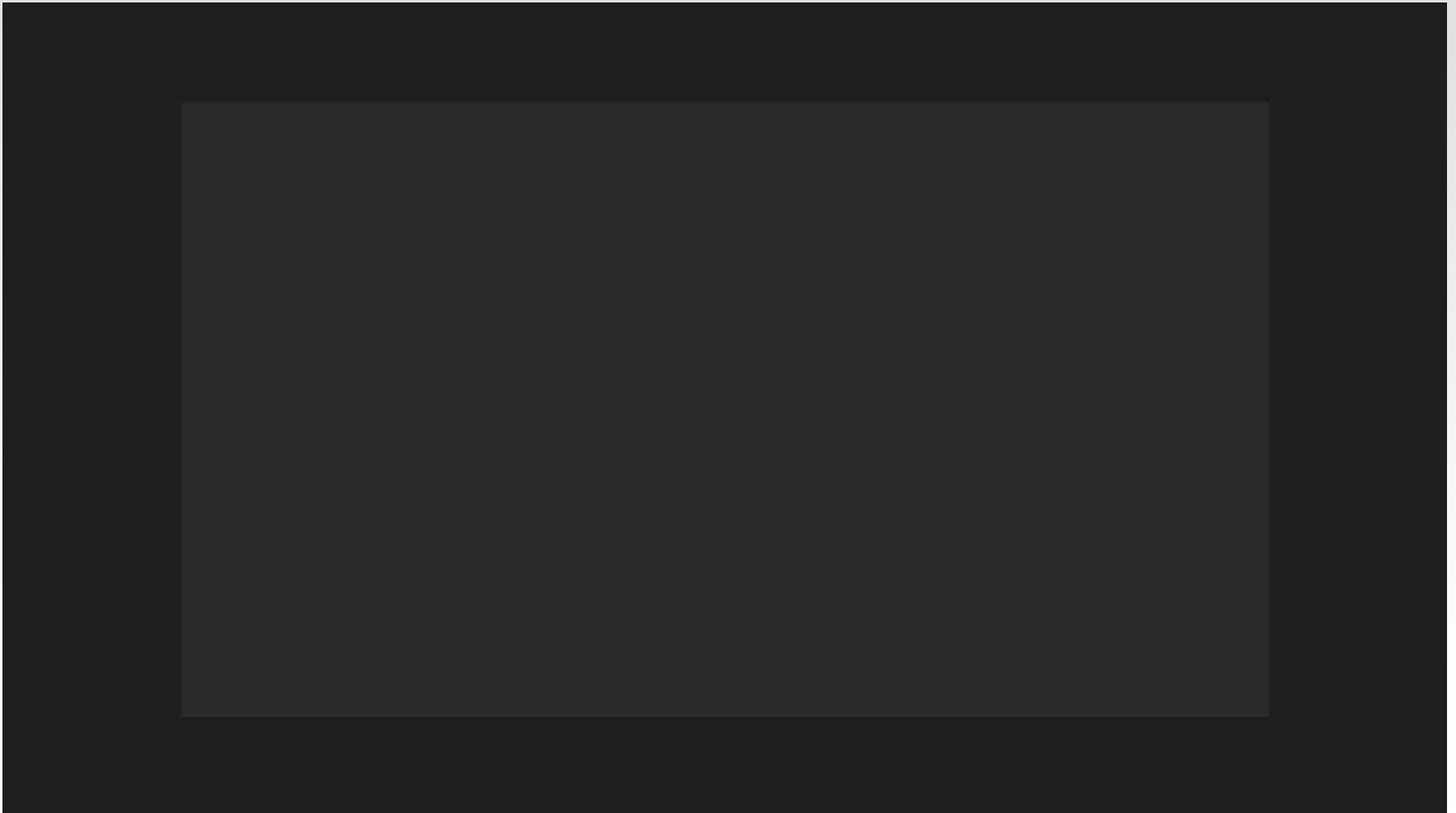
Ossified cephalhaematoma in CT and 3D CT



**Specifics of the CCI in children
under 2 years of age**

Cephalhaematoma

Ossified cephalhaematoma treatment - early neurosurgery at the age of 1-3 months



**Specifics of the CCI in children
under 2 years of age**

Cephalhaematoma



1 week after the surgery



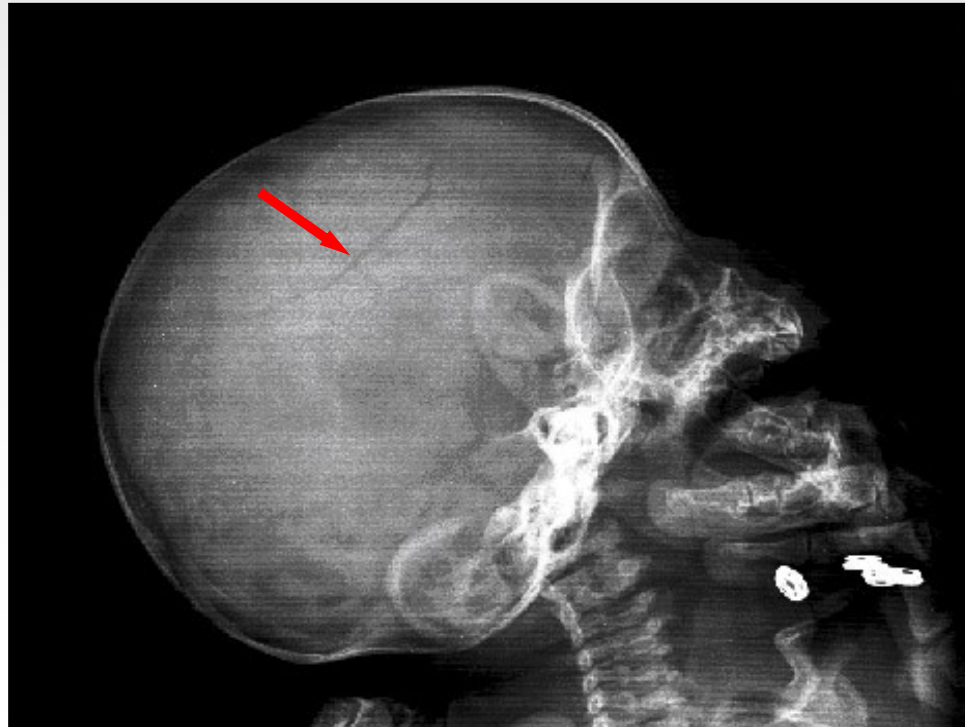
18 months after the surgery

**Specifics of the CCI in children
under 2 years of age**

Skull fractures

Linear fracture

- The most common type of fracture
- Conservative treatment (observation in hospital for 5 days)
- To rule out serious intracranial complications - brain sonography over a large fontanel



**Specifics of the CCI in children
under 2 years of age**

Skull fractures

Growing fracture (leptomeningeal cyst)

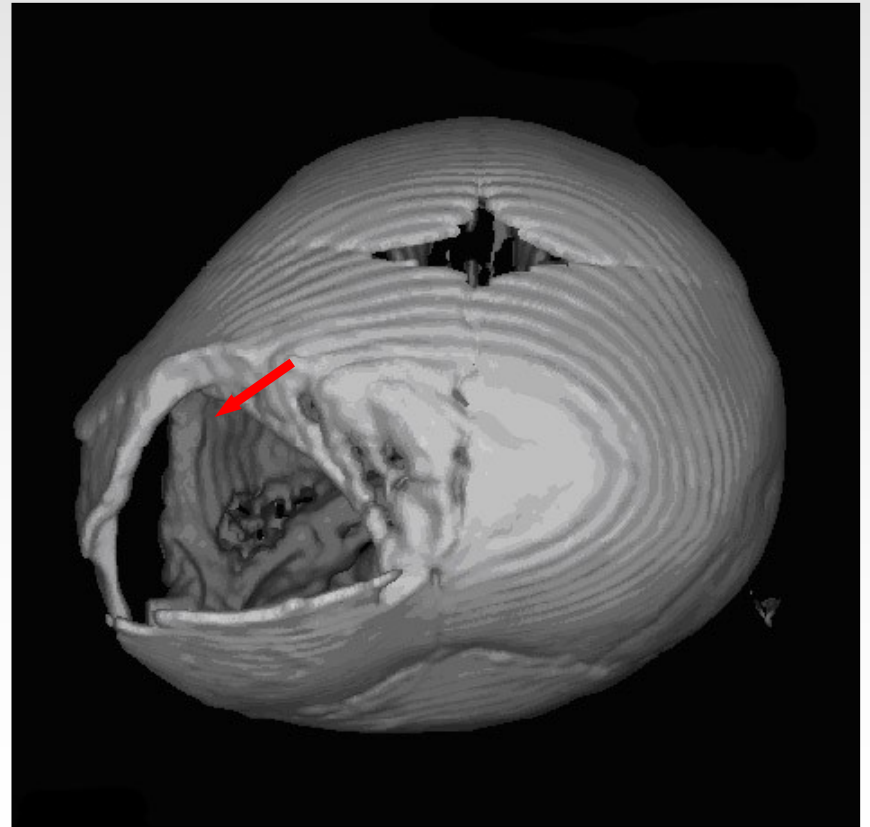
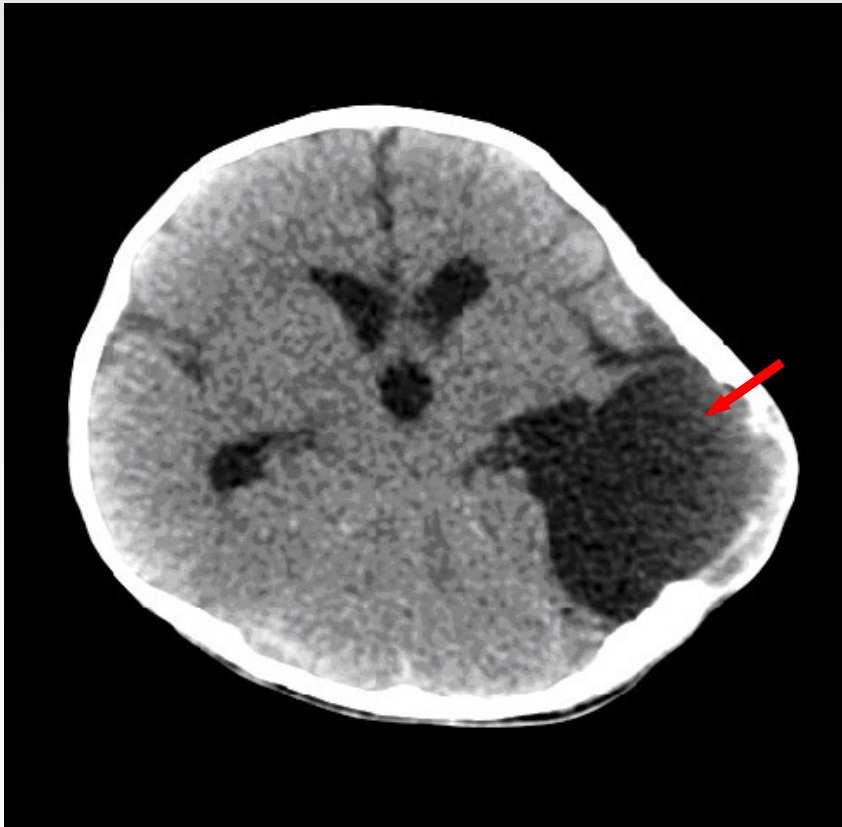
- occurs rarely (less than 1%), predominantly in the parietal localization
- rupture of the dura mater leads to leptomeningeal cyst
- filled with cerebrospinal fluid
- progressive dilatation of the fissure edges



**Specifics of the CCI in children
under 2 years of age**

Skull fractures

Growing fracture in CT and 3D CT



**Specifics of the CCI in children
under 2 years of age**

Skull fractures

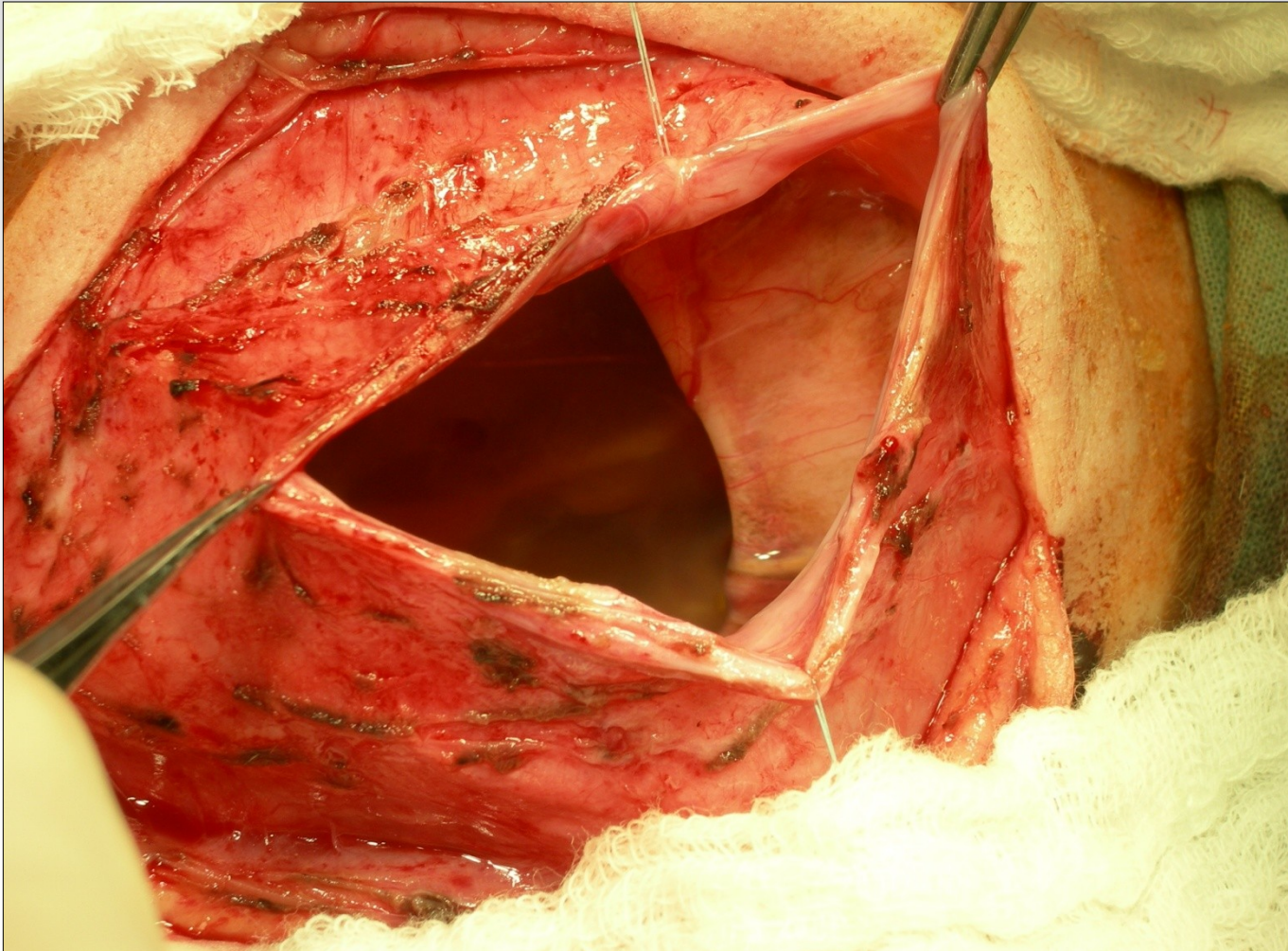
Growing fracture surgery treatment



**Specifics of the CCI in children
under 2 years of age**

Skull fractures

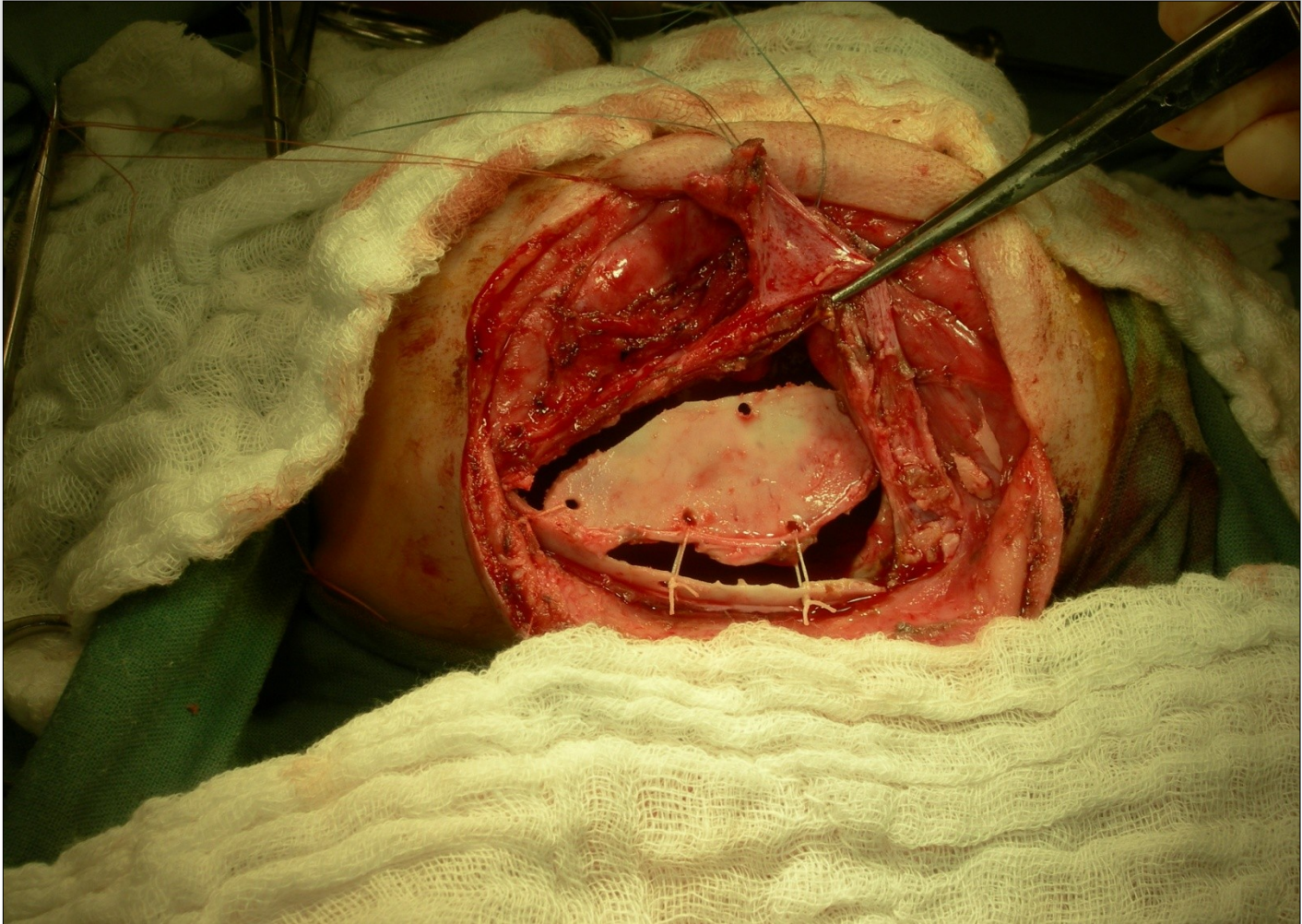
Growing fracture surgery treatment



**Specifics of the CCI in children
under 2 years of age**

Skull fractures

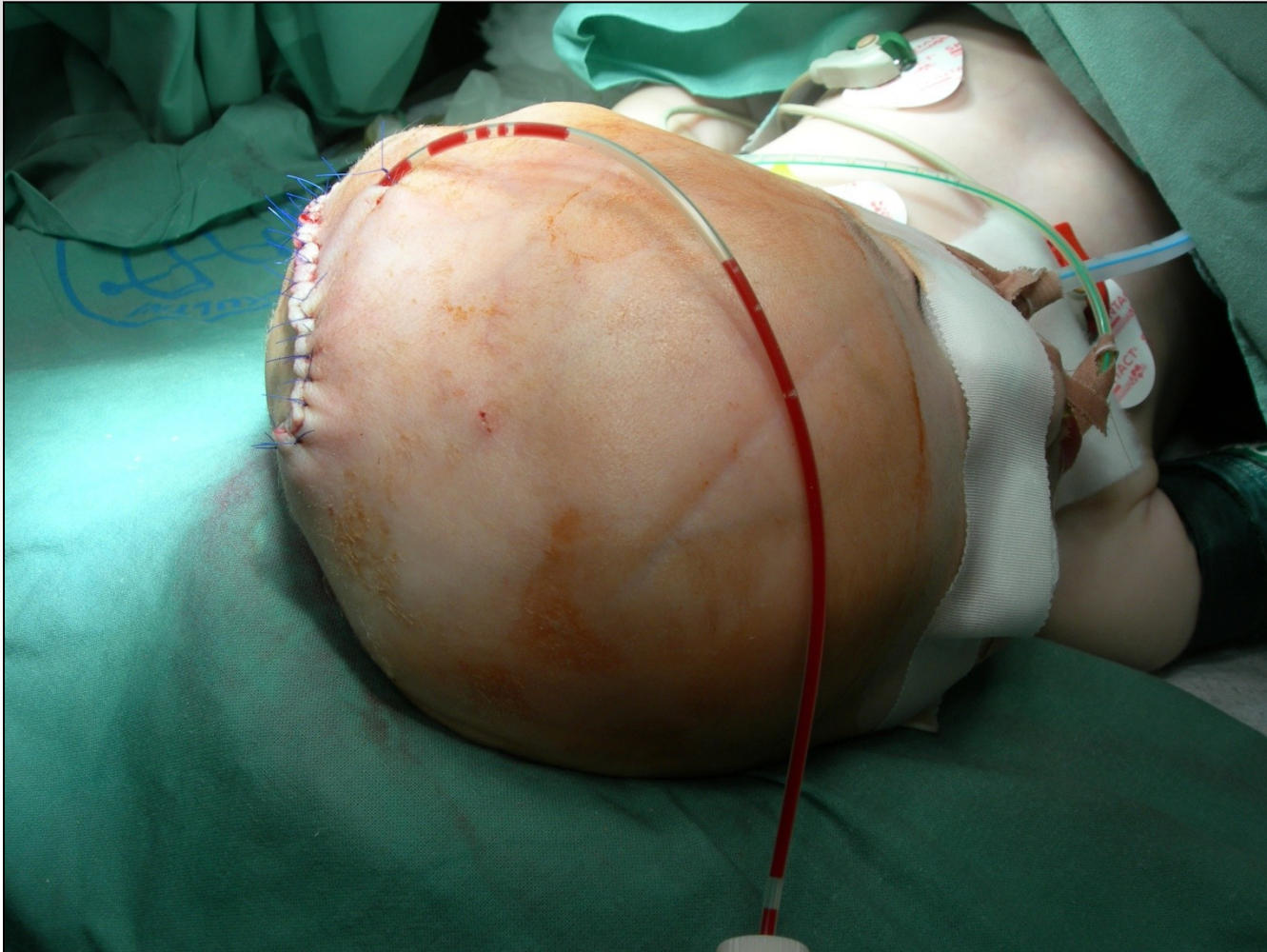
Growing fracture surgery treatment



**Specifics of the CCI in children
under 2 years of age**

Skull fractures

Growing fracture surgery treatment



**Specifics of the CCI in children
under 2 years of age**

Skull fractures

Impressive fracture

Ping-pong fracture

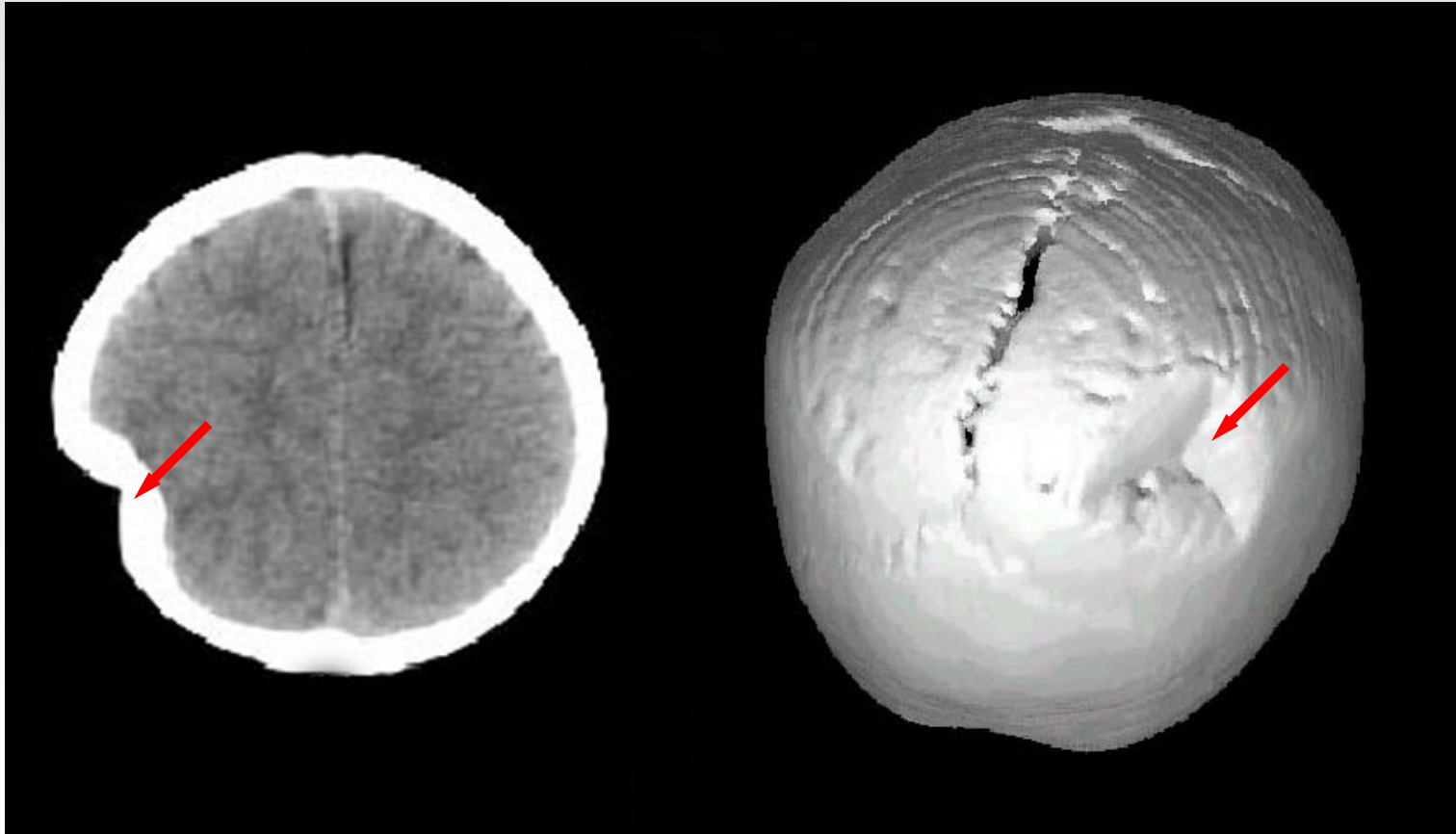
Causes: birth trauma or fall on the edge of the object



**Specifics of the CCI in children
under 2 years of age**

Skull fractures

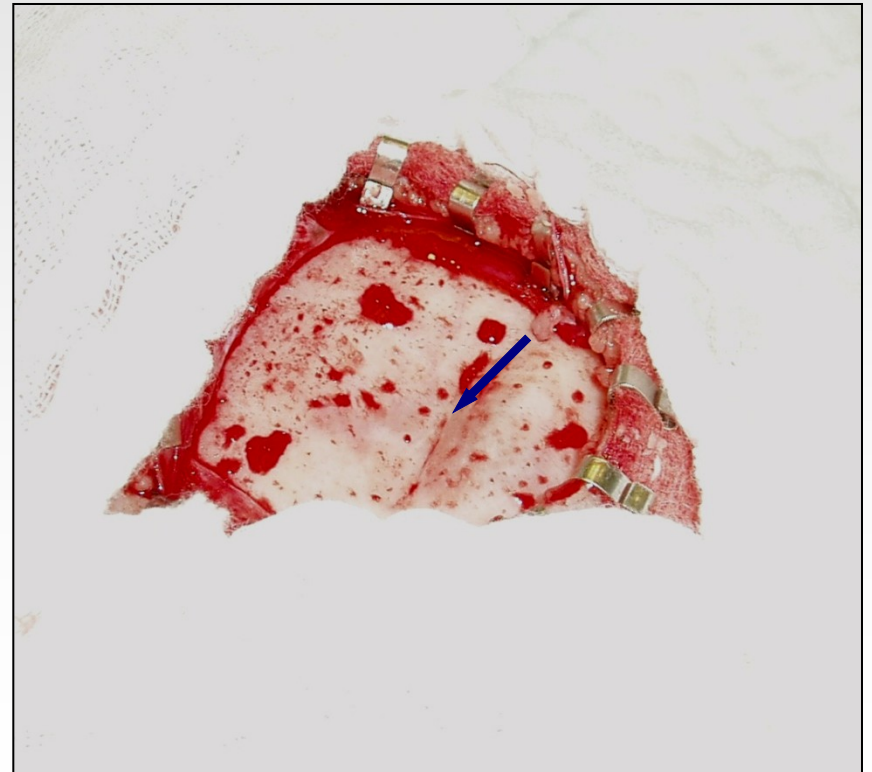
Ping-pong fracture in CT and CT 3D



**Specifics of the CCI in children
under 2 years of age**

Skull fractures

Ping-pong fracture – before and during surgery



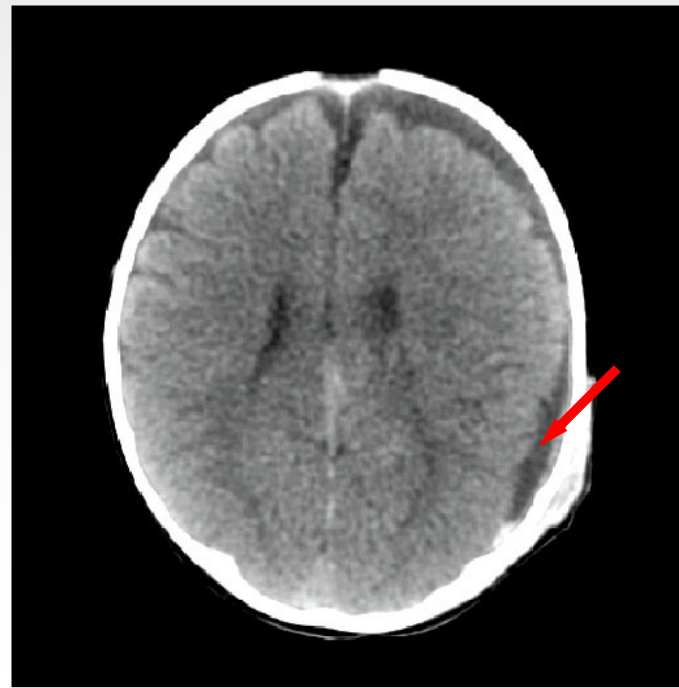
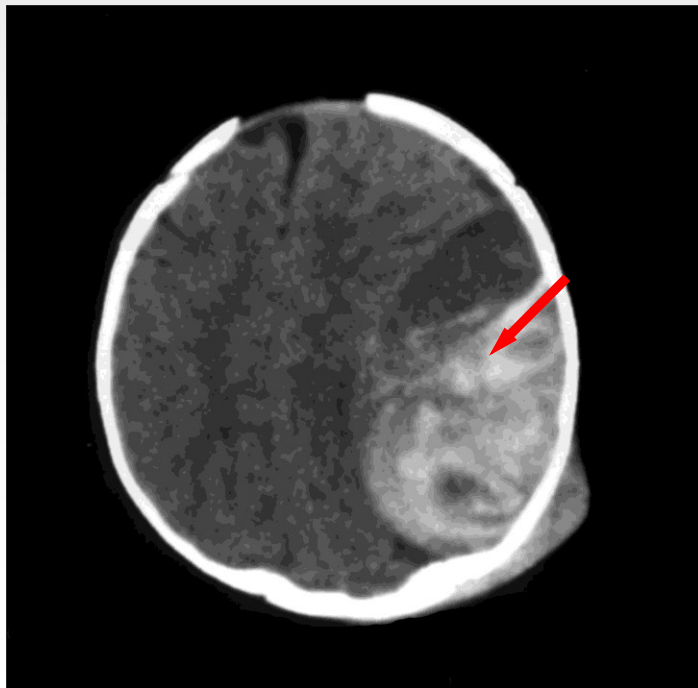
**Specifics of the CCI in children
under 2 years of age**

Epidural haematoma

Bleeding into epidural space (between the cranial bones and dura mater)

Skull X-ray finding of skull fracture represents an increased risk of epidural hematoma
absence of fracture does not preclude the development of epidural hematoma!

In newborns and infants with non-ossified skull sutures increased intracranial volume symptoms
appear much more later!

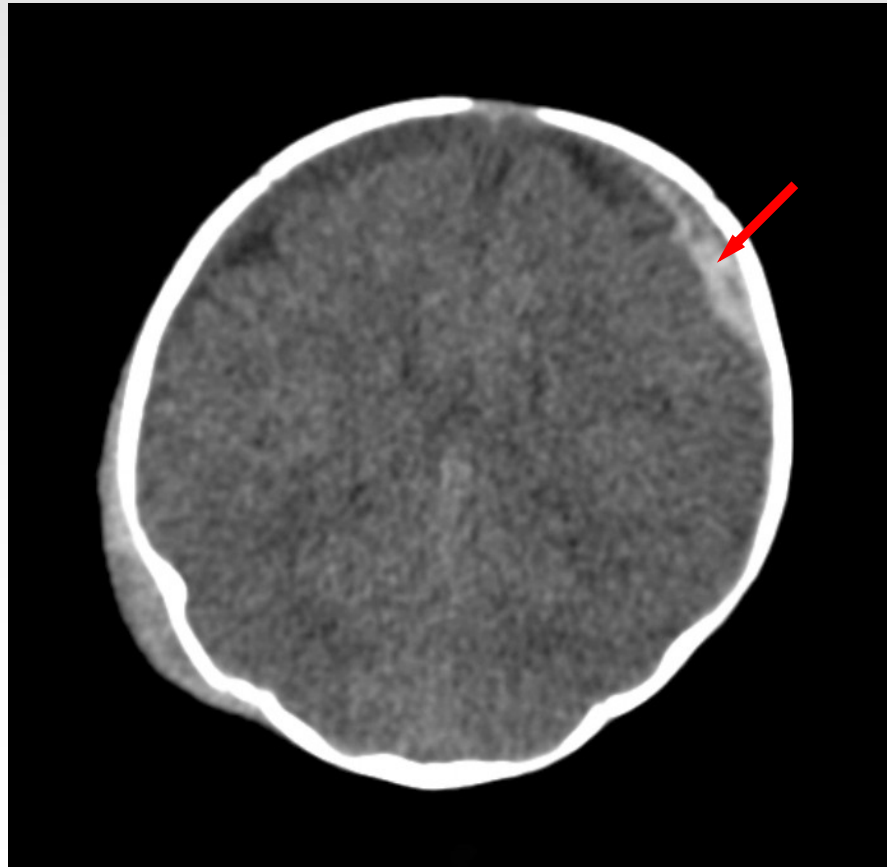


**Specifics of the CCI in children
under 2 years of age**

Subdural haematoma

Bleeding into subdural space (between hard and soft mater)

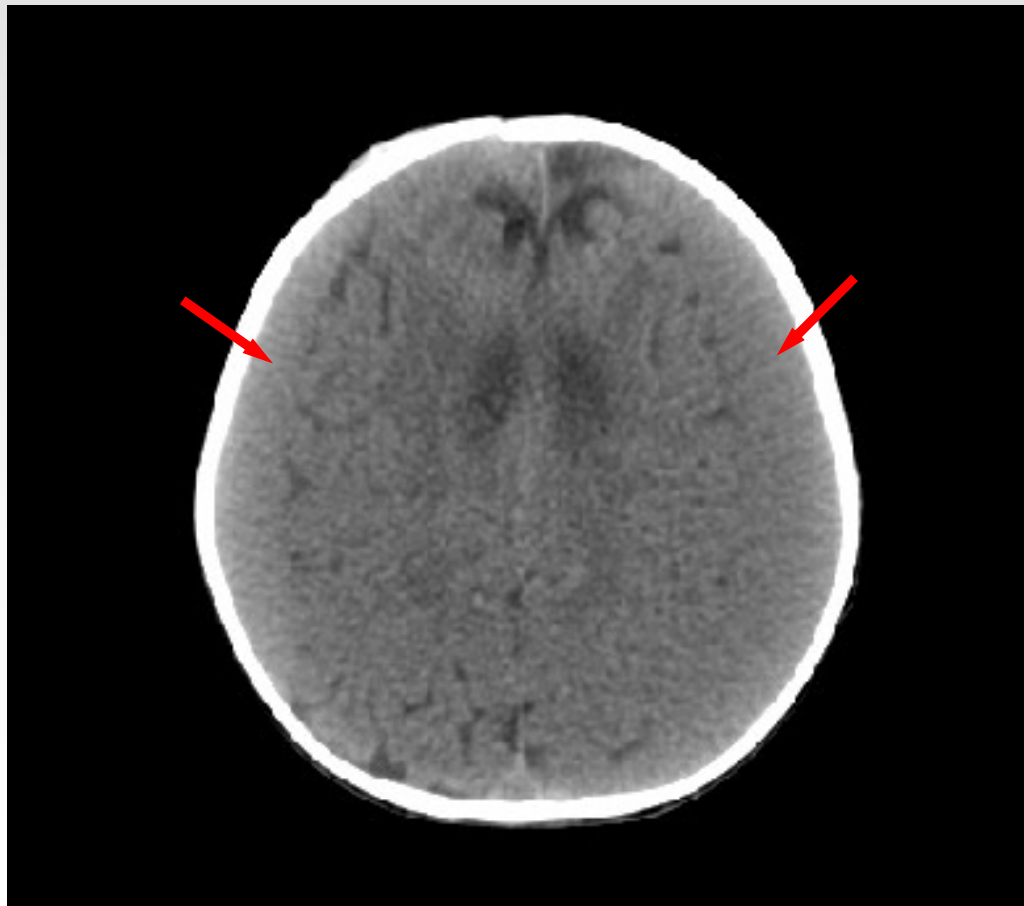
Acute subdural hematoma



**Specifics of the CCI in children
under 2 years of age**

Subdural haematoma

Isodense subdural haematoma



**Specifics of the CCI in children
under 2 years of age**

Extraaxial collection

Collection of blood or cerebrospinal fluid in the subdural or subarachnoidal space
(differentiation is difficult)

Includes concepts of **chronic subdural hematoma**, **hygroma** or **effusion**

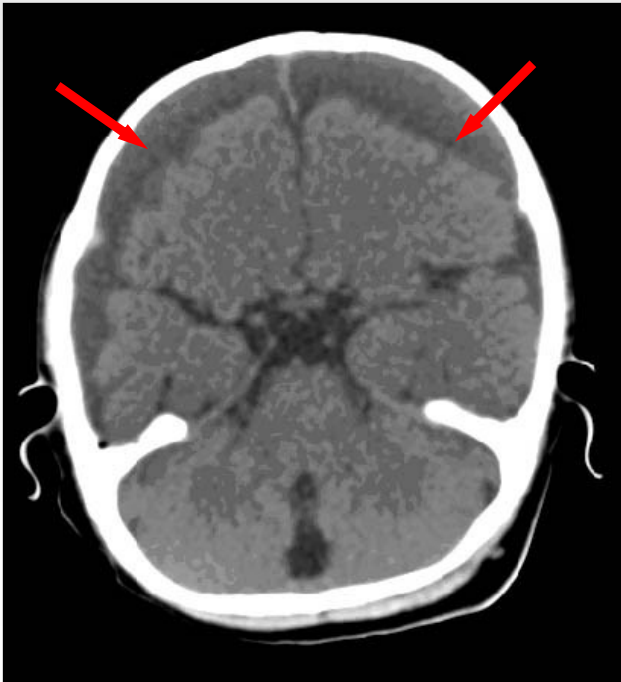
Benign extraaxial collection - mostly bifrontal
- mostly spontaneous regression



**Specifics of the CCI in children
under 2 years of age**

Extraaxial collection

Symptomatic extraaxial collection - intracranial hypertension syndrome



Specifics of the CCI in children under 2 years of age

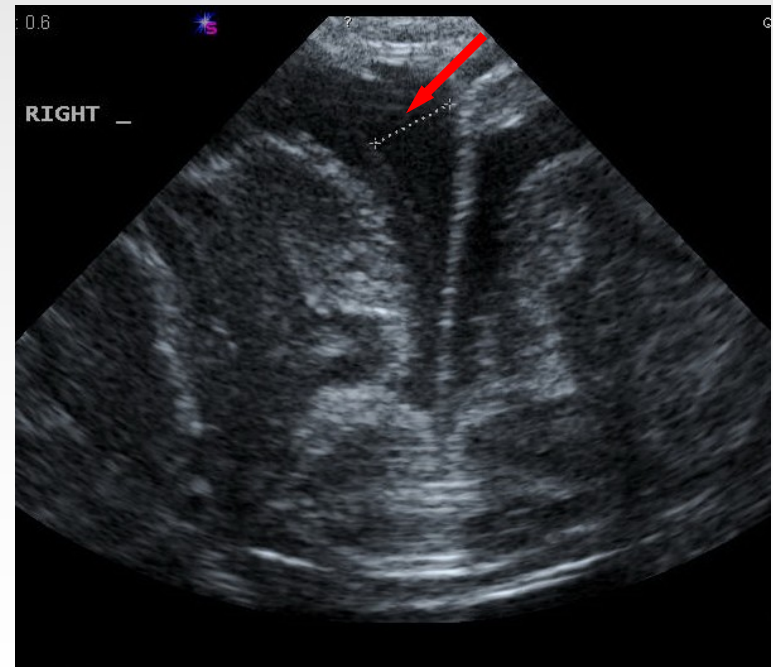
Extraaxial collection

Treatment of symptomatic extraaxial collections

- Puncture over a large fontanel
- Trepanation and evacuation
- Temporary external drainage
- Subduro-peritoneal shunt



Puncture over a large fontanel



Control ultrasound

**Specifics of the CCI in children
under 2 years of age**

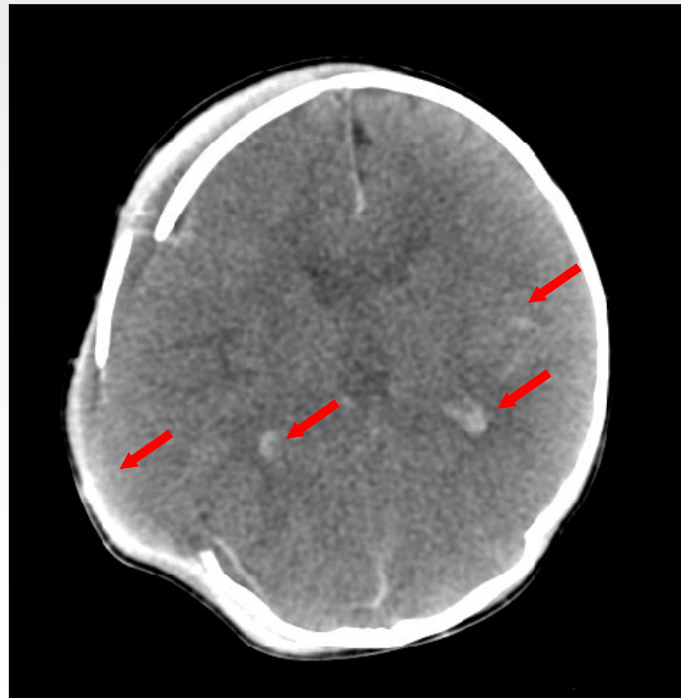
**Abused child syndrome
(Battered child)**

Serious social and legal problem

The discrepancy between the anamnestic data and severe clinical findings

Multiple fractures, retinal haemorrhage, subcutaneous aematoma, intracranial haemorrhage
of various ages

Deep structures minor haemorrhage or interhemispheric subdural hematoma
(„Shaken baby“)



Craniocerebral trauma in children older than 2 years

Skull fully ossified, the lesions are more similar to adults

Simple skull fractures without any other traumatic intracranial lesions occur less often than in children under 2 years of age

The most frequent cause of hospitalization is cerebral concussion

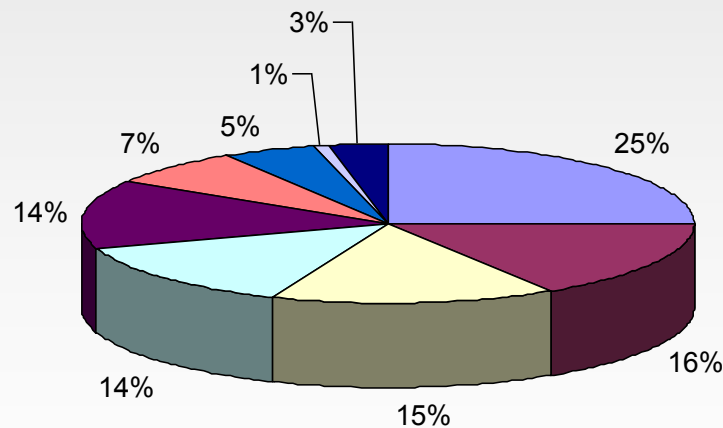
Different aetiology of injuries, increasing number of traffic and sports accidents



Craniocerebral trauma in children older than 2 years

Struck by vehicle
Fall in motion
Car accident
Falling
Fall from height
Impact of object
Impact against hard obstacles
Child abuse
Other

Traffic accidents 56% !



Patients hospitalized with severe CCI
in the Faculty Hospital Brno

- Sražení dopravním prostředkem
- Pád za jízdy
- Autonehody
- Upadnutí
- Pád z výšky
- Úder předmětem
- Náraz do pevné překážky
- Týrané dítě
- Jiné

Craniocerebral trauma in children older than 2 years

Cerebral concussion

Functional, fully reversible impairment of brain function without detectable morphological changes

The most common type of craniocerebral injury in children older than 2 years

Short-term unconsciousness, amnesia for trauma

Nausea, vomiting

Headache

Treatment: 2-day observation in the hospital, bedrest

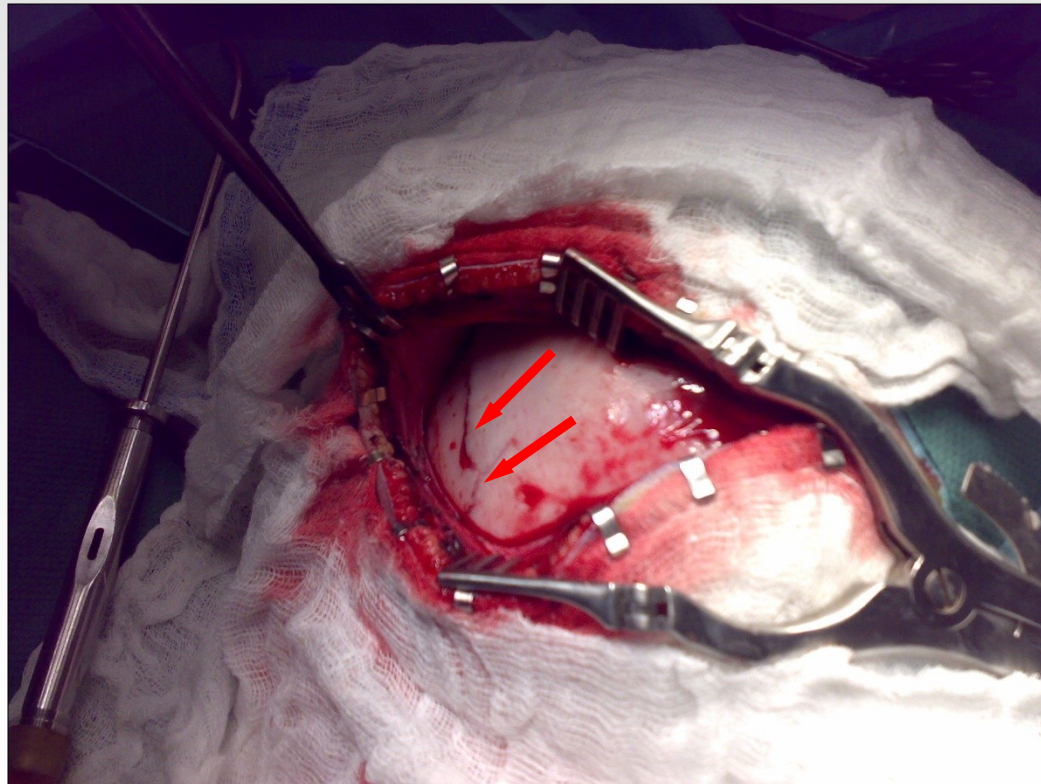
Regimen serves as a prevention of further difficulties (post-concussion syndrome)
(Autonomic dysfunction, fatigue, impaired concentration, sleep disturbances and headaches)

Craniocerebral trauma in children older than 2 years

Skull fractures

Linear fractures

Usually associated with intracranial injury

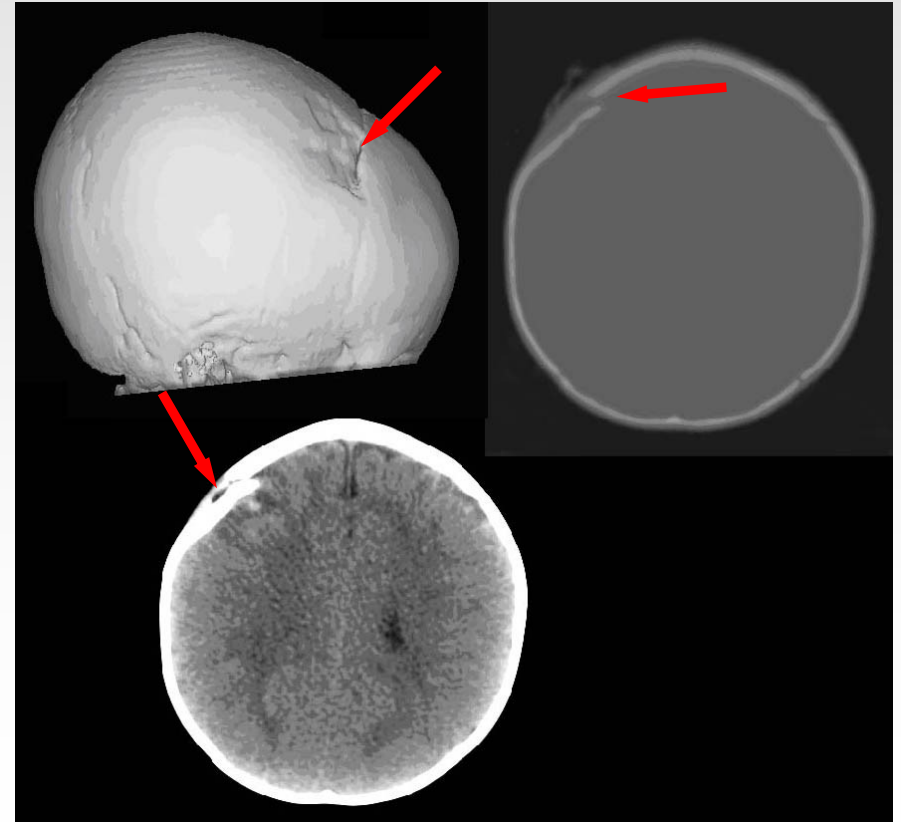
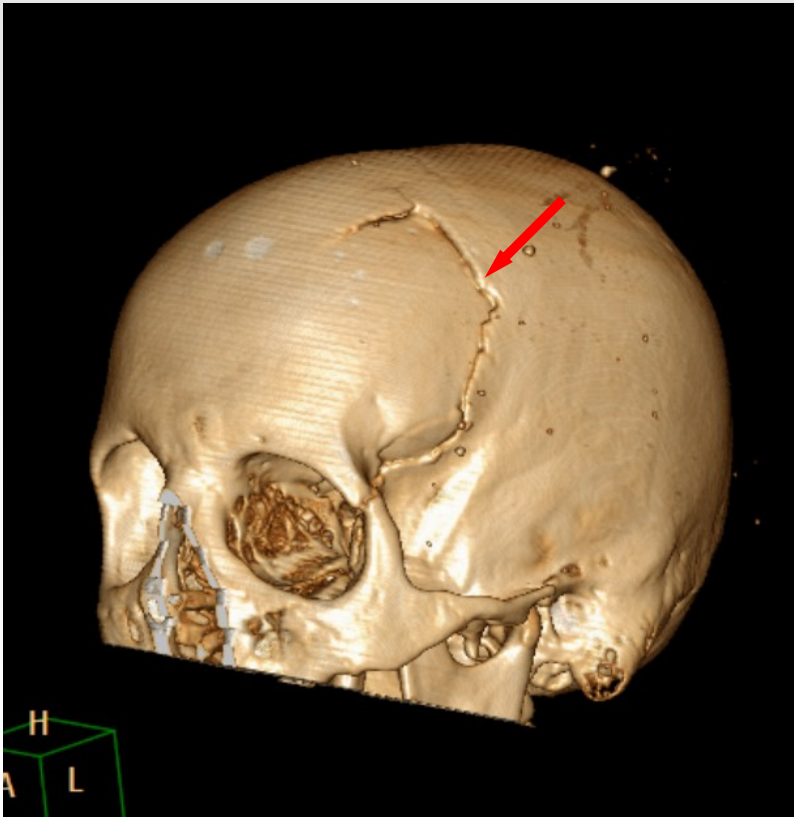


Craniocerebral trauma in children older than 2 years

Skull fractures

Simple impressive fractures

Surgical treatment for inverted over the thickness of the cranial bones



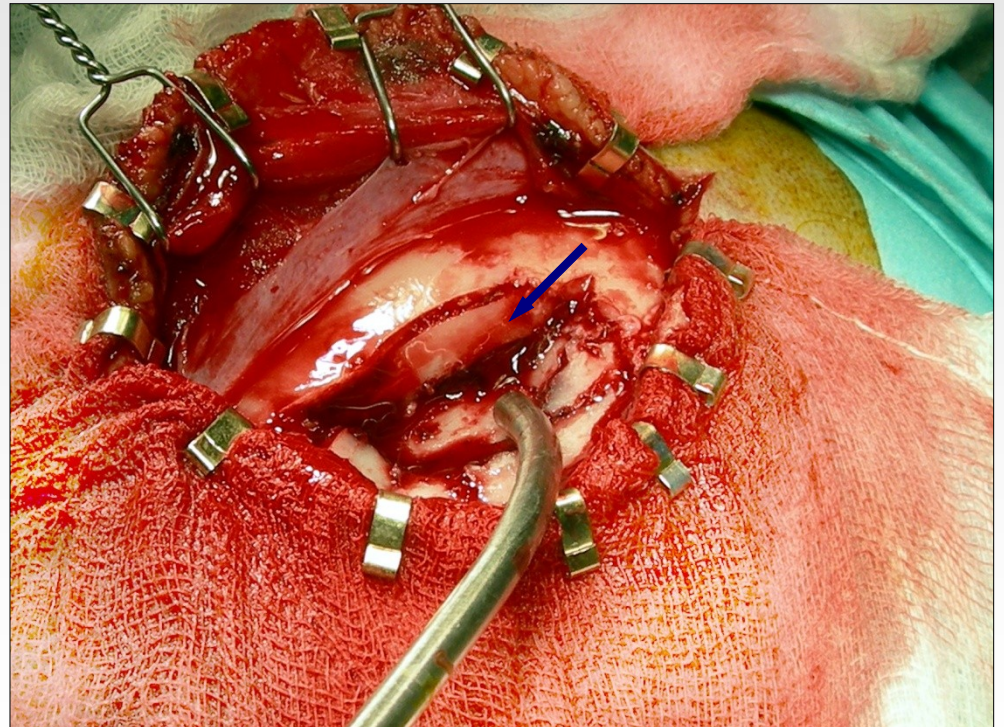
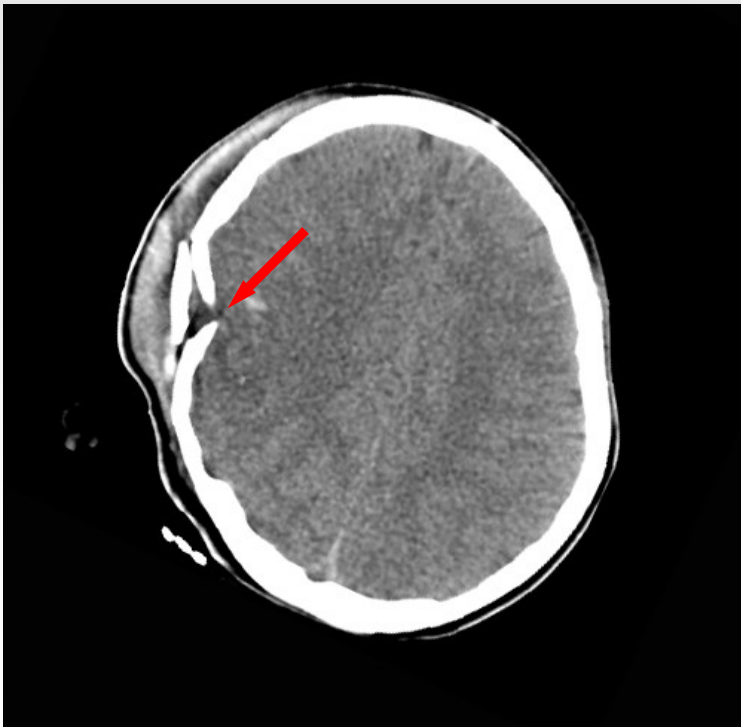
Craniocerebral trauma in children older than 2 years

Skull fractures

Comminuted impressive fracture

Fracture - open
- closed

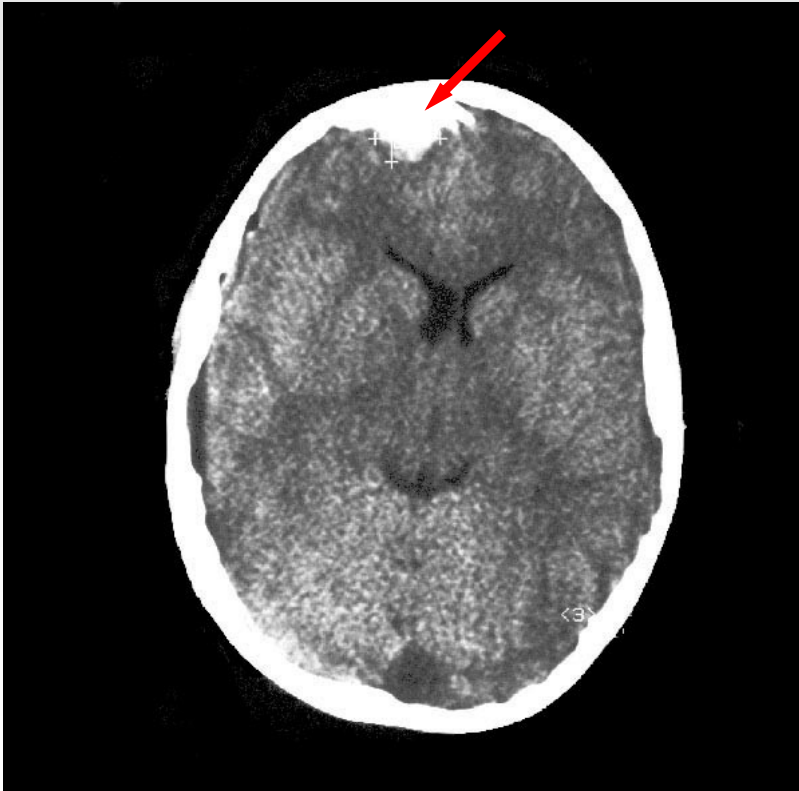
Fracture - penetrated
- non-penetrated



Craniocerebral trauma in children older than 2 years

Skull fractures

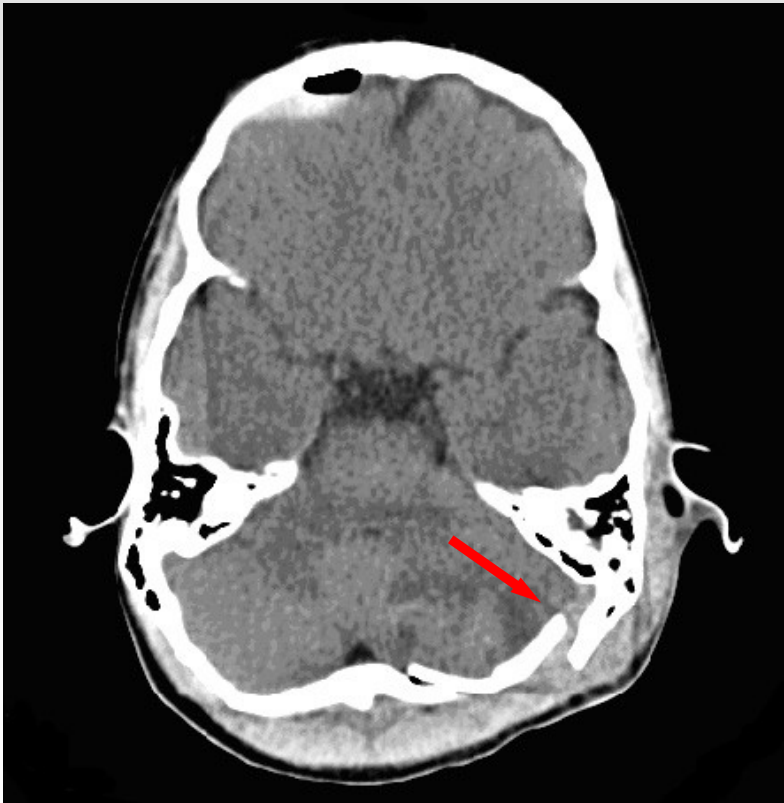
Impressive fracture in the venous sinuses



Craniocerebral trauma in children older than 2 years

Skull fractures

Impressive fracture in the posterior cranial fossa



Craniocerebral trauma in children older than 2 years

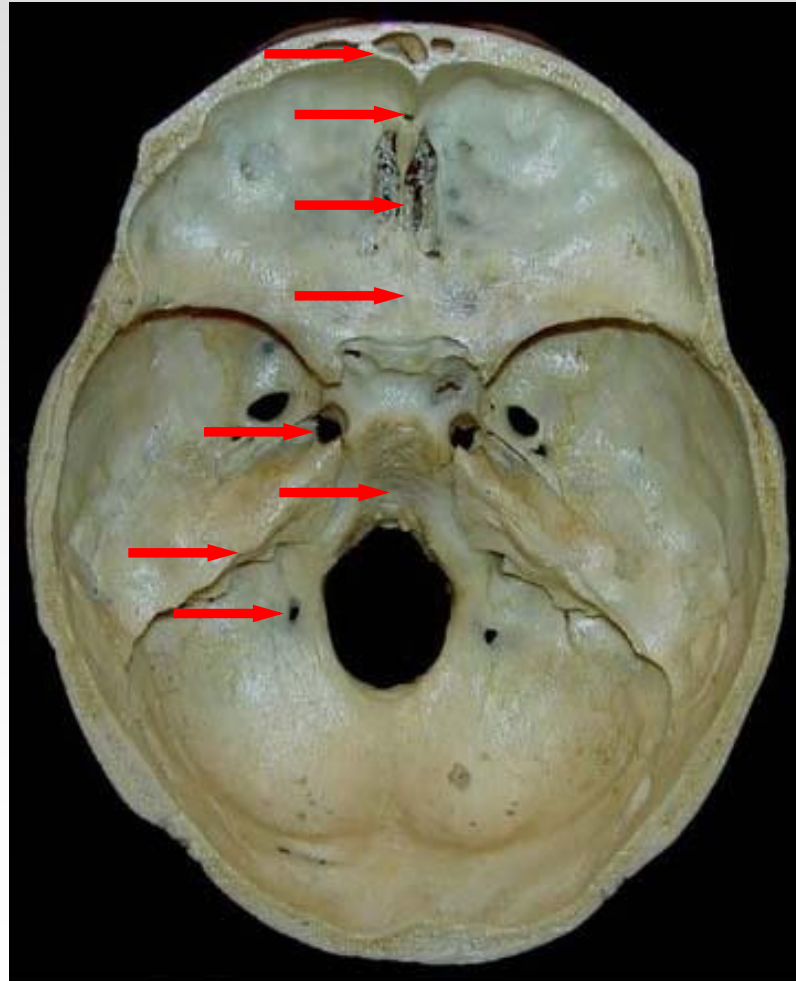
Skull fractures

Fractures of the Skull Base

anterior fossa

middle fossa

posterior fossa

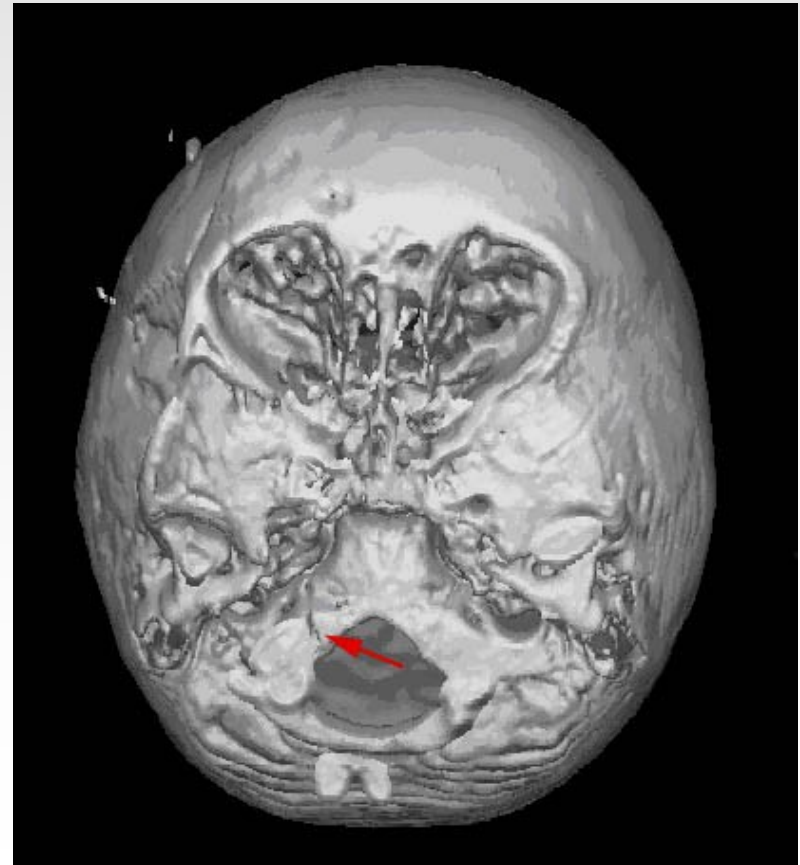
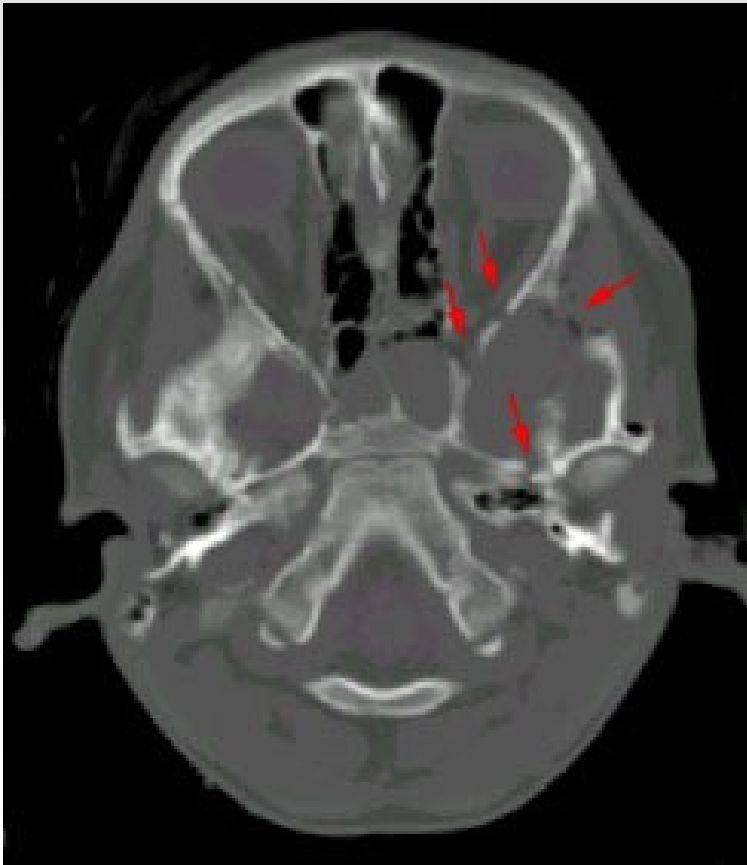


Craniocerebral trauma in children older than 2 years

Skull fractures

Fractures of the Skull Base

Fractures of the anterior, middle and posterior cranial fossa in CT and 3D CT



Craniocerebral trauma in children older than 2 years

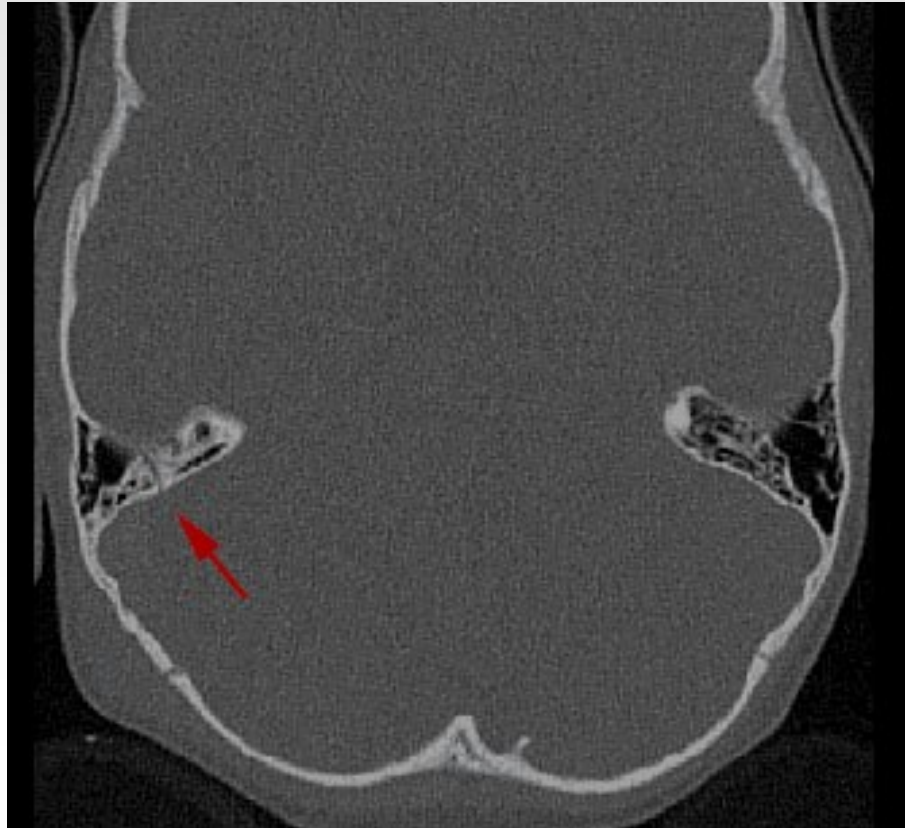
Skull fractures

Fractures of the Skull Base

Transverse fracture of the pyramid can cause othorea

More frequent type of liquorrhoea in children than in adults

Nearly 100% resolve spontaneously



Craniocerebral trauma in children older than 2 years

Skull fractures

Fractures of the Skull Base

Liquorrhoea

Abnormal communication between the subarachnoid space and the nasal cavity or tympanomastoideal space

Defect of the normal barrier between the CNS and the external environment, threatening infections of the CNS

By location:

- Rhinorrhoea
- Otoreea
- Paradoxical rhinorrhoea
- unilateral
- bilateral

Posttraumatic liquorrhoea in children is less frequent than in adults

- Greater flexibility of baby skull
- Smaller paranasal sinus pneumatization

Liquorrhoea in children usually heals spontaneously

Craniocerebral trauma in children older than 2 years

Epidural haematoma

The typical clinical course with loss of consciousness, lucid interval and the development of ipsilateral mydriasis and contralateral hemiparesis due to bleeding from a. meningica media in pediatric patients is rare.



Craniocerebral trauma in children older than 2 years

Epidural haematoma

The most common cause of epidural haematoma is bleeding from diploe blood vessels in cranial bone fracture.

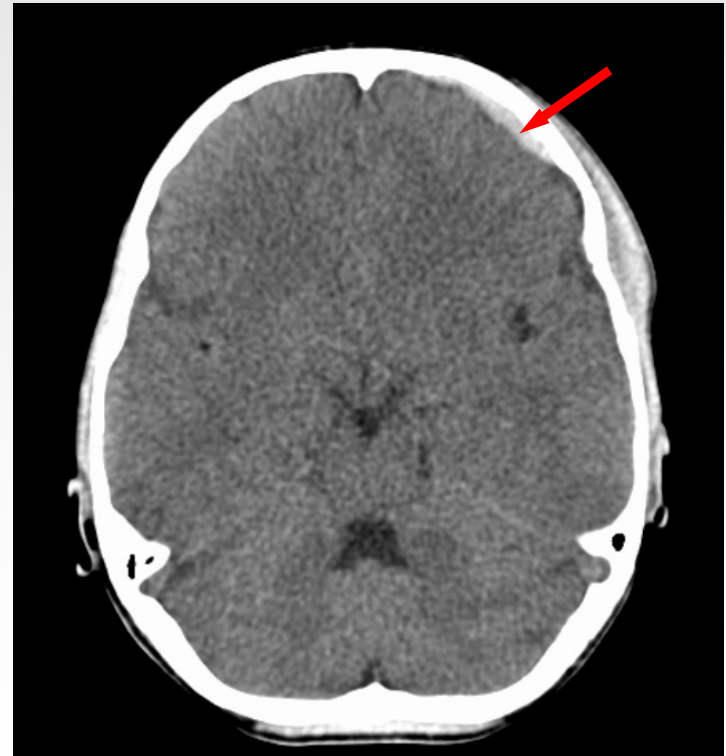


Craniocerebral trauma in children older than 2 years

Epidural haematoma

Frontopolar epidural haematoma

Frontopolar epidural haematoma develops slowly and spreads more equally than in adults because of less adherent dura mater



Craniocerebral trauma in children older than 2 years

Epidural haematoma

Infratentorial epidural haematoma

Posterior fossa epidural haematomas occur more frequently than in adults

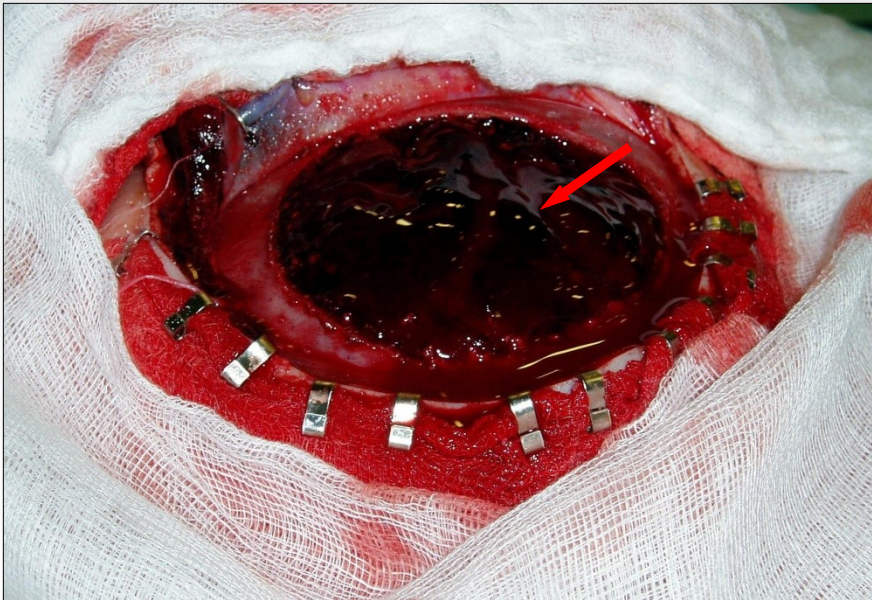
Symptoms: repeated vomiting, sudden deterioration of consciousness



Craniocerebral trauma in children older than 2 years

Epidural haematoma

Space occupying, expansive haematoma are treated by acute surgery



Craniocerebral trauma in children older than 2 years

Subdural haematoma

Acute subdural haematoma

A common cause is bleeding from bridging veins



Craniocerebral trauma in children older than 2 years

Subdural haematoma

Chronic subdural haematoma

Occurs very rarely in children, there is a hematoma discoloration and subdural hygroma formation



Craniocerebral trauma in children older than 2 years

Subarachnoidal haemorrhage

Traumatic subarachnoidal bleeding mostly accompanies brain contusion
Typically occurs along the falx or tentorium

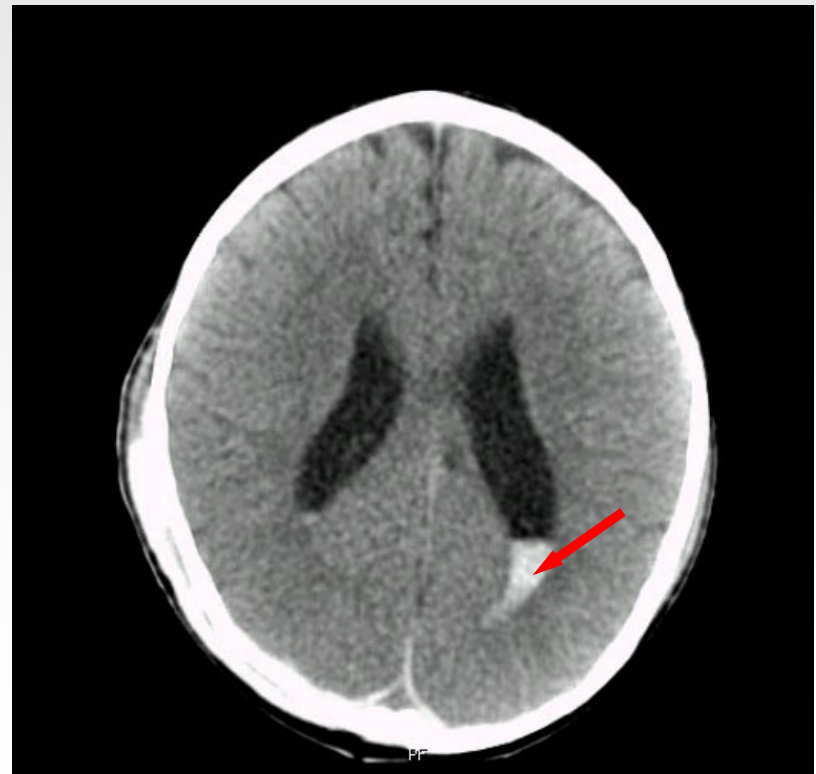


Craniocerebral trauma in children older than 2 years

Intraventricular haemorrhage

Intraventricular haemorrhage is caused by injuries of intraventricular veins or by the choroid plexus rupture

Threat of posthaemorrhagic hydrocephalus

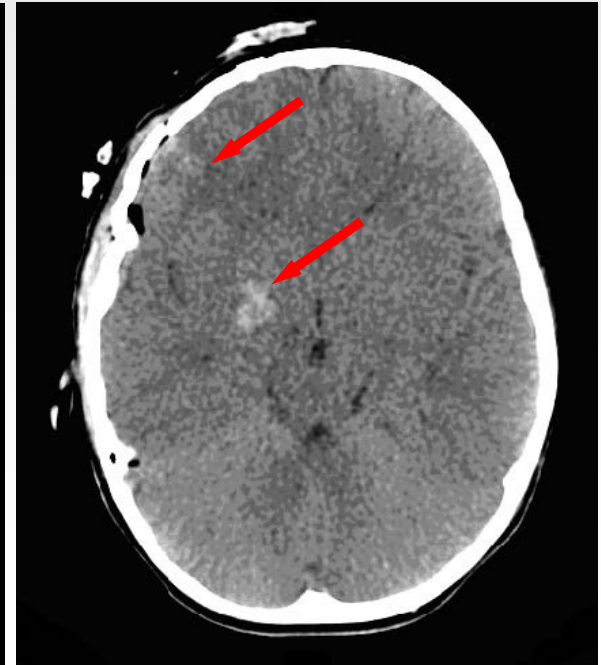
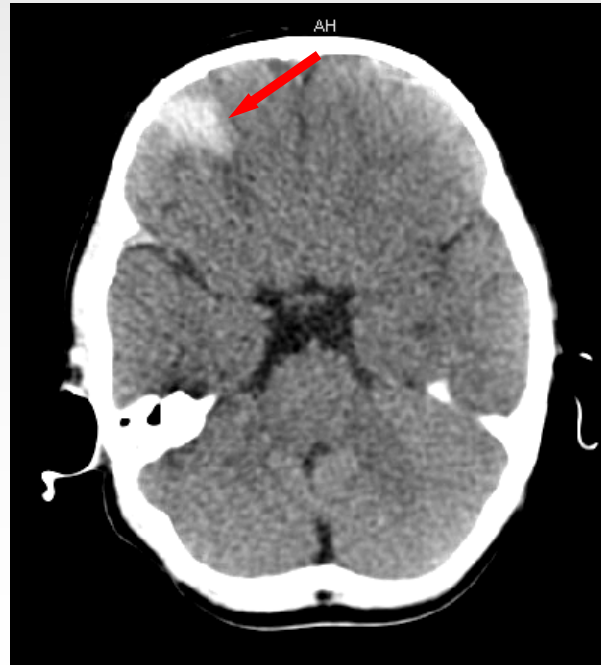


Craniocerebral trauma in children older than 2 years

Cerebral contusion

Focal bruising of brain tissue in place of direct impact or at the site opposite to impact (mechanism par contre coup)

Contusion in cortical, subcortical or deep brain structures

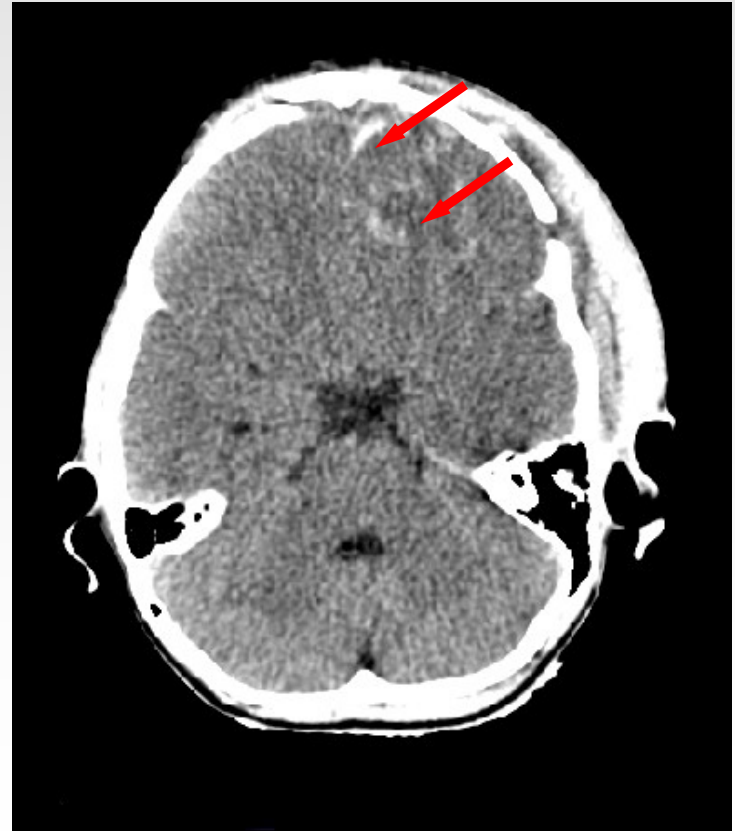
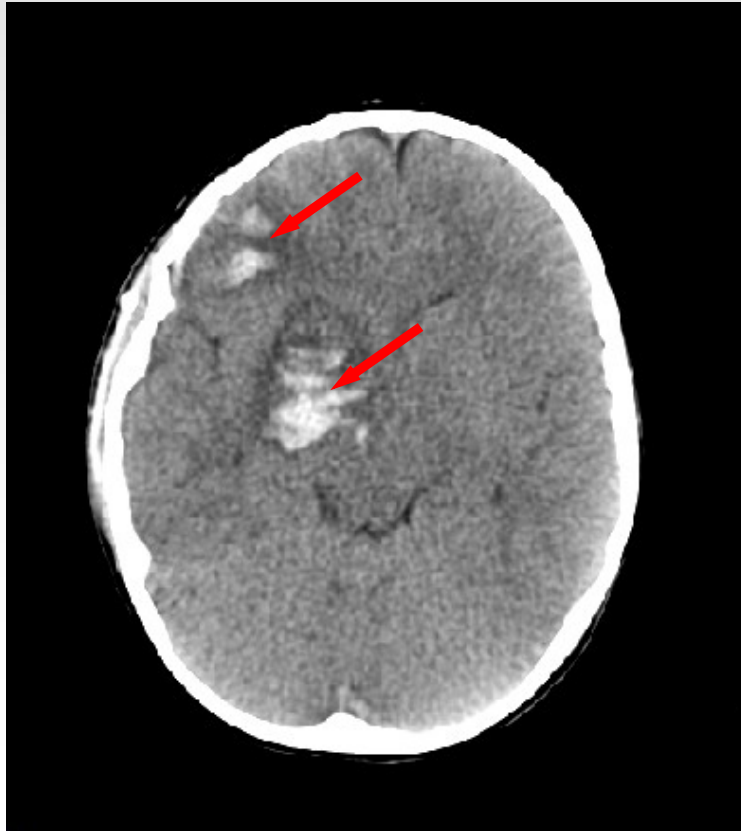


Craniocerebral trauma in children older than 2 years

Cerebral contusion

Treatment of brain contusion in children is predominantly conservative

Multiple cerebral contusion



Craniocerebral trauma in children older than 2 years

Haemorrhagic contusion

Bleeding to contusion causes traumatic intracerebral haematoma



Craniocerebral trauma in children older than 2 years

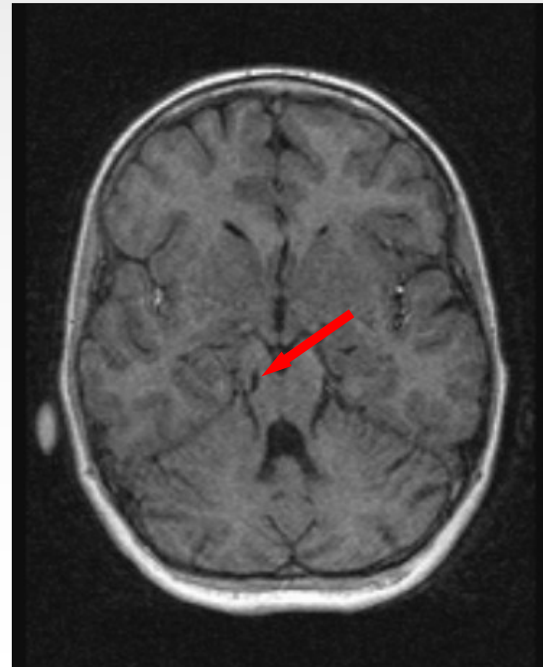
Diffuse axonal injury

Primary diffuse brain injury resulting from rotational, acceleration and deceleration mechanism

Microscopic level of axonal injury

The clinical picture is varied, the main symptom is coma of varying depth and duration

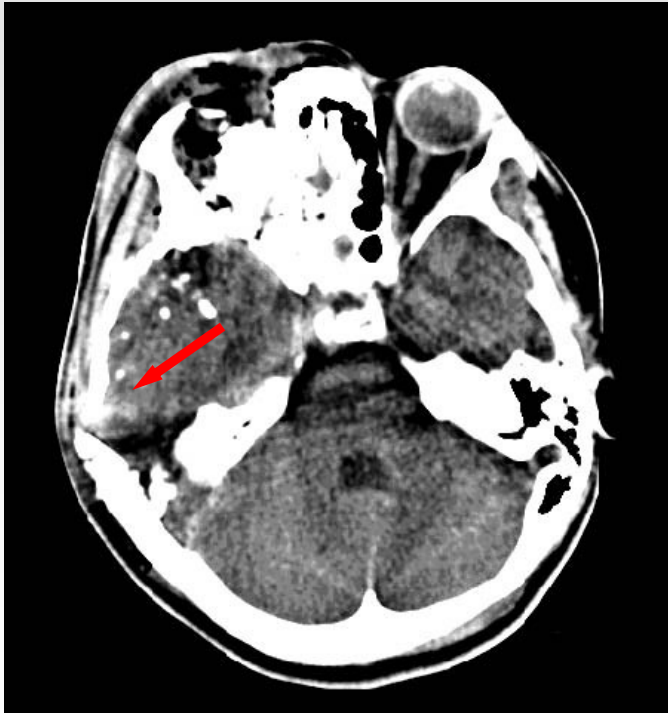
Delayed MRI shows a T1 hypointense lesions mostly in corpus callosum and mesencephalon



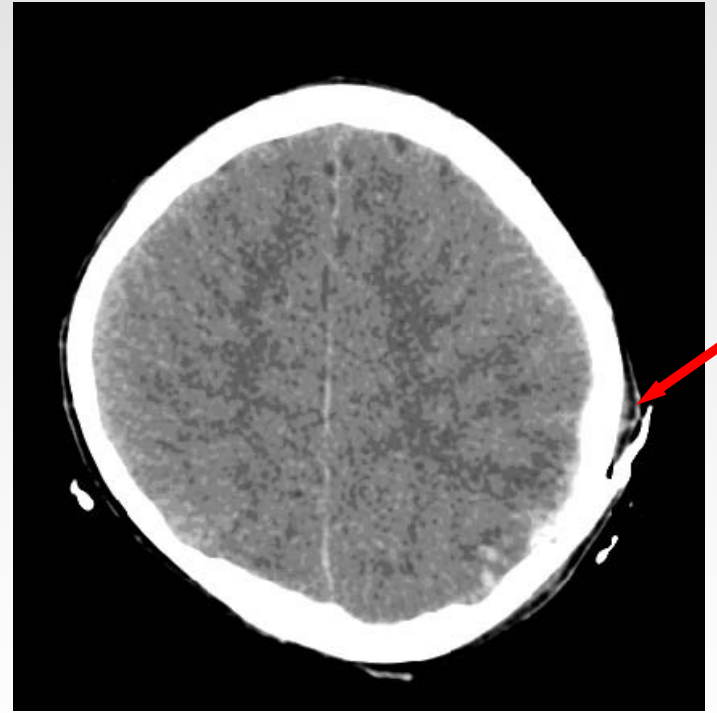
Craniocerebral trauma in children

Penetrating Brain Injury

Gunshot wounds



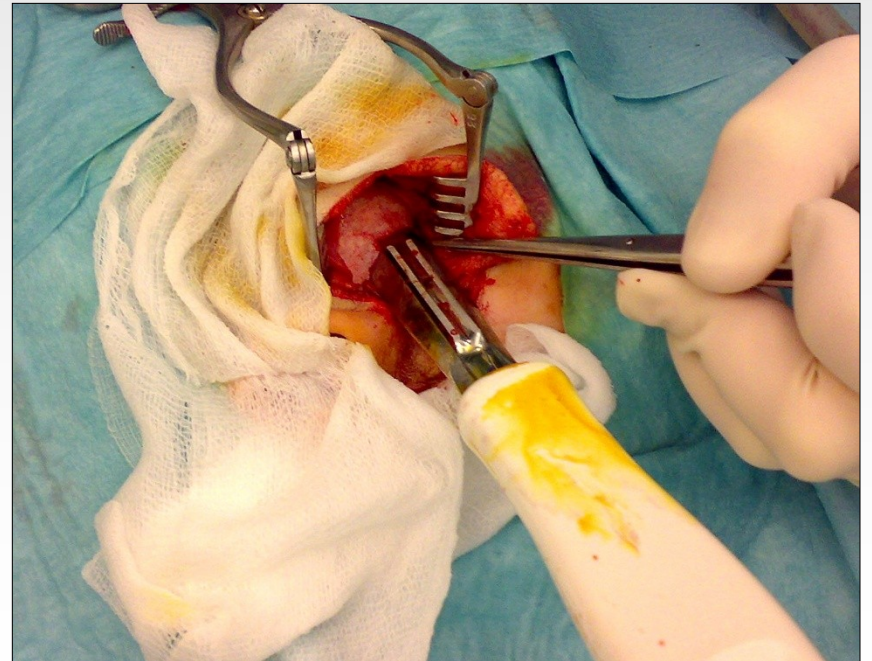
Cutting injury



Craniocerebral trauma in children

Penetrating Brain Injury

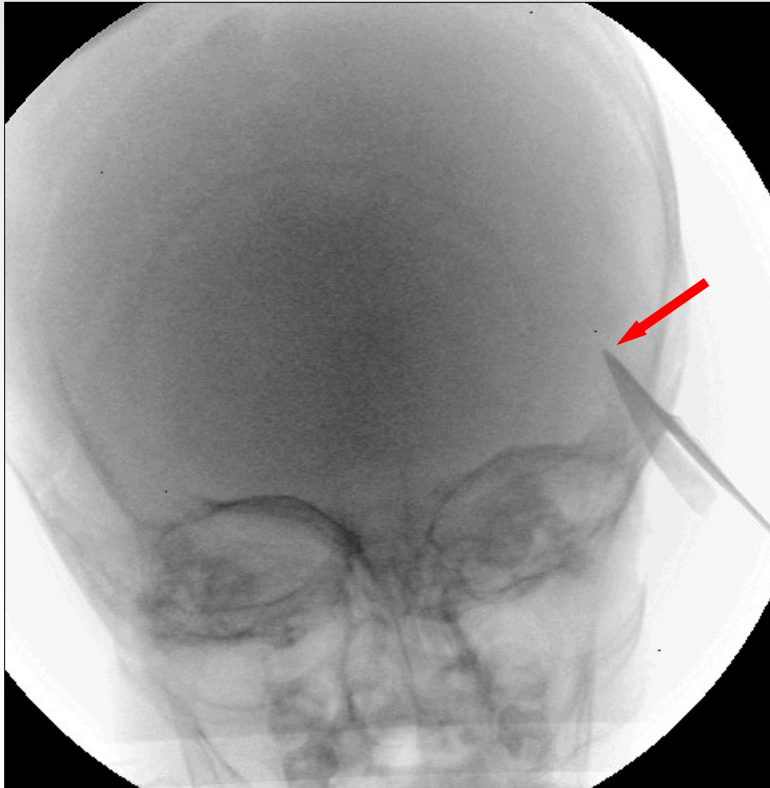
Stub injury



Craniocerebral trauma in children

Penetrating Brain Injury

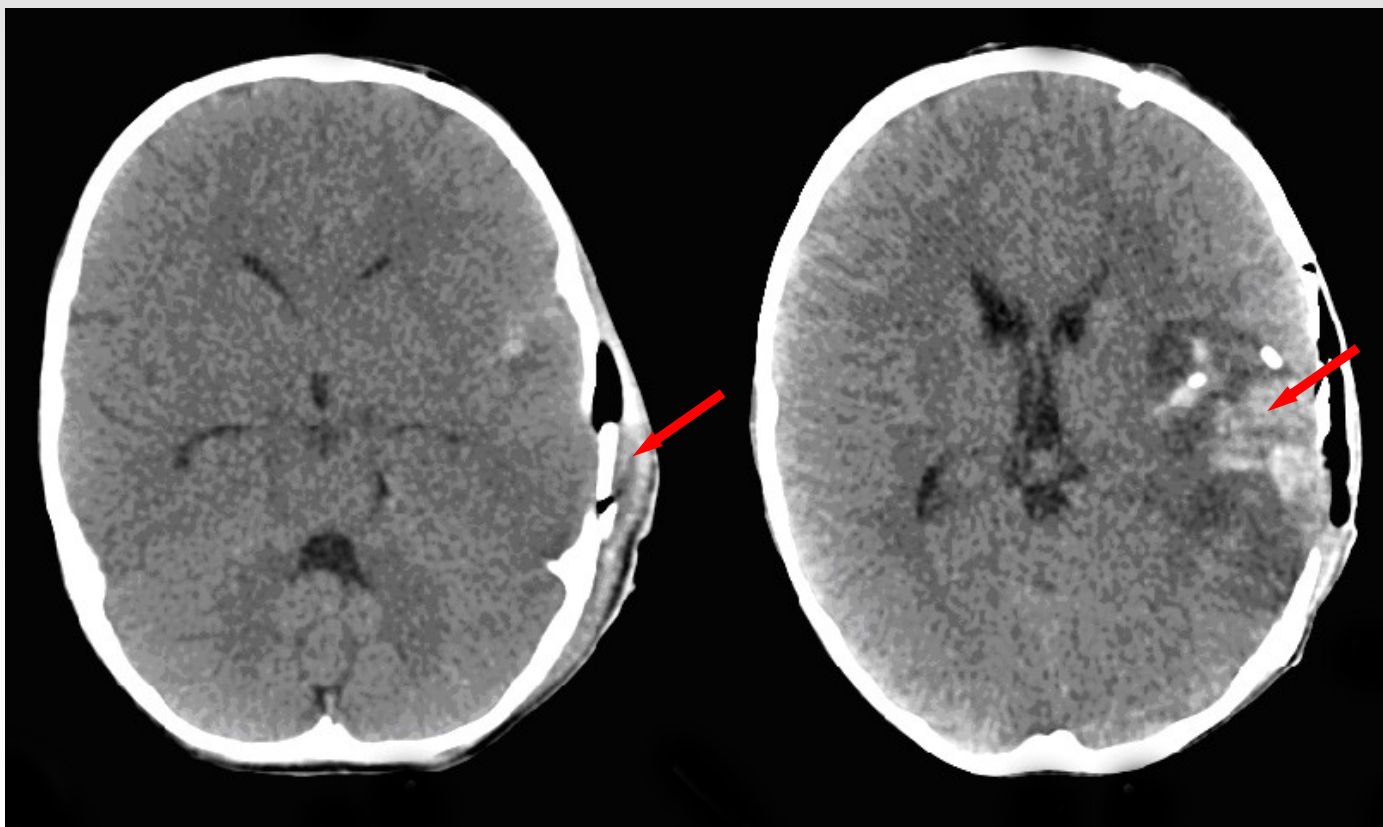
Stab injury - preoperative and postoperative X-ray and CT



Craniocerebral trauma in children

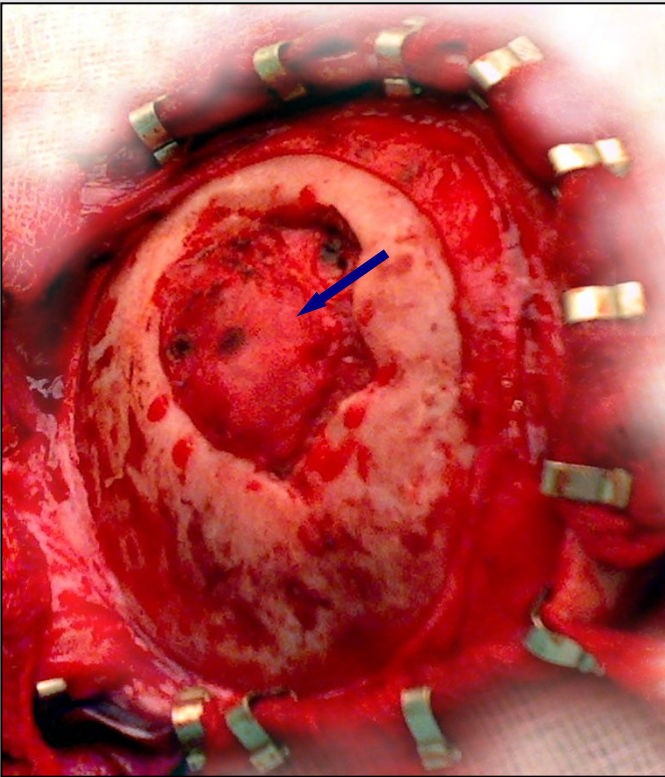
Penetrating Brain Injury

Dog bite



Posttraumatic skull defects in children

Result of extensive comminuted fractures, where primary cranioplasty is not possible

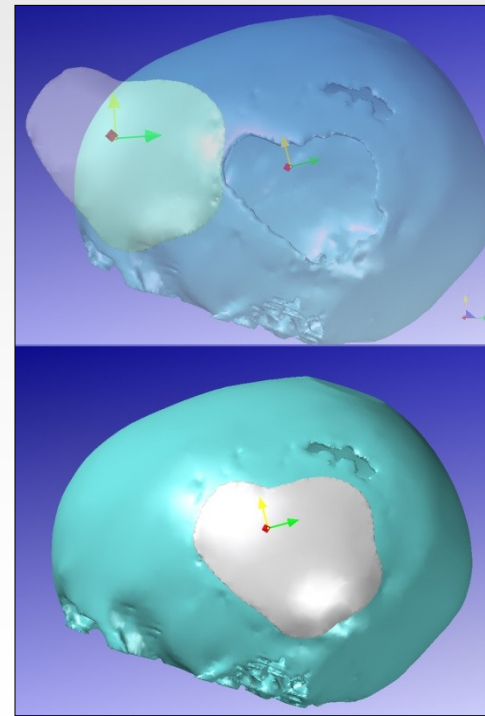
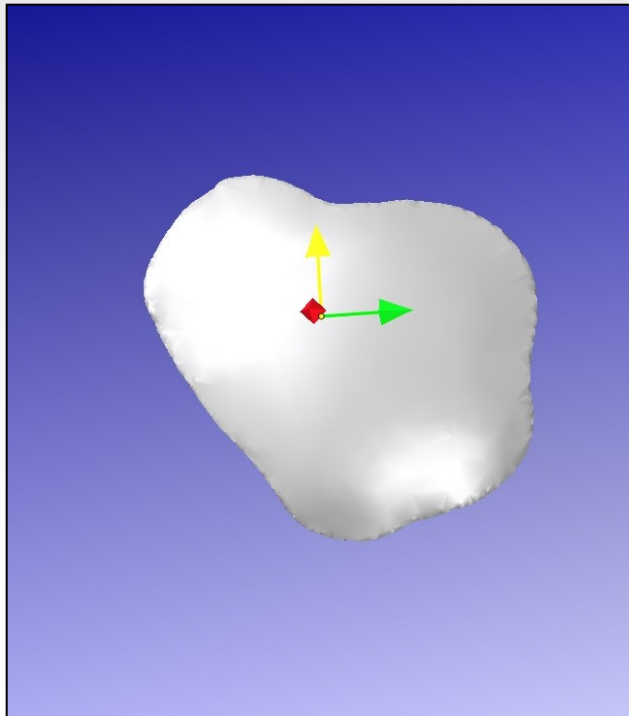


Posttraumatic skull defects in children

The specific topic of skull defects treatment in children with incomplete growth of the skull

Development of porous biomaterials, which allow host tissue ingrowth

Computer 3D processing, modeling and production of custom implants



**Thank you
for your attention**