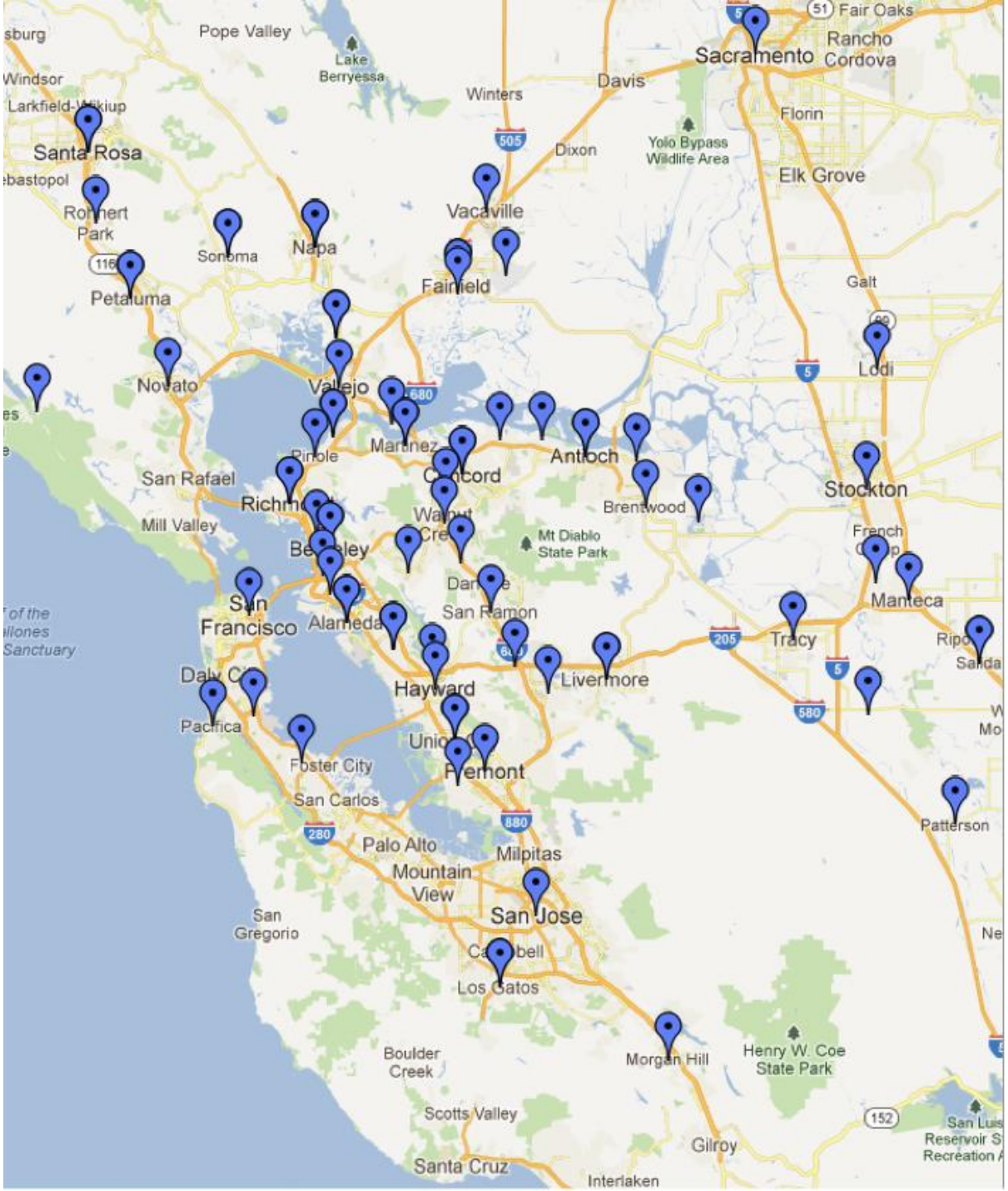
Pediatric Neurosurgical Disorders: from head to tail

Peter P. Sun, M.D.
Pediatric Neurosurgery


Oakland
TOP
DOCTORS


BABY
DIDI
BOY
It's a BOY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Windsor
Larkfield-Wikiup
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Rohnert Park
Sonoma
Napa
Petaluma
Novato
Vallejo
Winters
Davis
Dixon
Yolo Bypass Wildlife Area
Vacaville
Fairfield
Sacramento
Fair Oaks
Rancho Cordova
Florin
Elk Grove
Galt
Lodi
Stockton
Manteca
Tracy
Ripon
Patterson
Antioch
Brentwood
Concord
Martinez
Pinole
San Rafael
Mill Valley
Richmond
Berkeley
Walnut Creek
Mt Diablo State Park
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San Ramon
Alameda
San Francisco
Daly City
Pacifica
Foster City
San Carlos
Hayward
Livermore
Union City
Fremont
Palo Alto
Mountain View
Milpitas
San Jose
San Gregorio
Los Gatos
Morgan Hill
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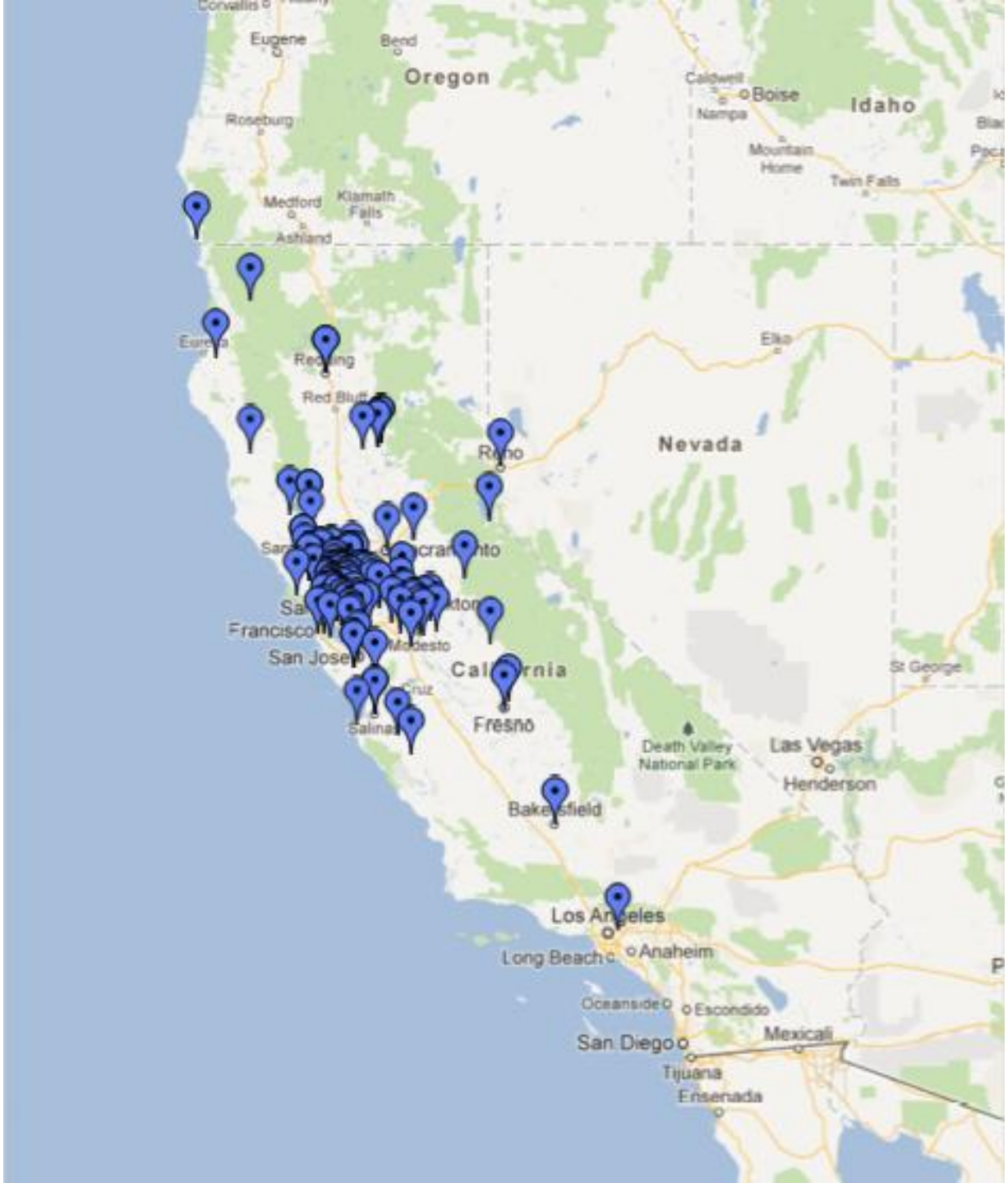
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Nevada
Reno
Modesto
San Jose
Fresno
Death Valley National Park
Las Vegas
Henderson
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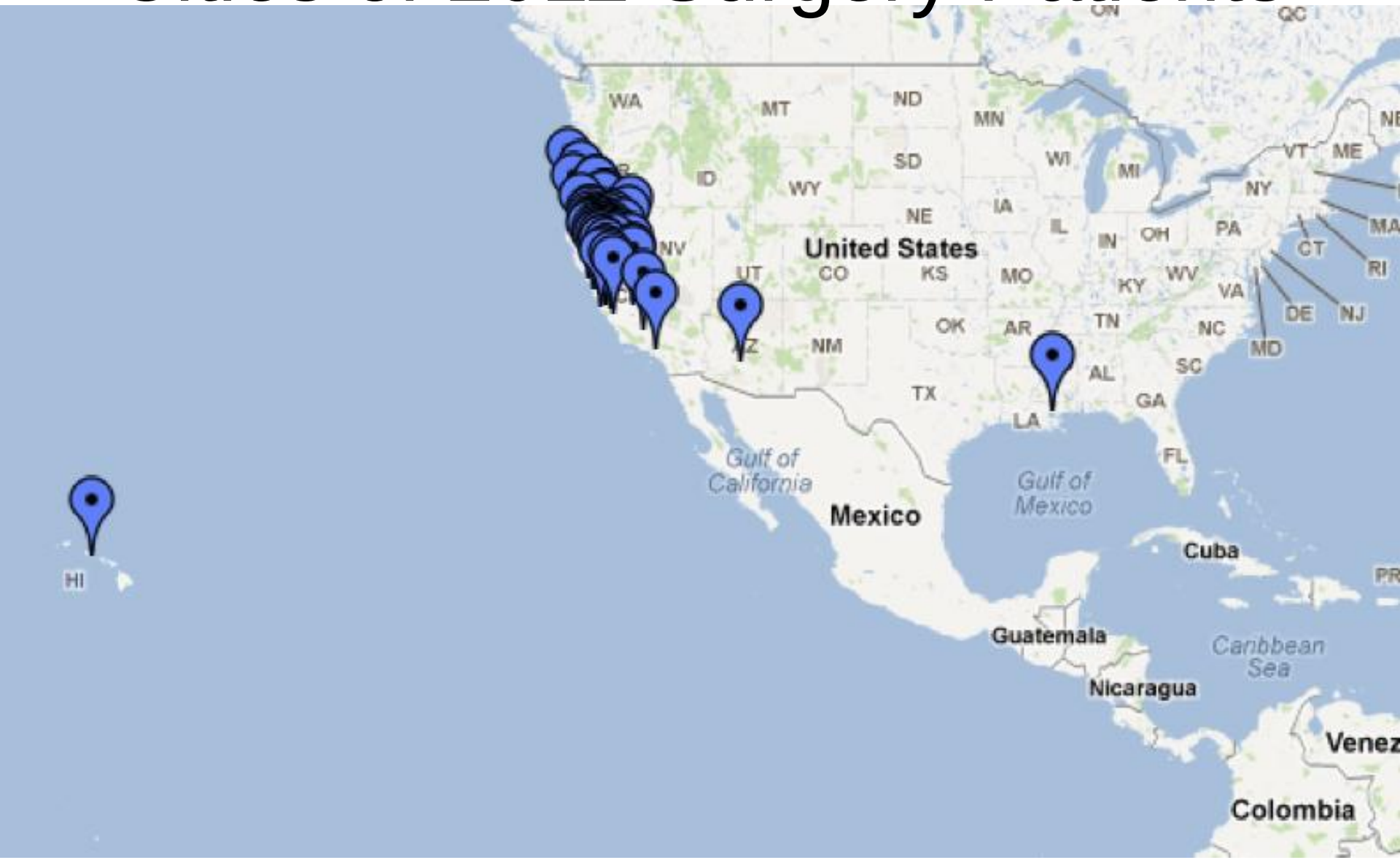
Anaheim
Oceanside
Escondido
San Diego
Mexicali
Tijuana
Ensenada

Cities of 2011 Surgery Patients

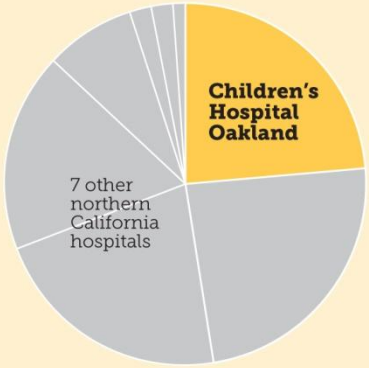


CHILDREN'S HOSPITAL
& RESEARCH CENTER AT OAKLAND

INPATIENT BRAIN TUMOR CASES, 2009

Children's performed nearly a quarter of all of northern California's pediatric inpatient brain tumor surgeries in 2009.

Primary & Secondary Service Areas (Alameda, Contra Costa, Marin, San Francisco, San Joaquin, Santa Clara, Solano, Sonoma, Stanislaus);Ages 0-17; ©2010 Children's Hospital & Research Center Oakland



INPATIENT CRANIOSYNOSTOSIS CASES, 2008-09

Children's treated over 39% of all of northern California's pediatric inpatient craniosynostsosis cases in 2008-09.

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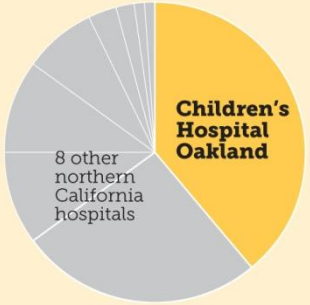

INPATIENT SPASTICITY CASES, 2008-09

Children's treated nearly half of all of northern California's pediatric spasticity cases in 2008-09.

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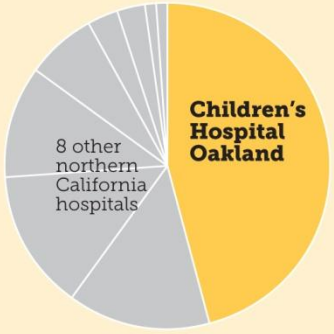
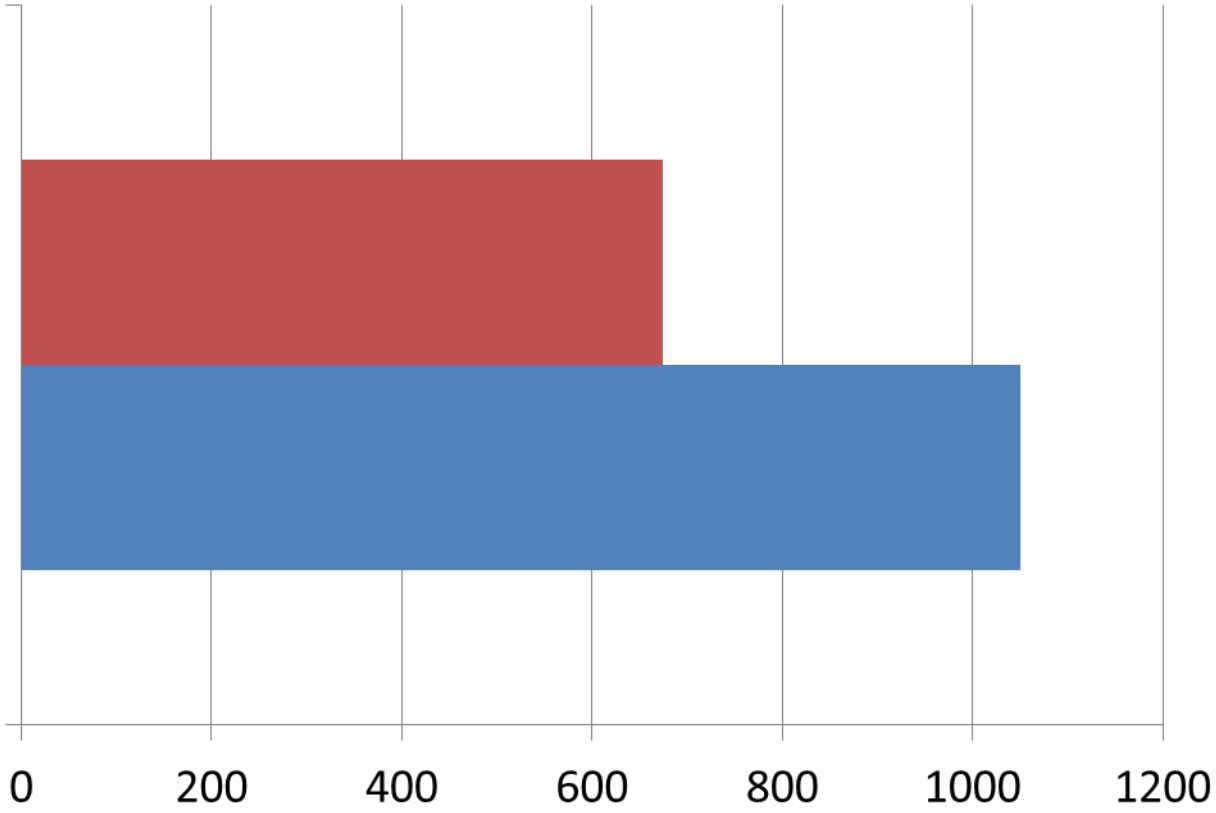


Surgical volume 2009-2011



OR Minutes, 2011

Neurosurgery

Surgeon: Peter P. Sun, MD

Case Count: 307

Minutes: 74,591= 73%

Minutes + Set Up/Tear Down: 83,291

Surgeon: Kurtis I. Auguste, MD

Case Count: 107

Minutes: 26,050

Minutes + Set Up/Tear Down: 29,800

Total Case Minutes: 101,592

(including Dr. Gupta and Dr. Sheinberg)

Total Minutes + Set Up/Tear Down: 114,252

Top 5 Services Ranked by Minutes

GPS

Minutes: 166,653 = 32%

ORT

Minutes: 120,626 = 23%

NES

Minutes: 101,592 = 19%

OTO

Minutes: 90,670 = 17%

PLS

Minutes: 44,078 = 8%

Total OR Minutes (not including Set Up/Tear Down): 523,619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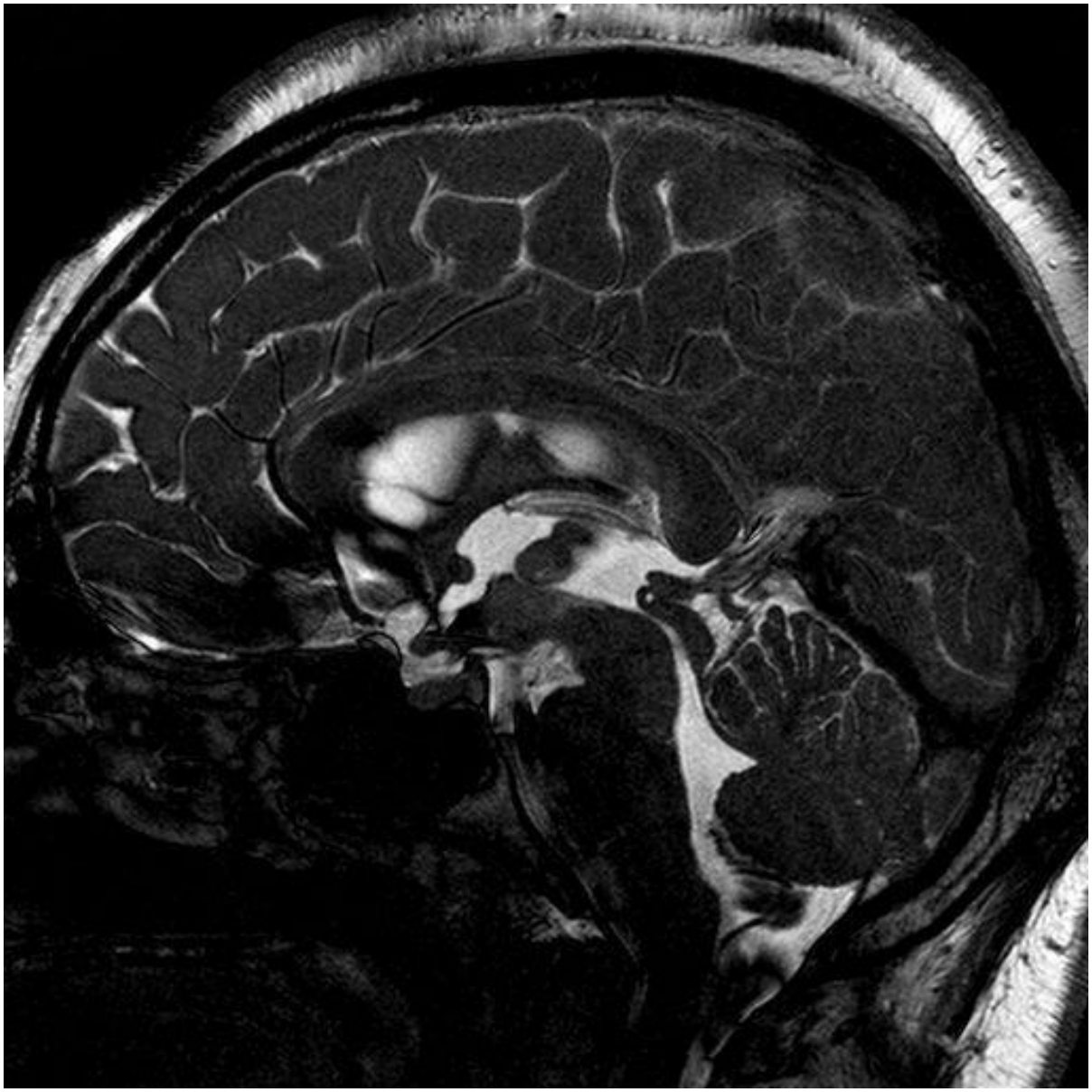
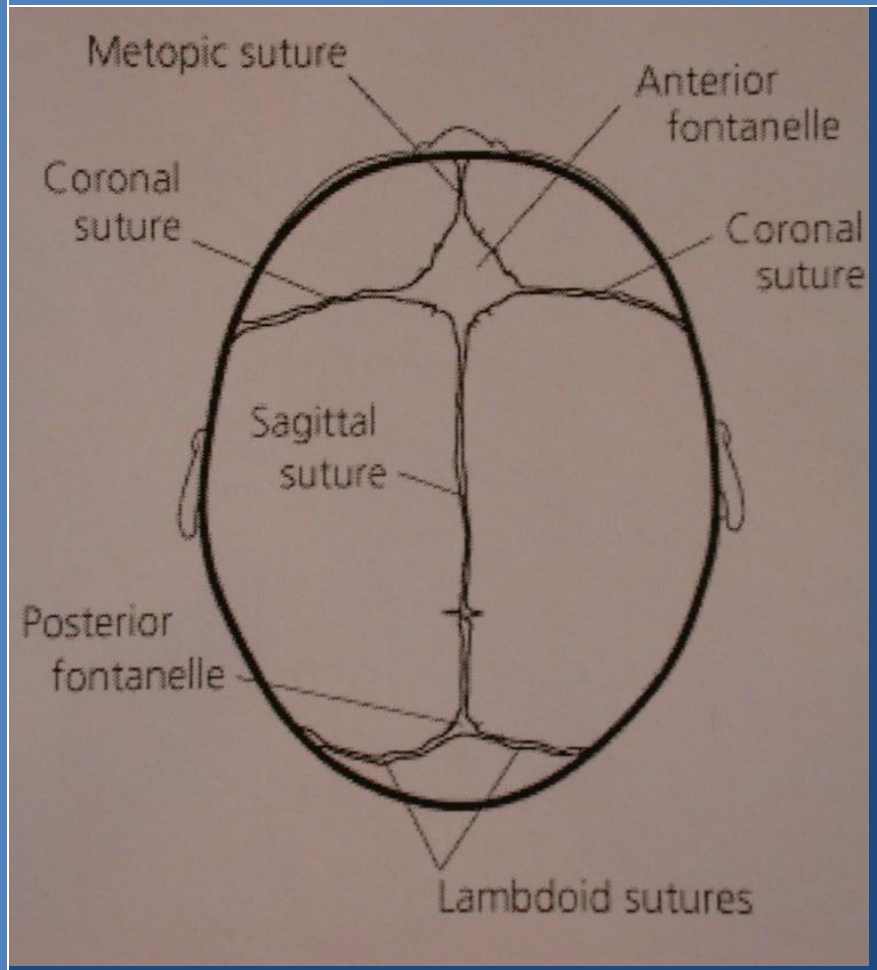
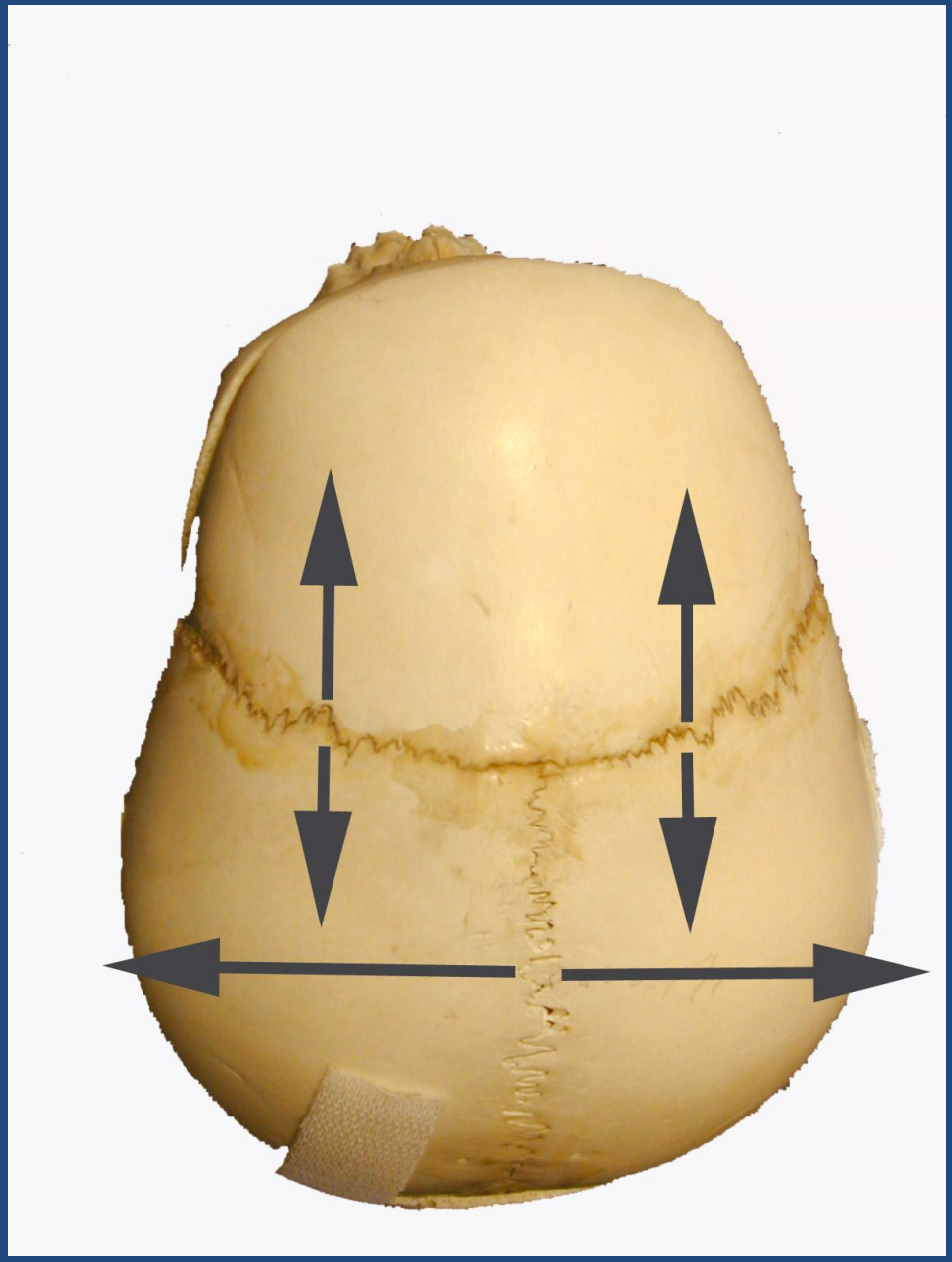
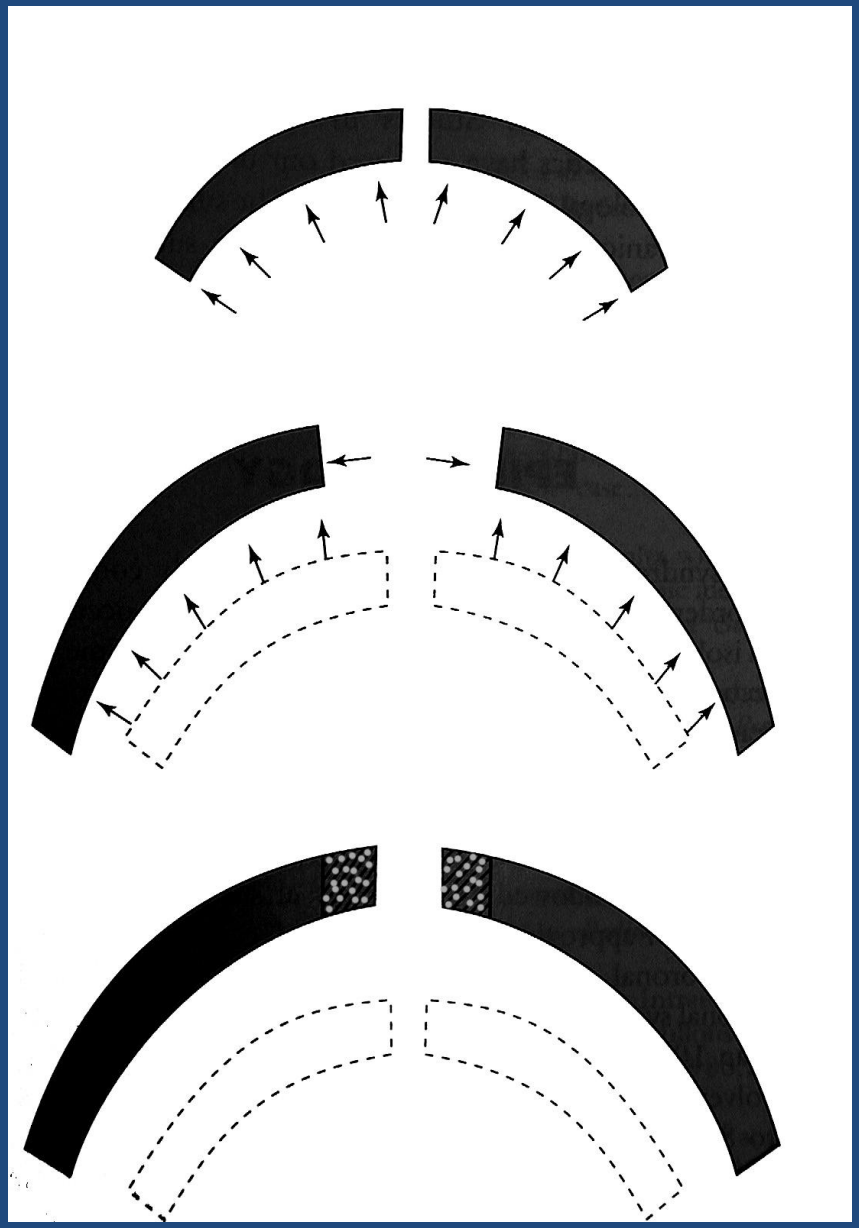



Metopic suture
Anterior fontanelle
Coronal suture
Coronal suture
Sagittal suture
Posterior fontanelle
Lambdoid sutures





Skull Biology

- Sutures form at borders of advancing skull ossification centers with inductive signals from underlying dura
- New bone is laid down perpendicular to the suture line
- Bone deposition at the suture is driven by brain growth
- 87% of adult head size by age 2

Abnormal Head Shape

- Craniosynostosis: premature closure or absence of calvarial suture
  - creates characteristic skull deformities at birth
- External forces
- Compensatory changes from brain disorders

Abnormal Head Shape

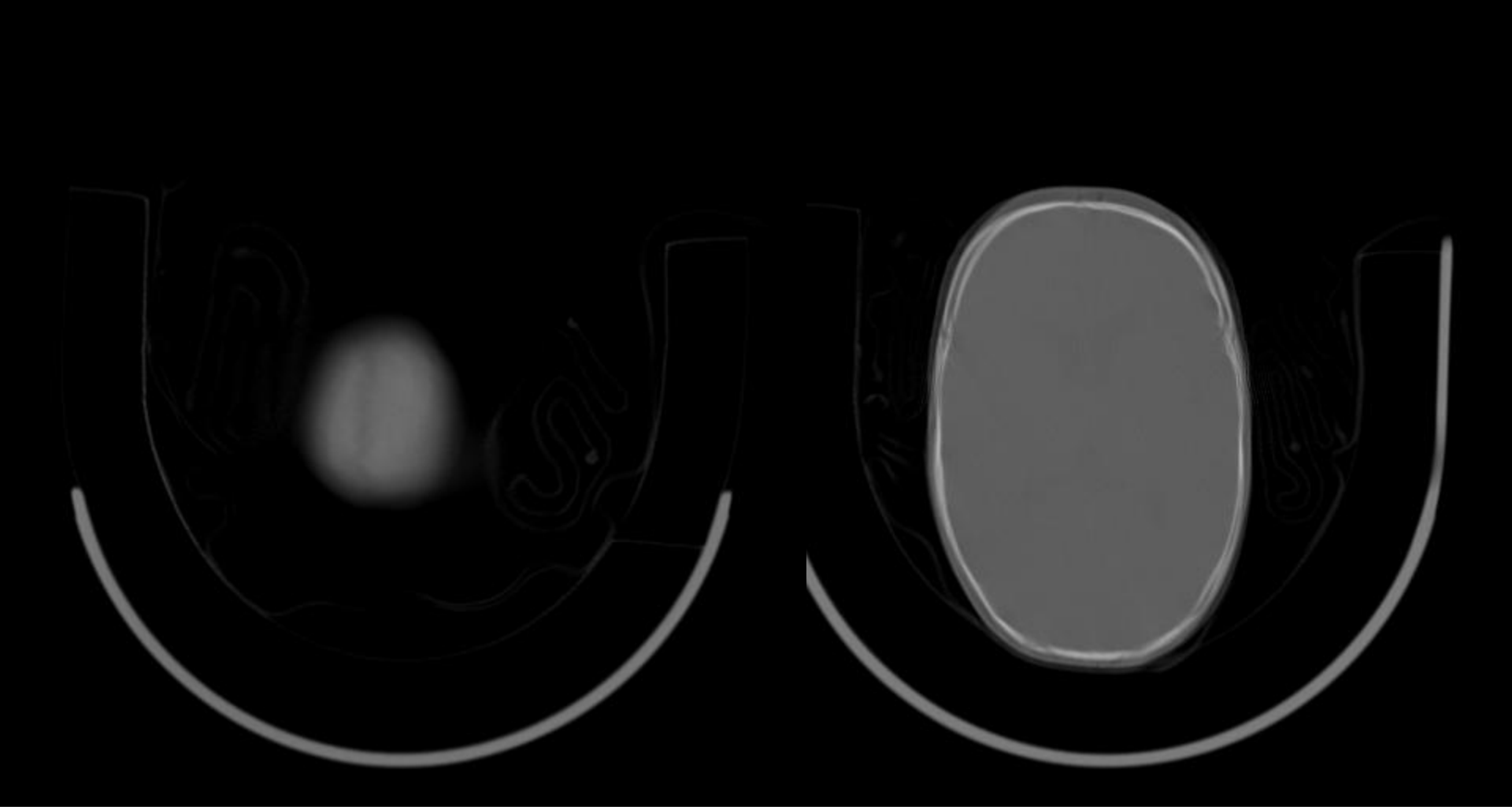
- Plagiocephaly
- Scaphocephaly/Dolichocephaly
- Turricephaly
- Brachycephaly
- Trigonocephaly

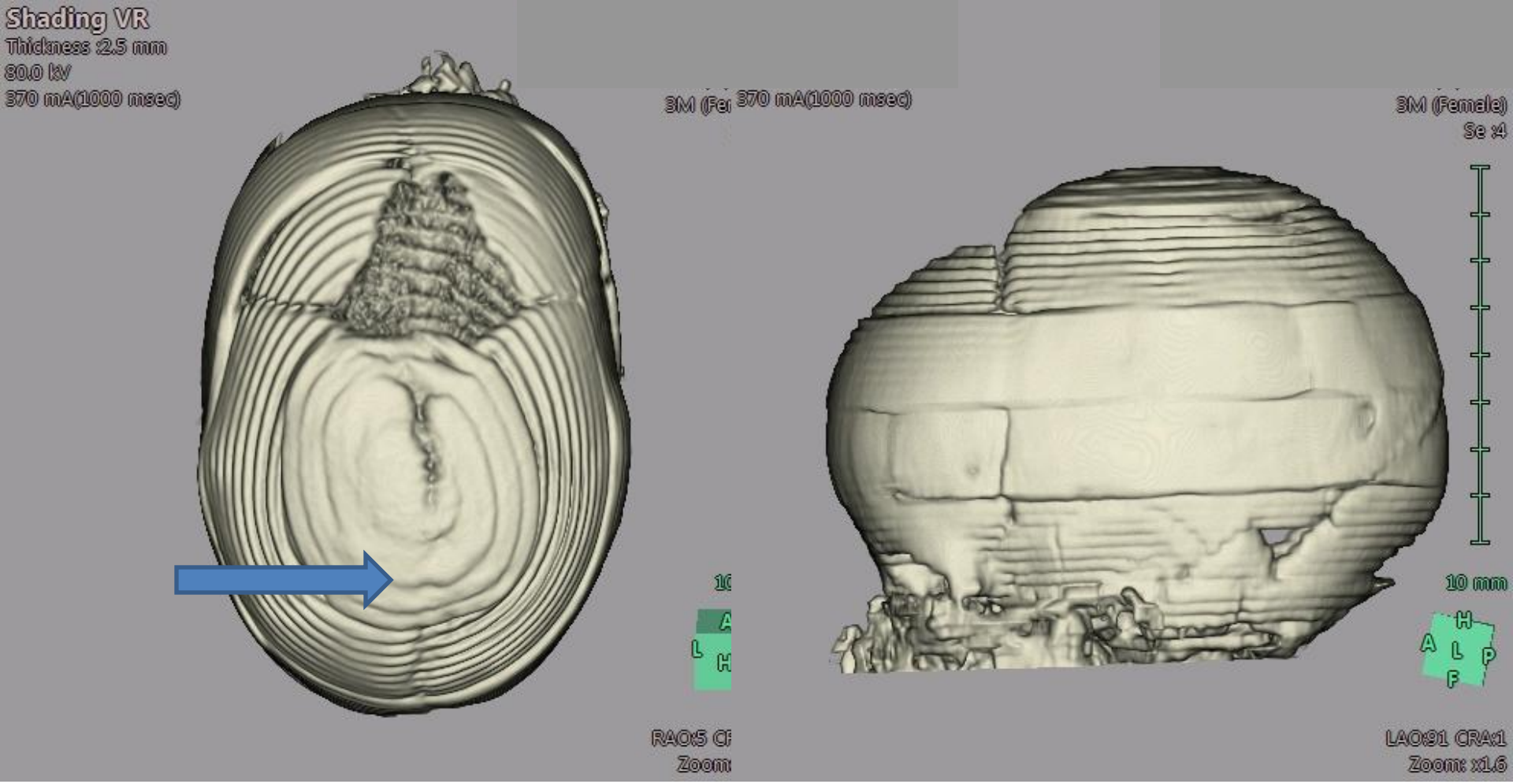
Diagnosis

History: present at or apparent shortly after birth

Exam: shape
palpate suture separation
ridge over fused *midline* sutures

Radiographs : confirmatory
CT: for surgical planning





Computer reconstruction can give false positive !

Frontal plagiocephaly

Positional frontal plagiocephaly

- Primary, or secondary to occipital positional plagiocephaly

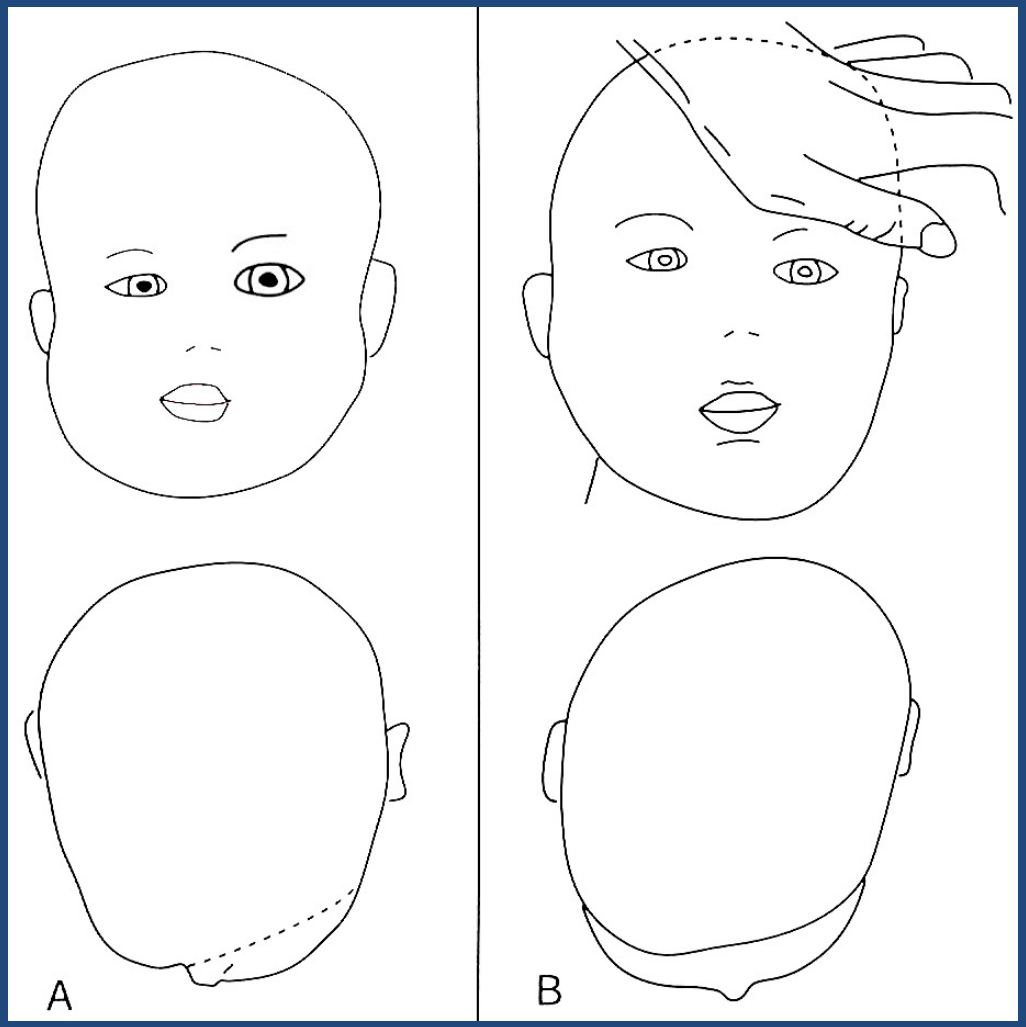
Frontal plagiocephaly

Unilateral coronal synostosis:

-1/10,000

-frontal plagiocephaly, ipsilateral enlarged orbit, Contralateral nasal deviation, strabismus

- Not familial, 15% with FGR mutaitons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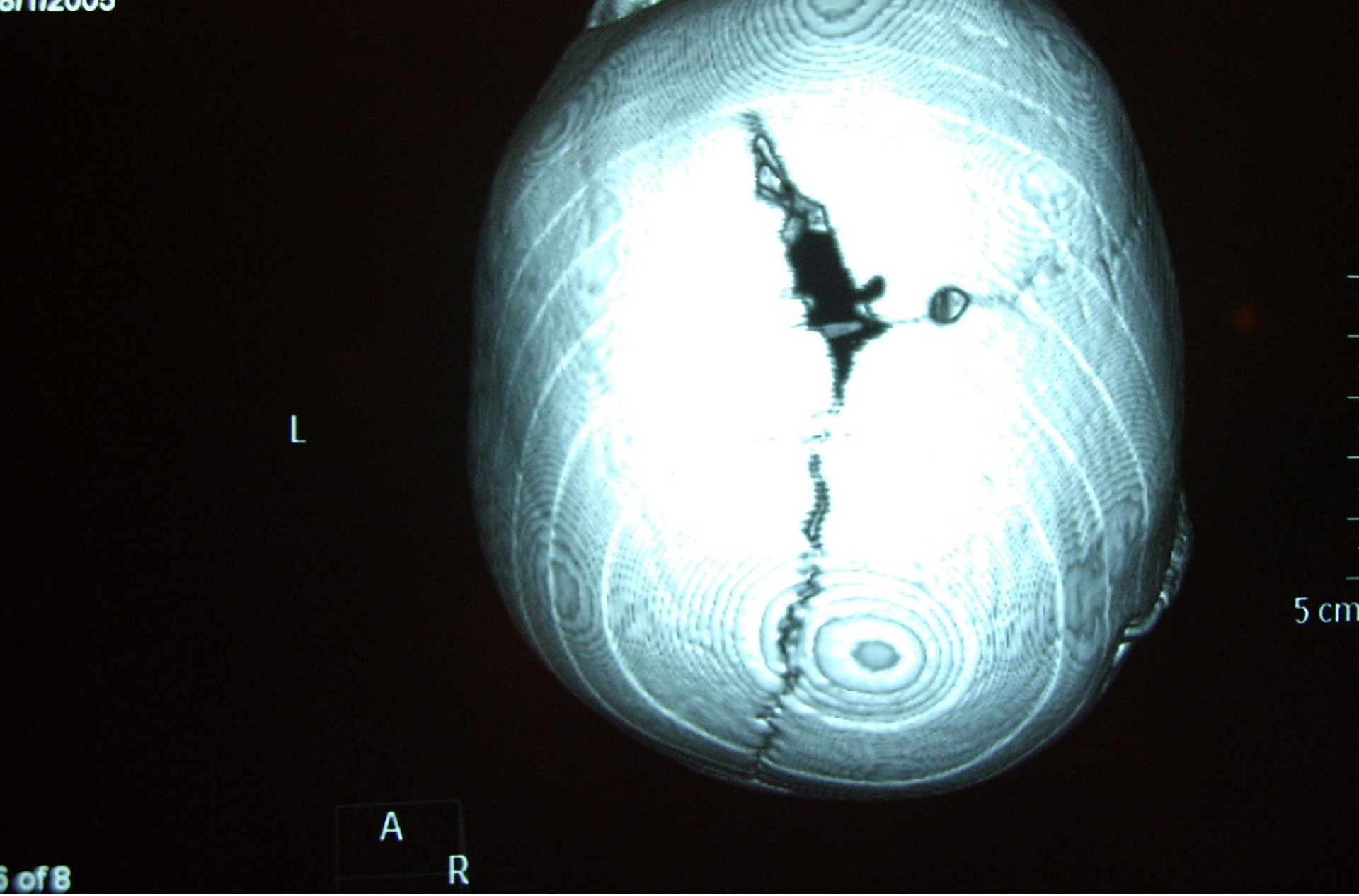
L
A
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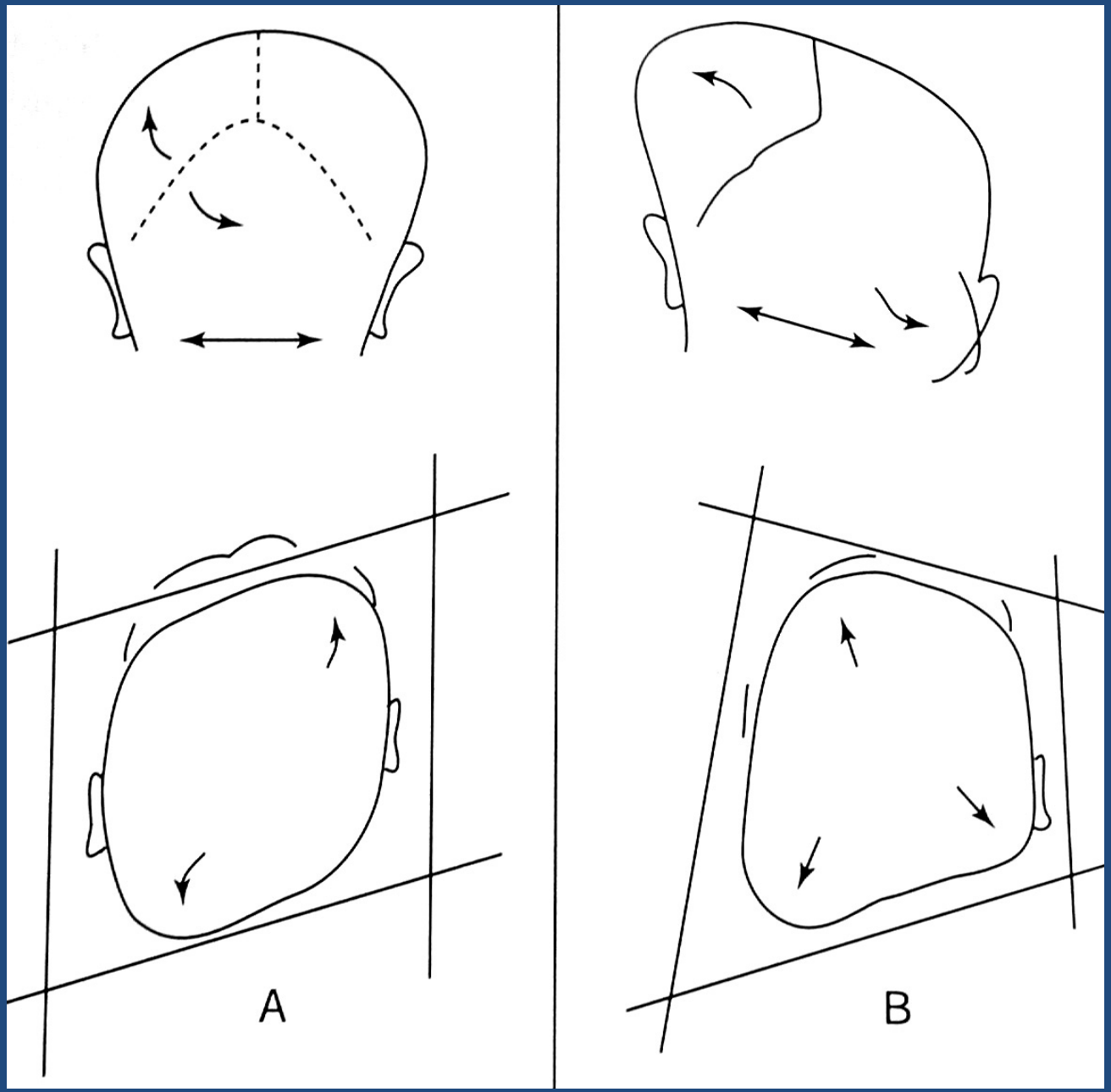
5 cm

Occipital plagiocephaly

Positional plagiocephaly vs lambdoid synostisis

1/300 – 48% vs 3/100,000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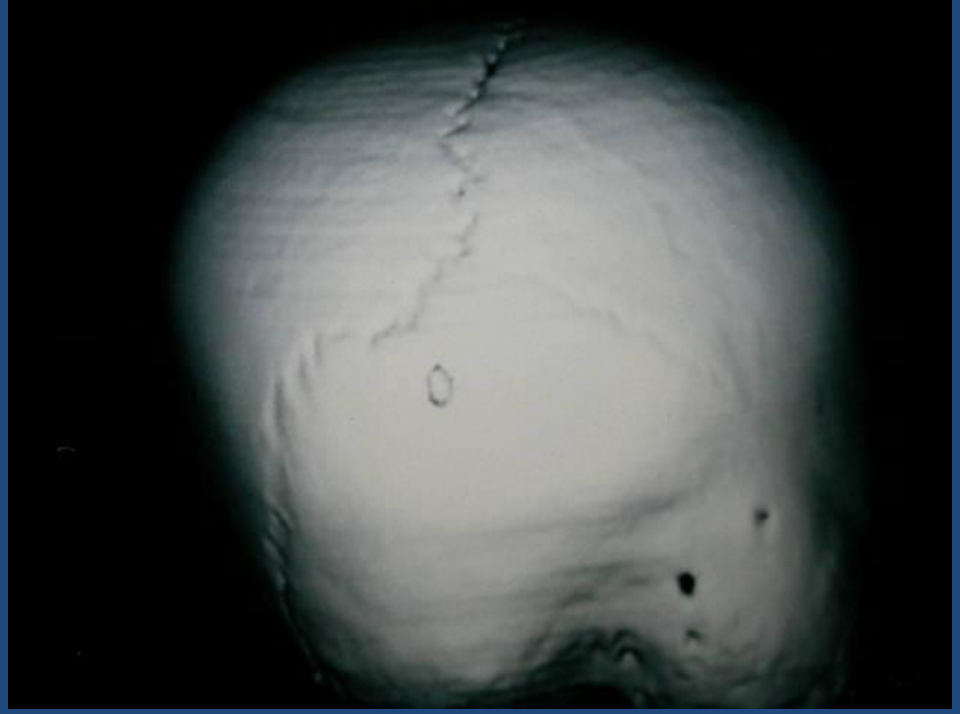
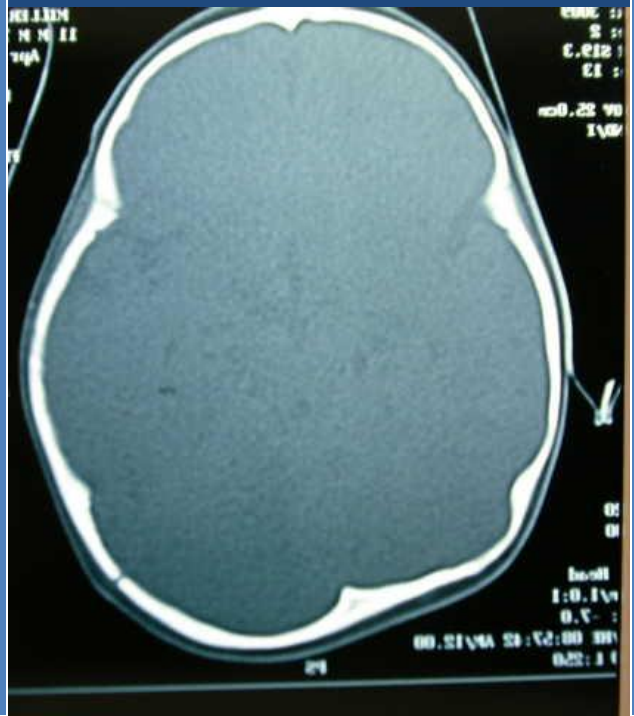
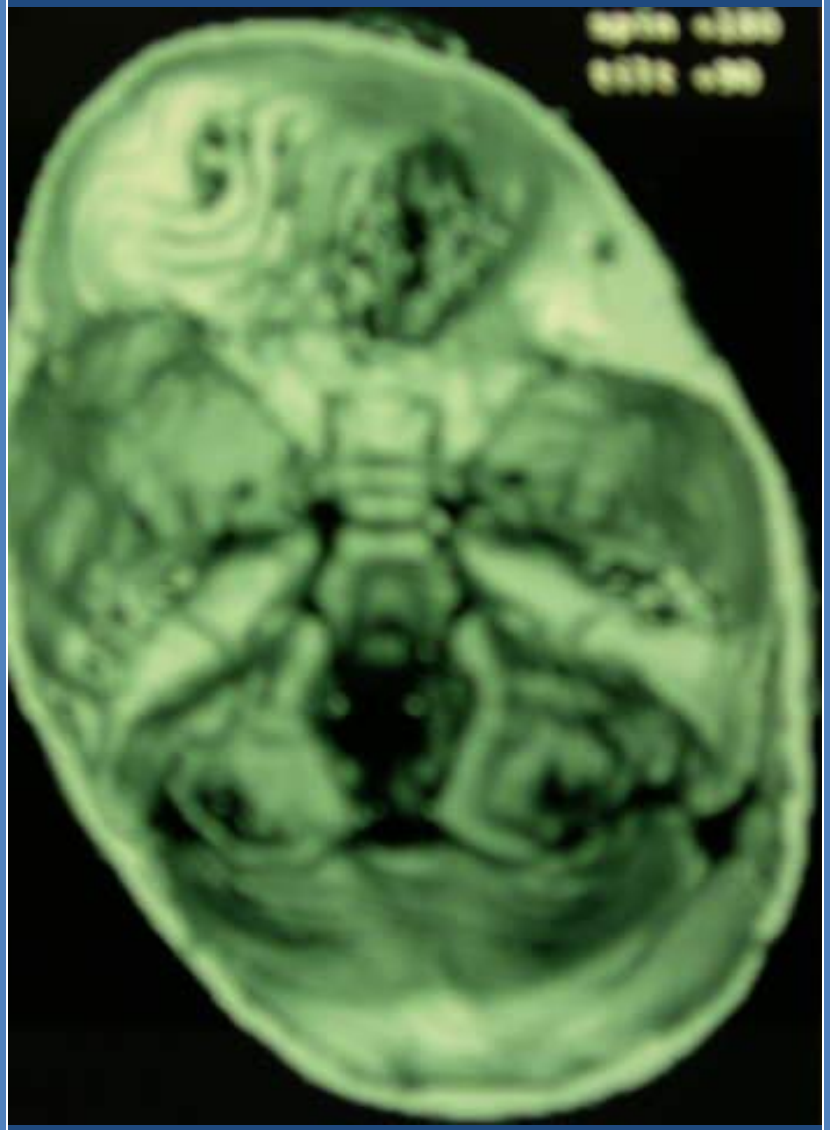






Occipital plagiocephaly

Lambdoid synostosis

-3/100,000

-some ipsilateral occipital flattening
compensatory parietal and mastoid bulges

-trapazoid vertex view

Occipital plagiocephaly

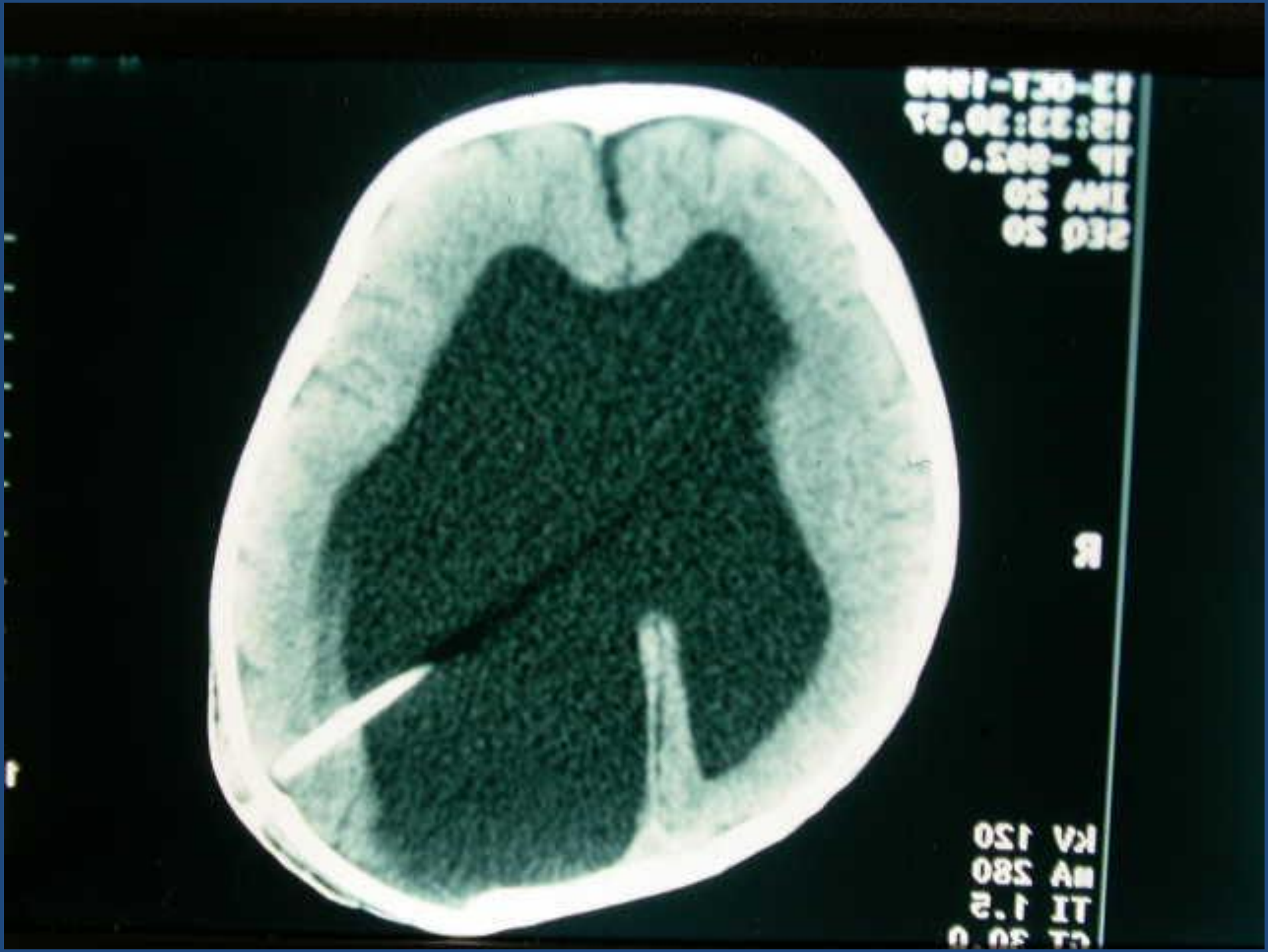
Positional plagiocephaly (deformational plagiocephaly, flat head)

-common

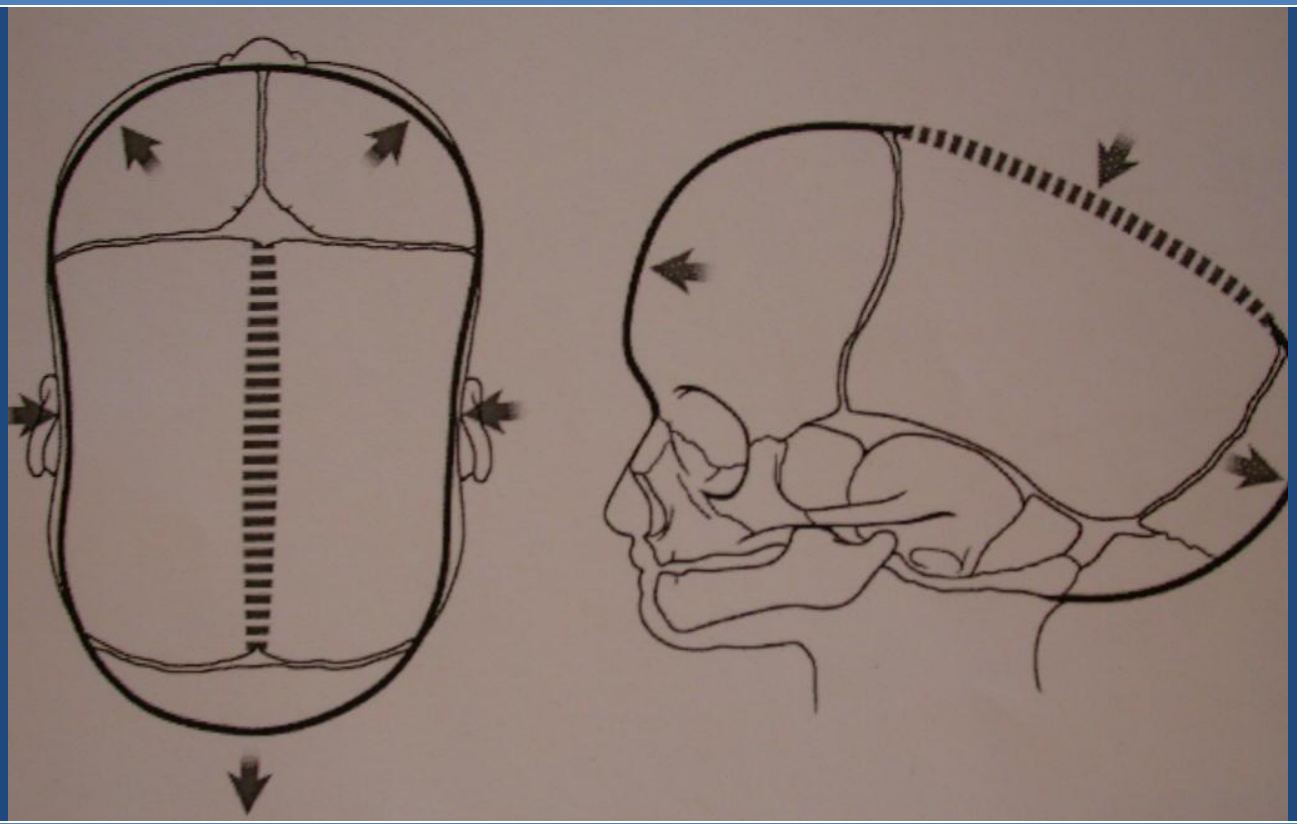
-occipital only, parallelegram with compensatory frontal plagiocephaly, bi-occipital

- Helmet for severe cases


STAR
ORTHOMERICA



Scaphocephaly

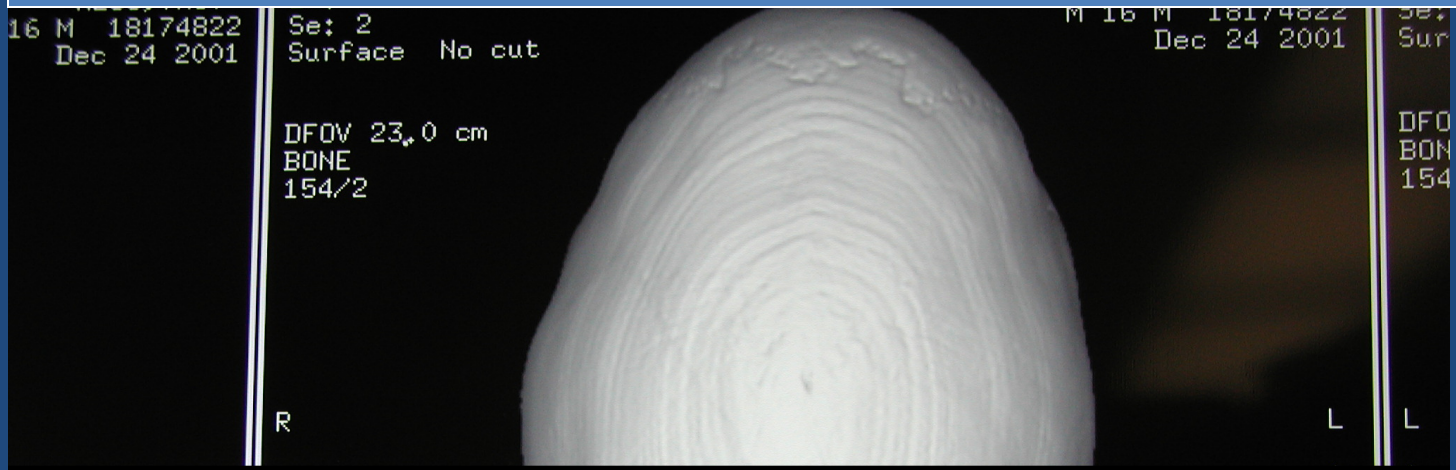


Sagittal synostosis

Scaphocephaly

- Sagittal synostosis

- 2/10,000
-Frontal bossing, occipital keel, scaphocephaly
-Early dx offers option of less invasive correction
- 15% of uncorrected pts develop elevated ICP (only single suture synostosis to have proven ICP complication)
- Possible higher incidence of developmental delays unrelated to the timing of correction
- 6% familial in an autosomal dominant pattern

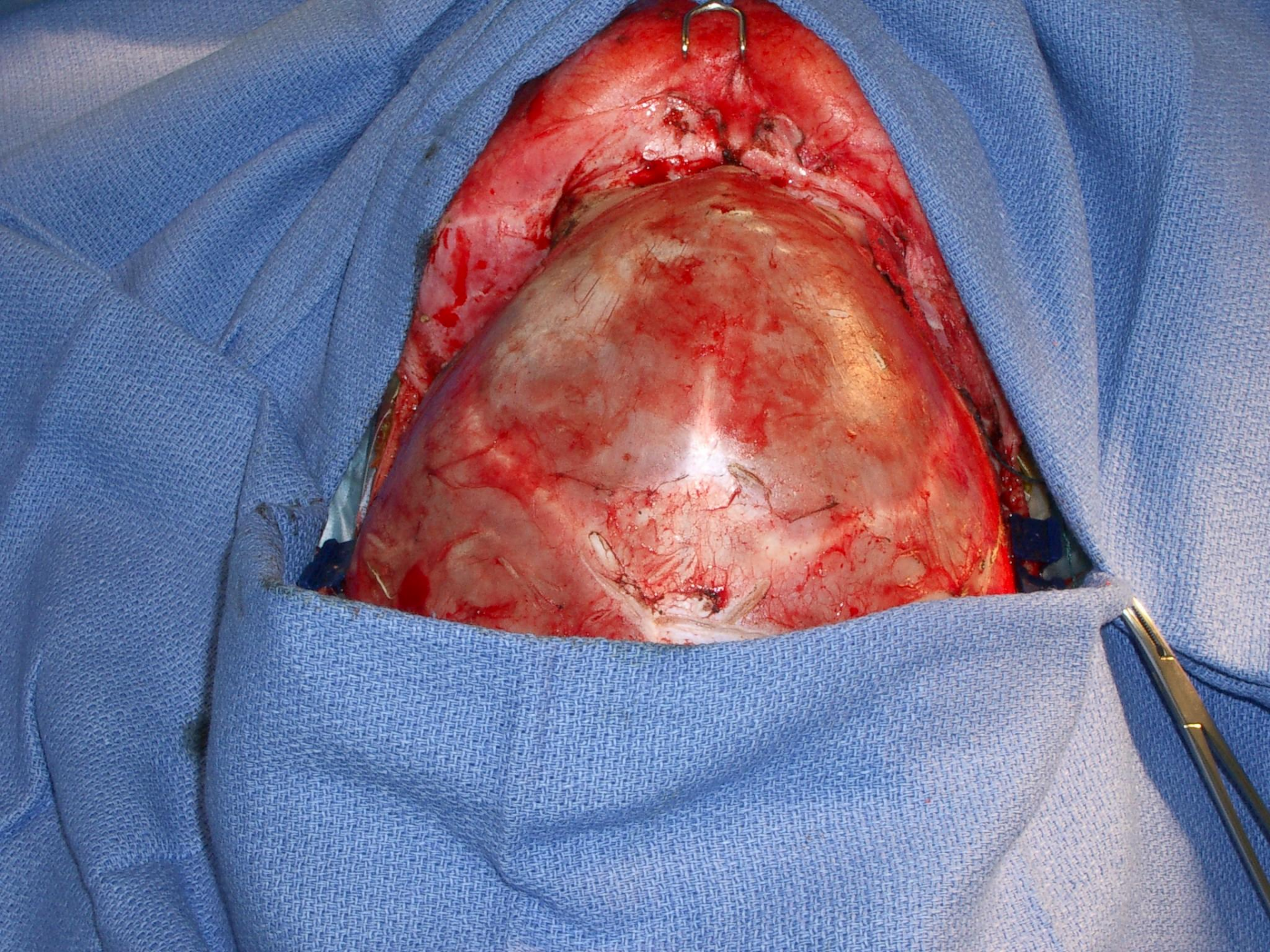

16 M 18174822
Dec 24 2001
Se: 2
Surface No cut
DFOV 23.0 cm
BONE
154/2
R
Dec 24 2001
L
L

Shunted hydrocephalus
Premi head shape

Trigonocephaly

Metopic synsotosis

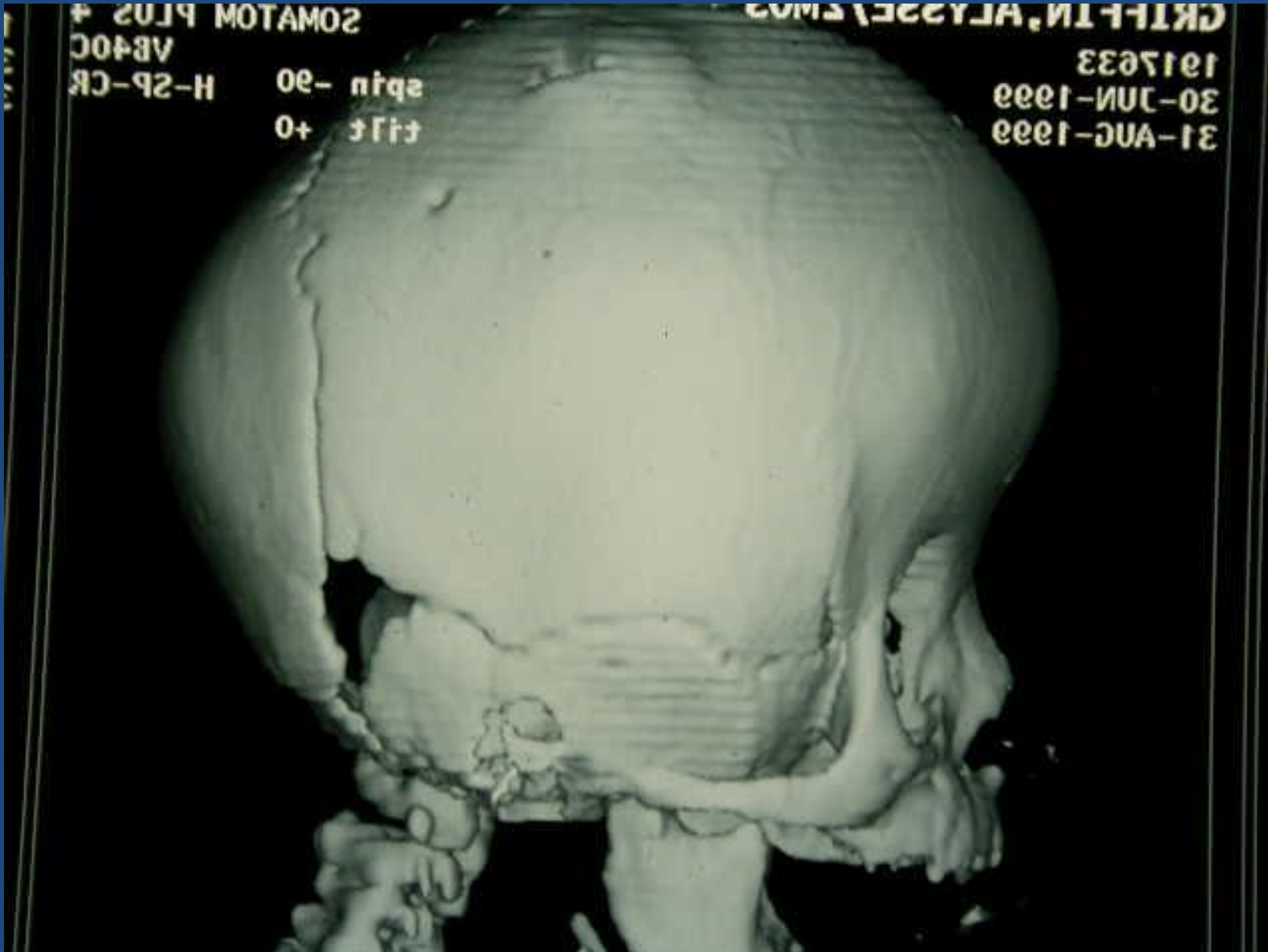
- 10-20% of synostosis
- Wide spectrum of manifestations: triangular forehead to minor midline ridge
- Surgery based on degree of deformity
- 15% associated with other anomalies: heart, GU, brain
- 5.6 % familial



Turricephaly/Brachycephaly

Bicoronal synostosis

- Mostly with syndromic craniosynostosis: Apert's, Crouzon's, Pfeiffer's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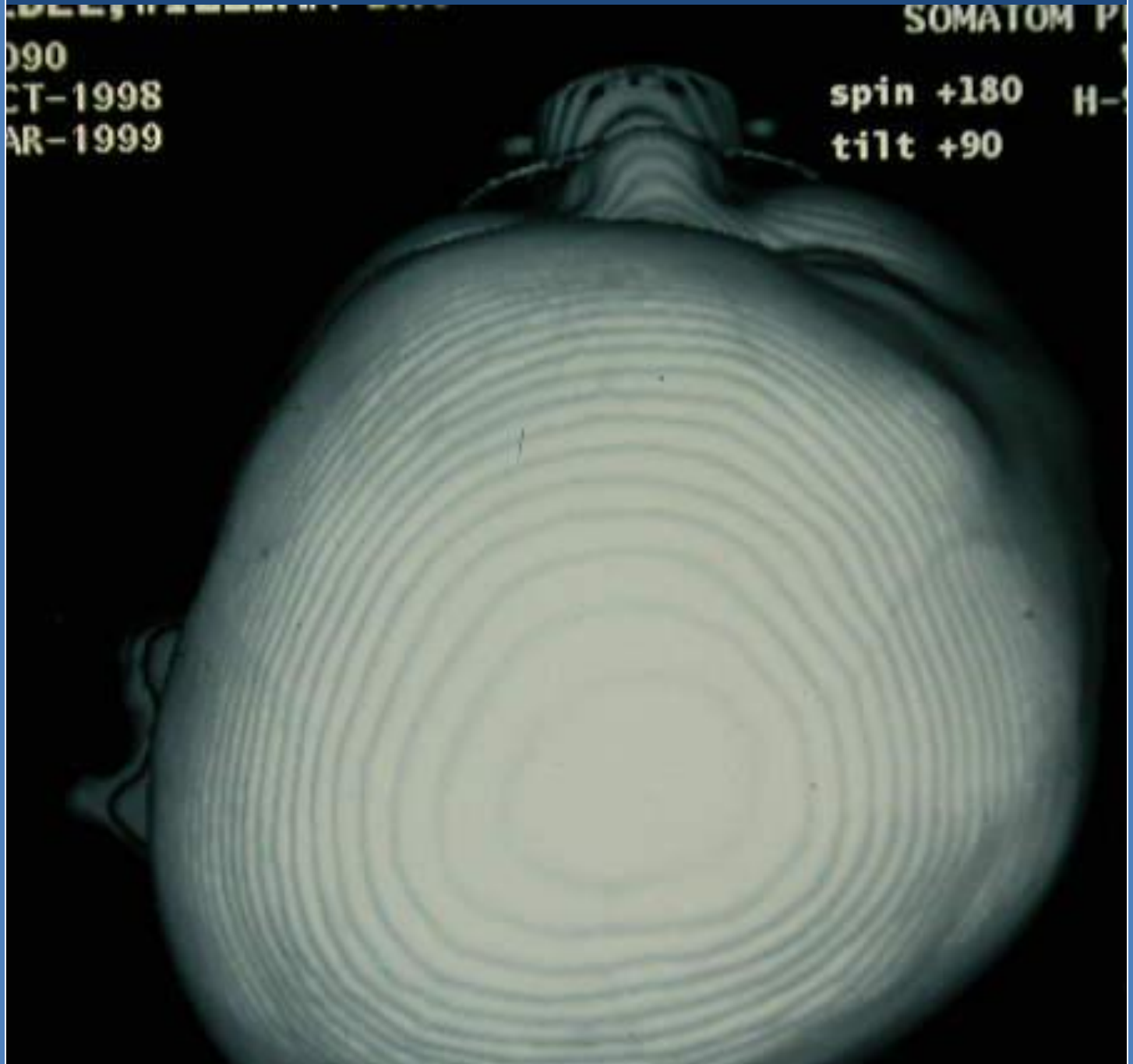
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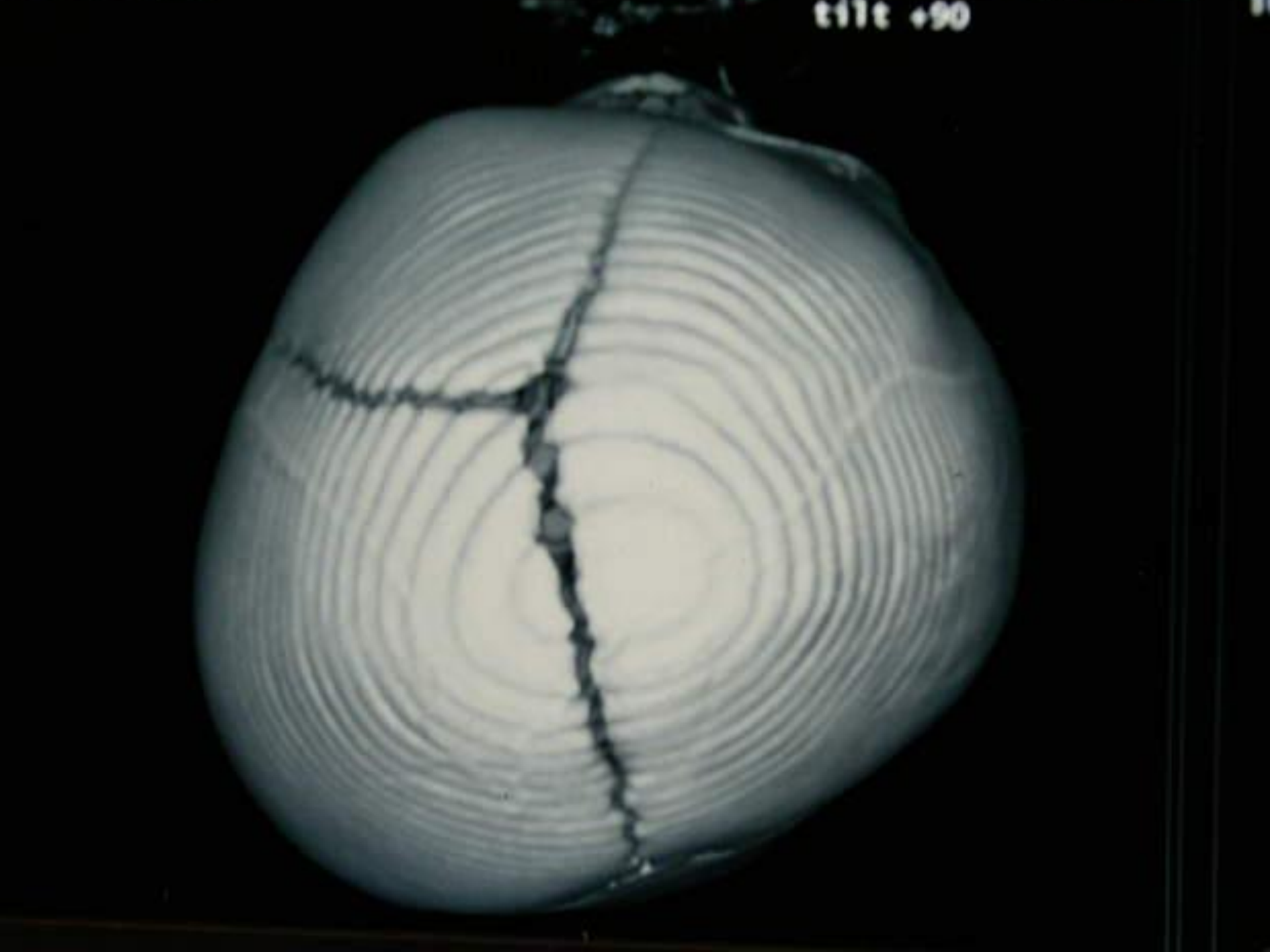
tilt +90

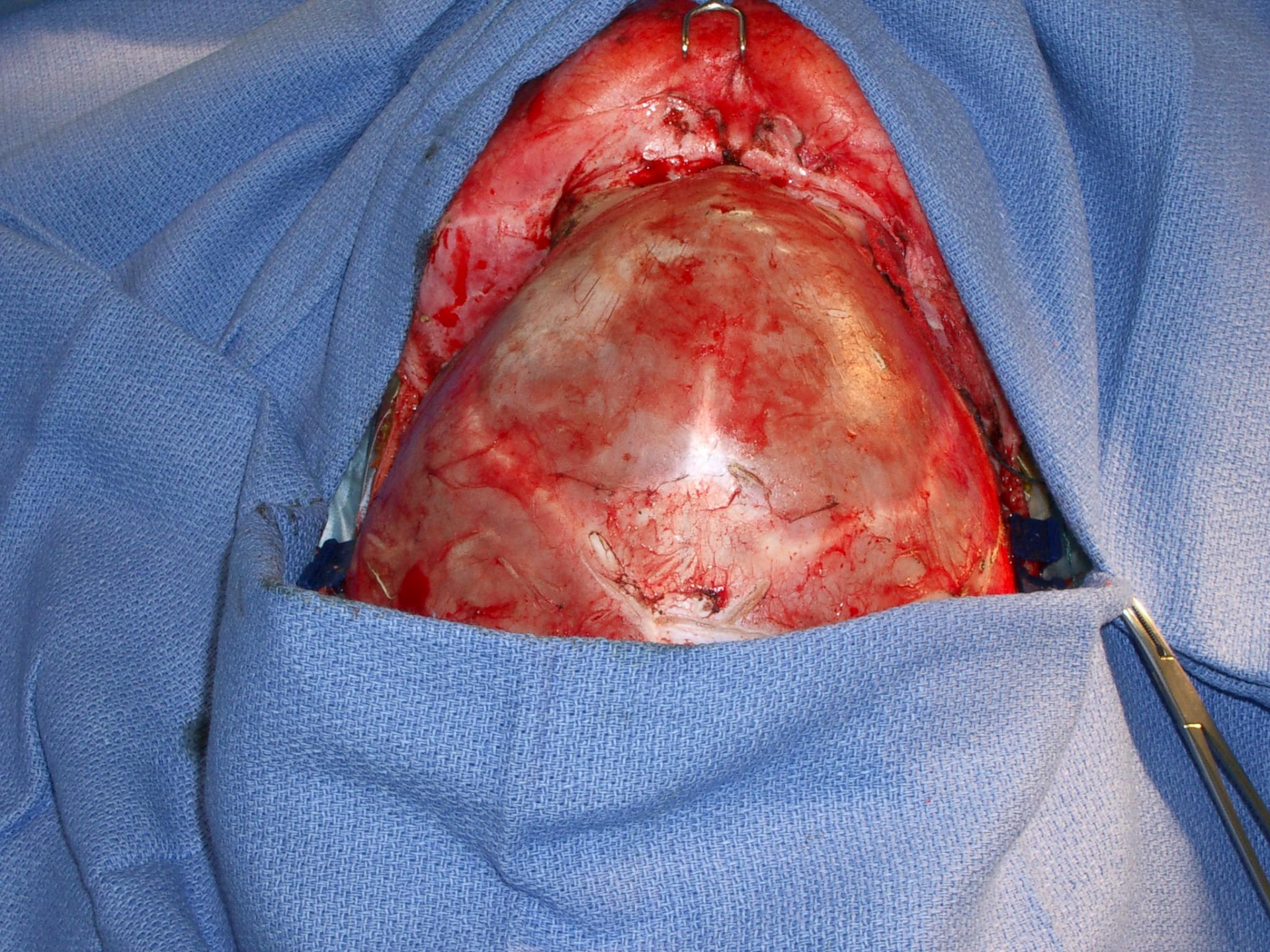

tilt +90

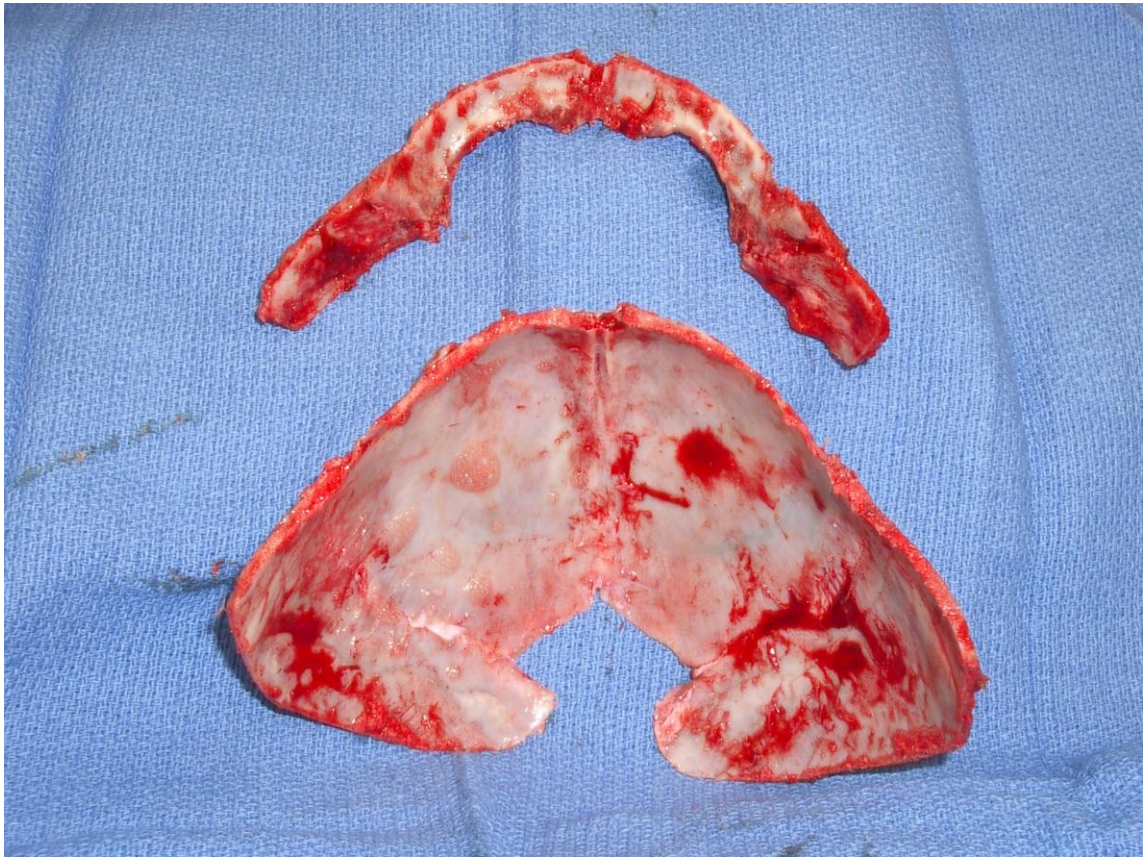
Craniosynostosis Treatment

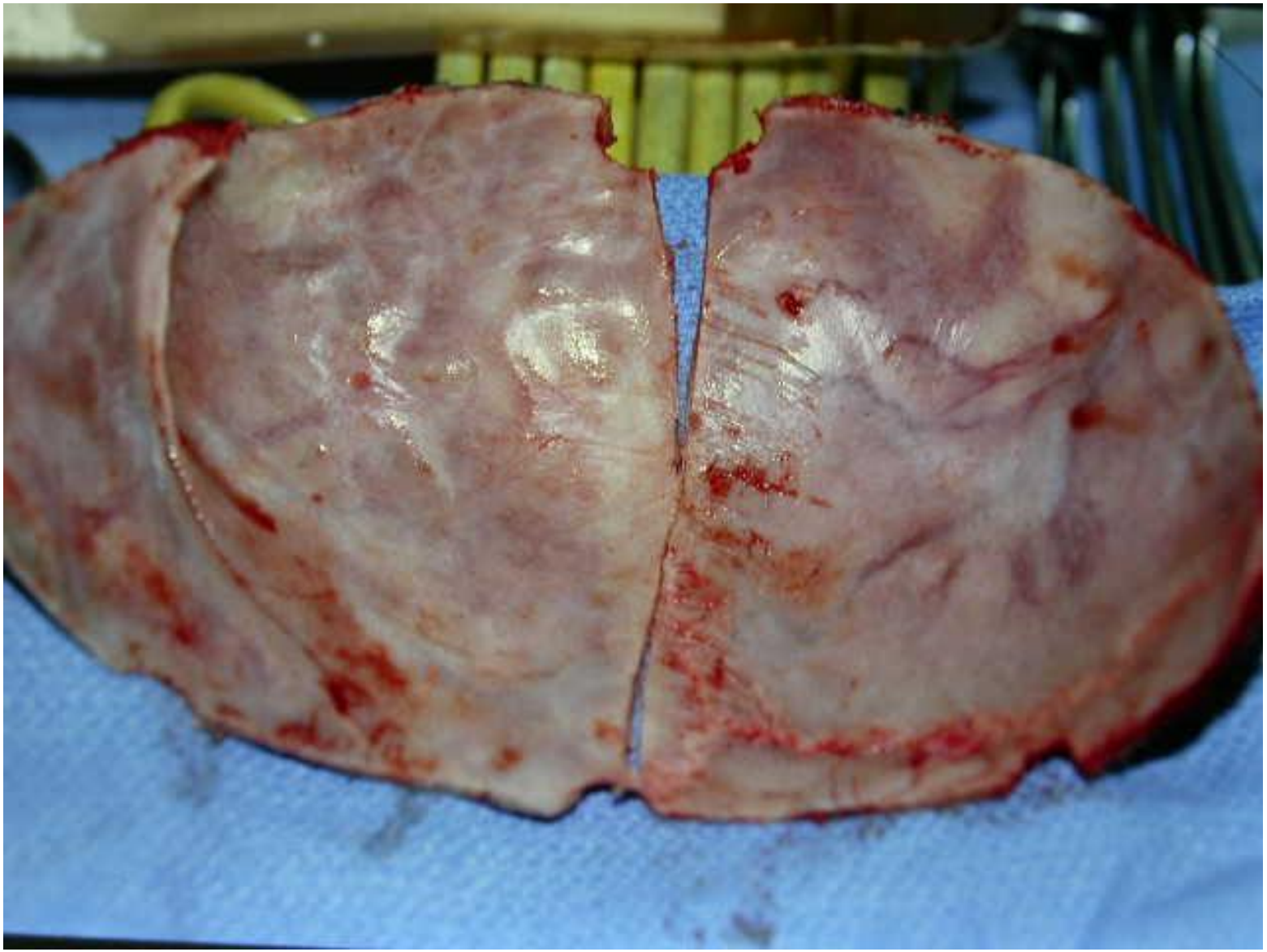
- Correct deformity: psychosocial benefits of deformity correction outweighs risk of surgery
- Reduce the risk of elevated ICP in sagittal synostosis

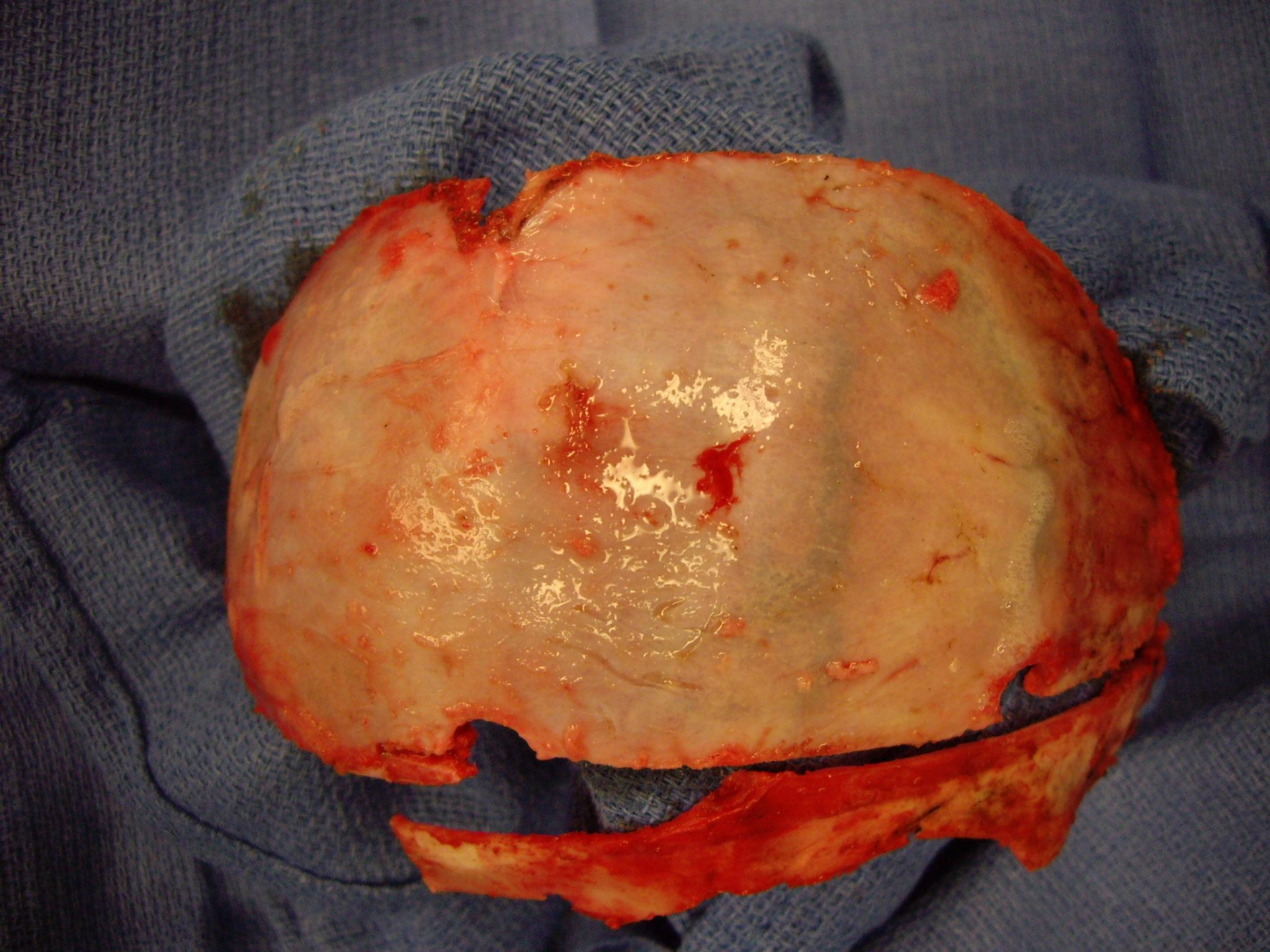
- Traditional reconstruction 6-9 months of age
- Endoscopic assisted craniectomy + helmet < 3months of age

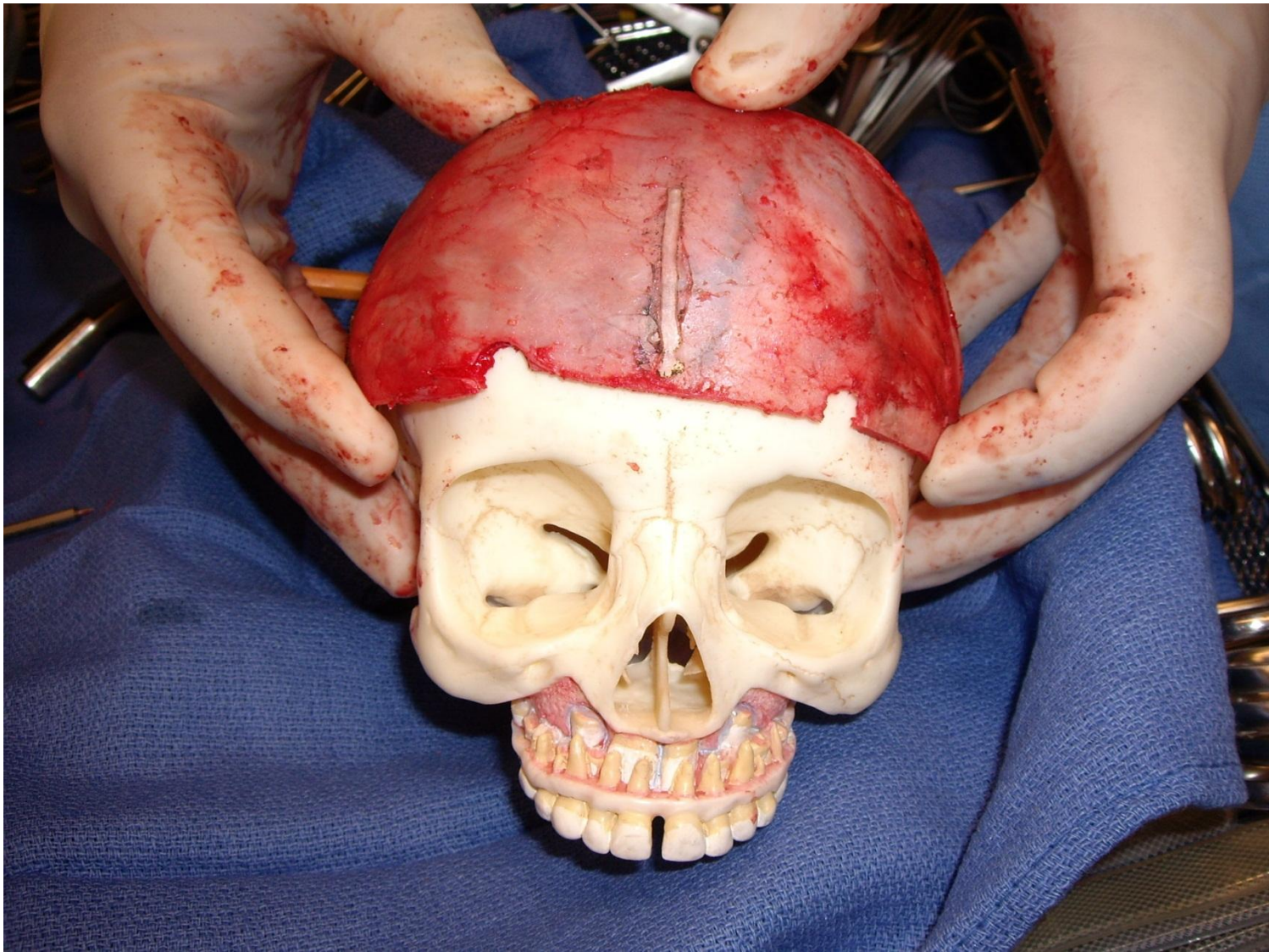
- Craniofacial Team approach for syndromic patients: neurosurgeon, plastic surgeon, ENT, orthodontist, oral surgeon, neuropsychologist, social worker etc…



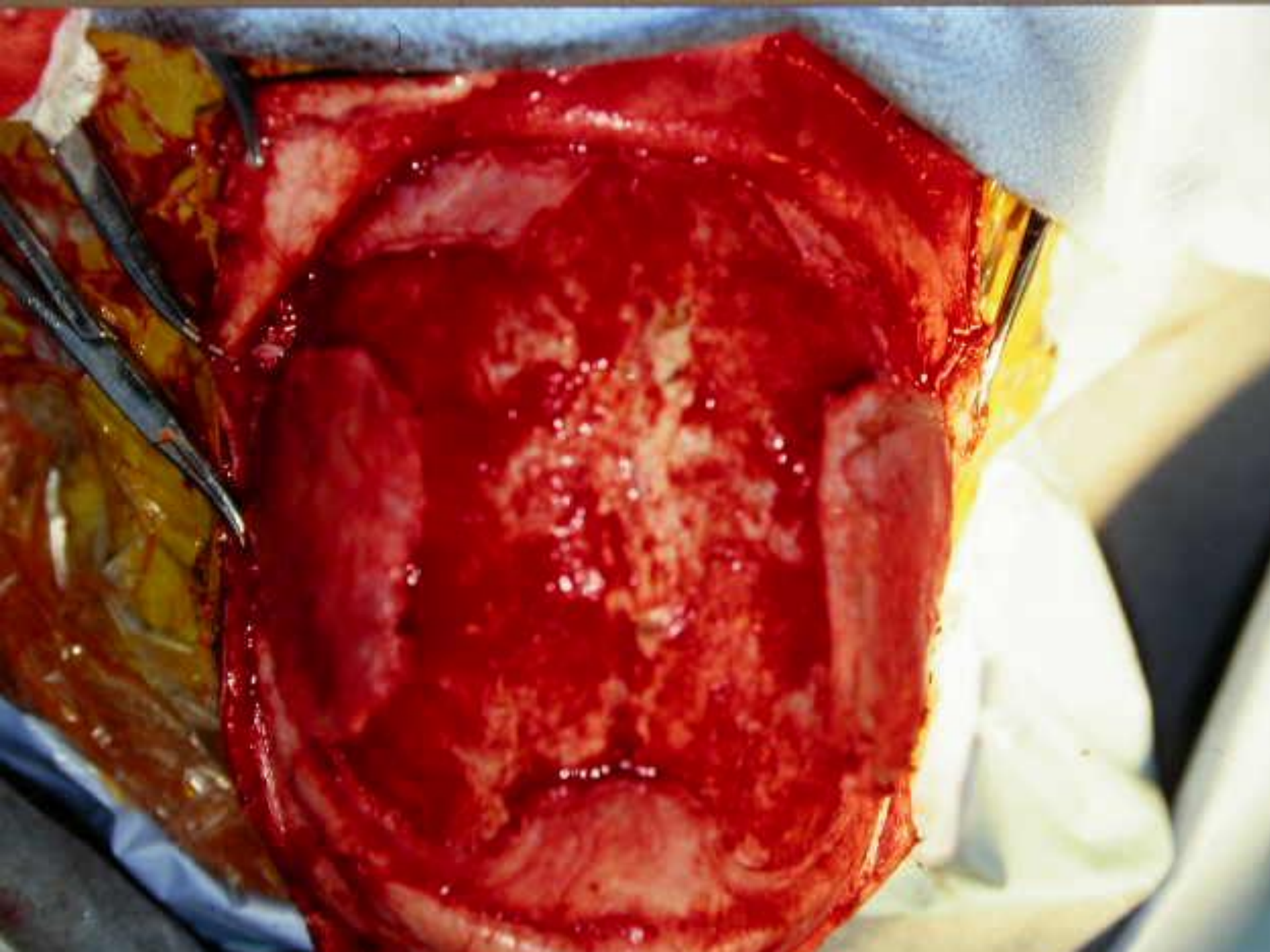








3 years post-op

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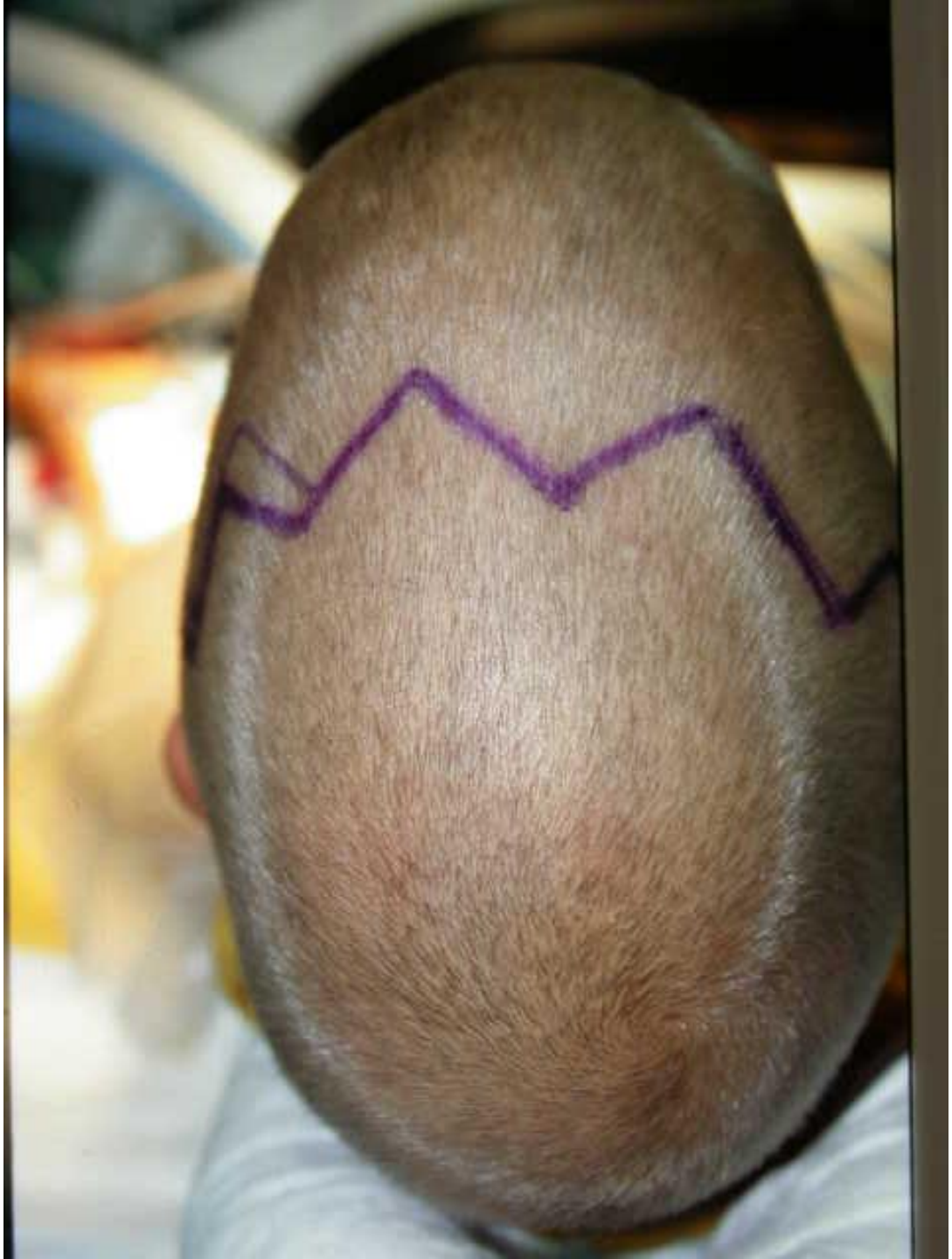
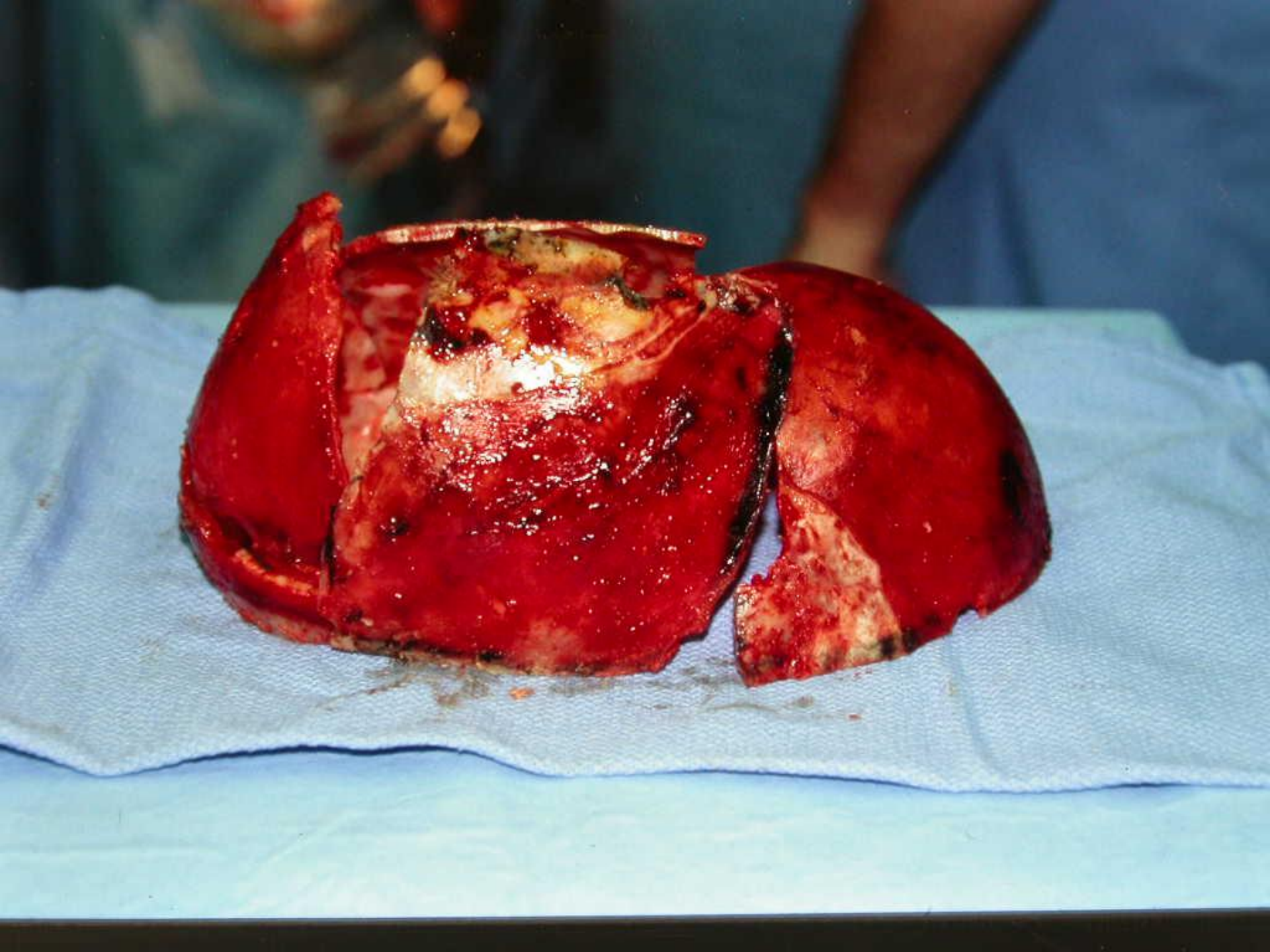


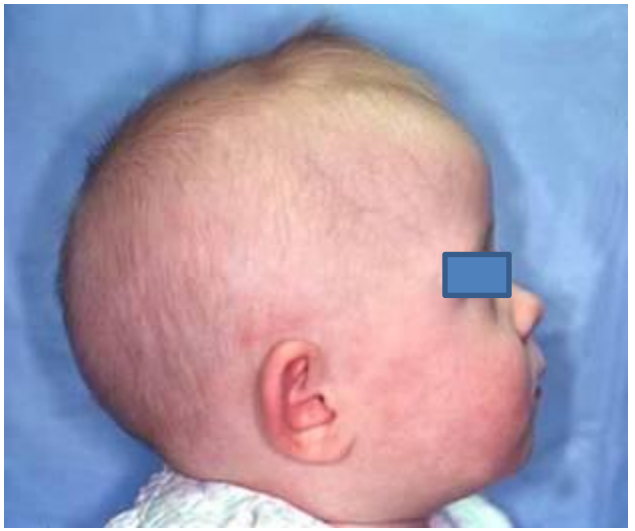


Endoscopically Assisted

Craniosynostosis Treatment

- Endoscopic repair:
  - not yet widely accepted
  - needs post op helmet for optimal correction
  - 2 small scars = minimally invasive..

- EARLY DX!!

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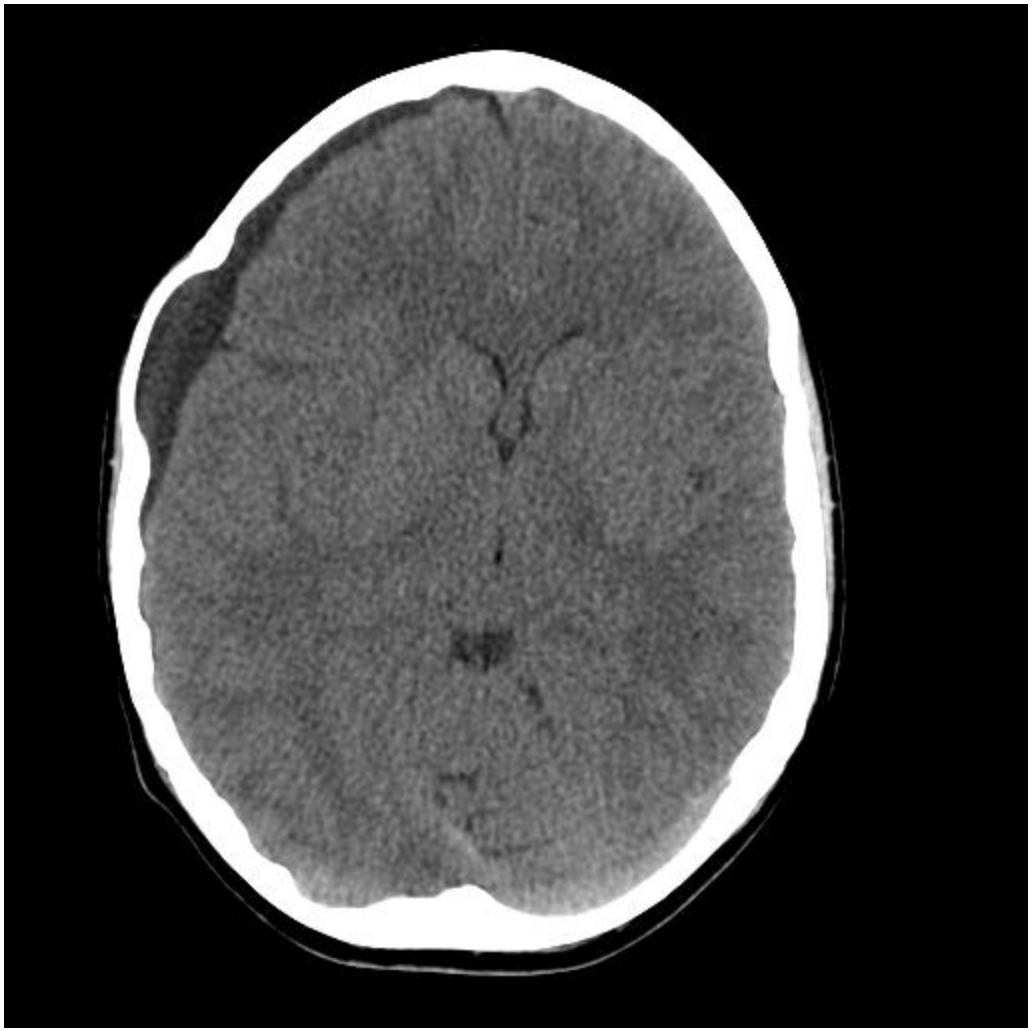

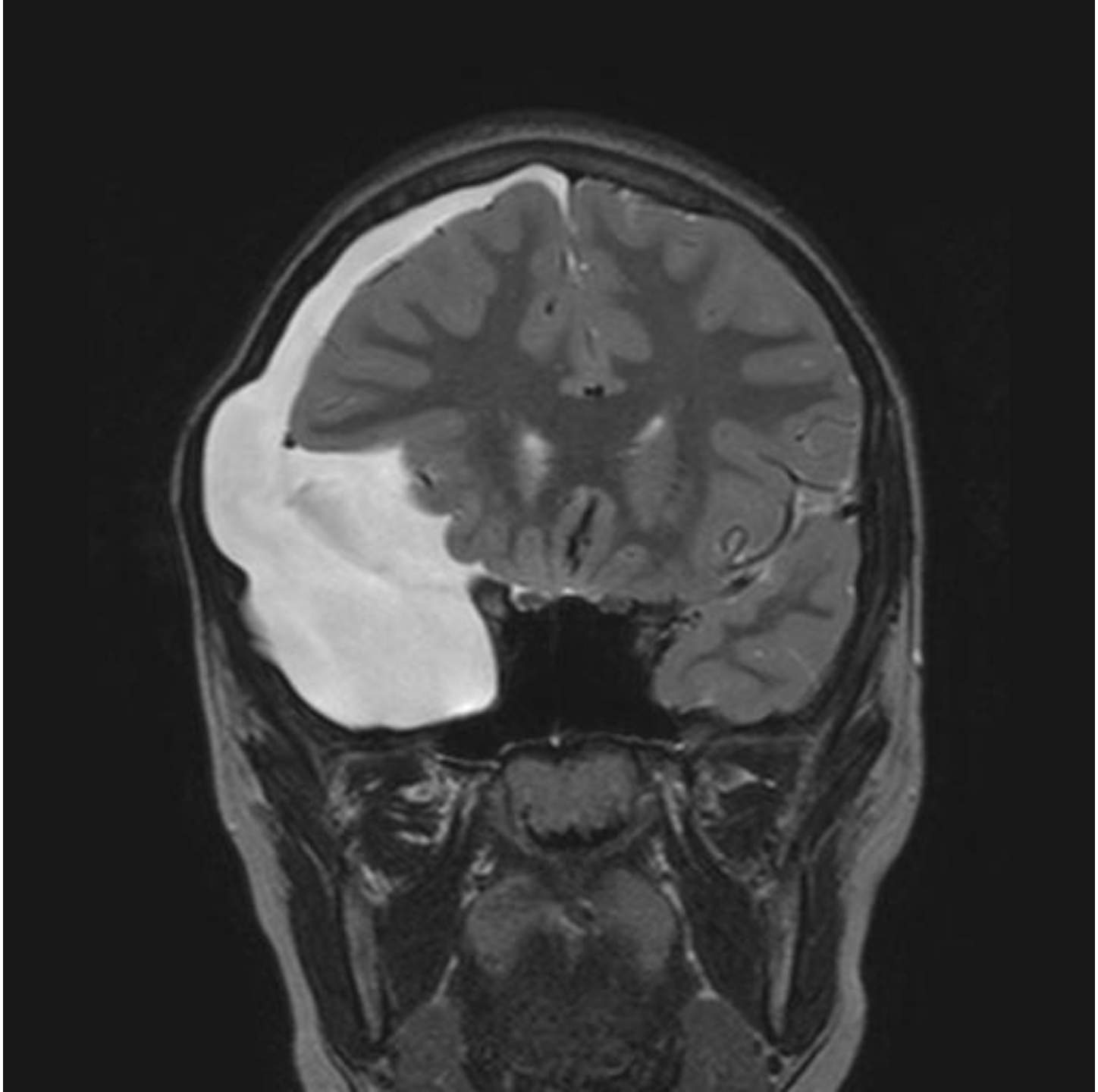

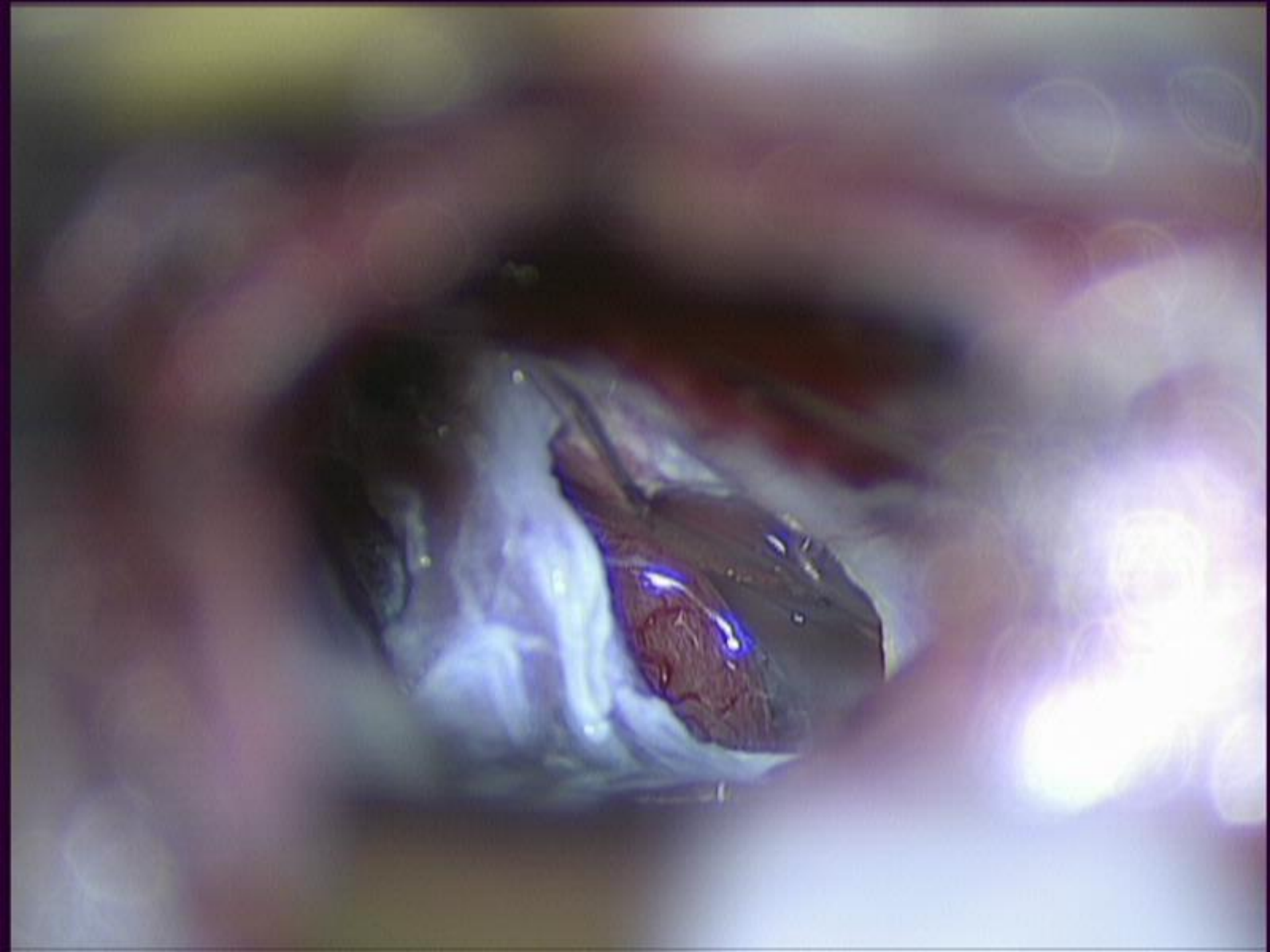


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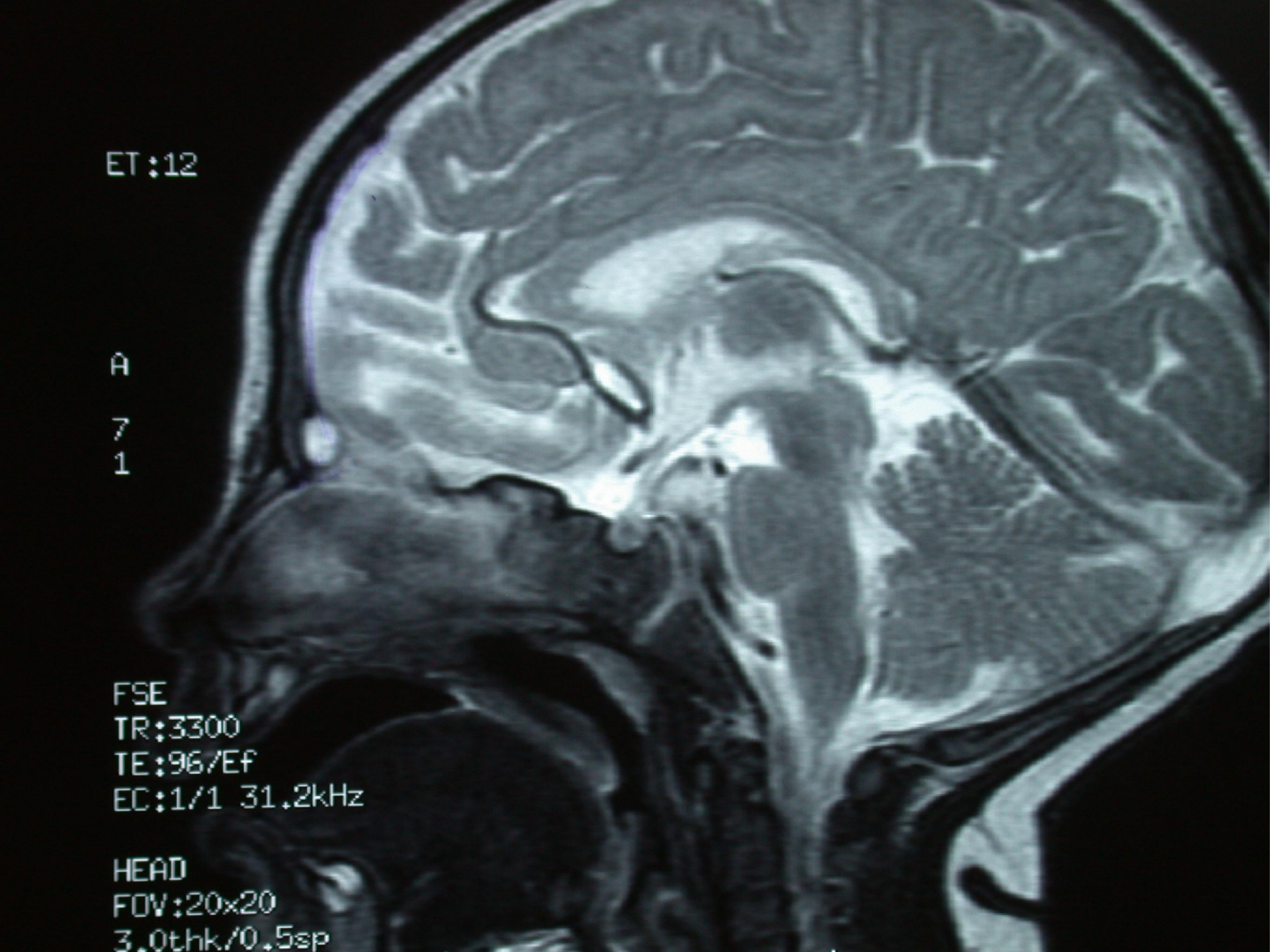
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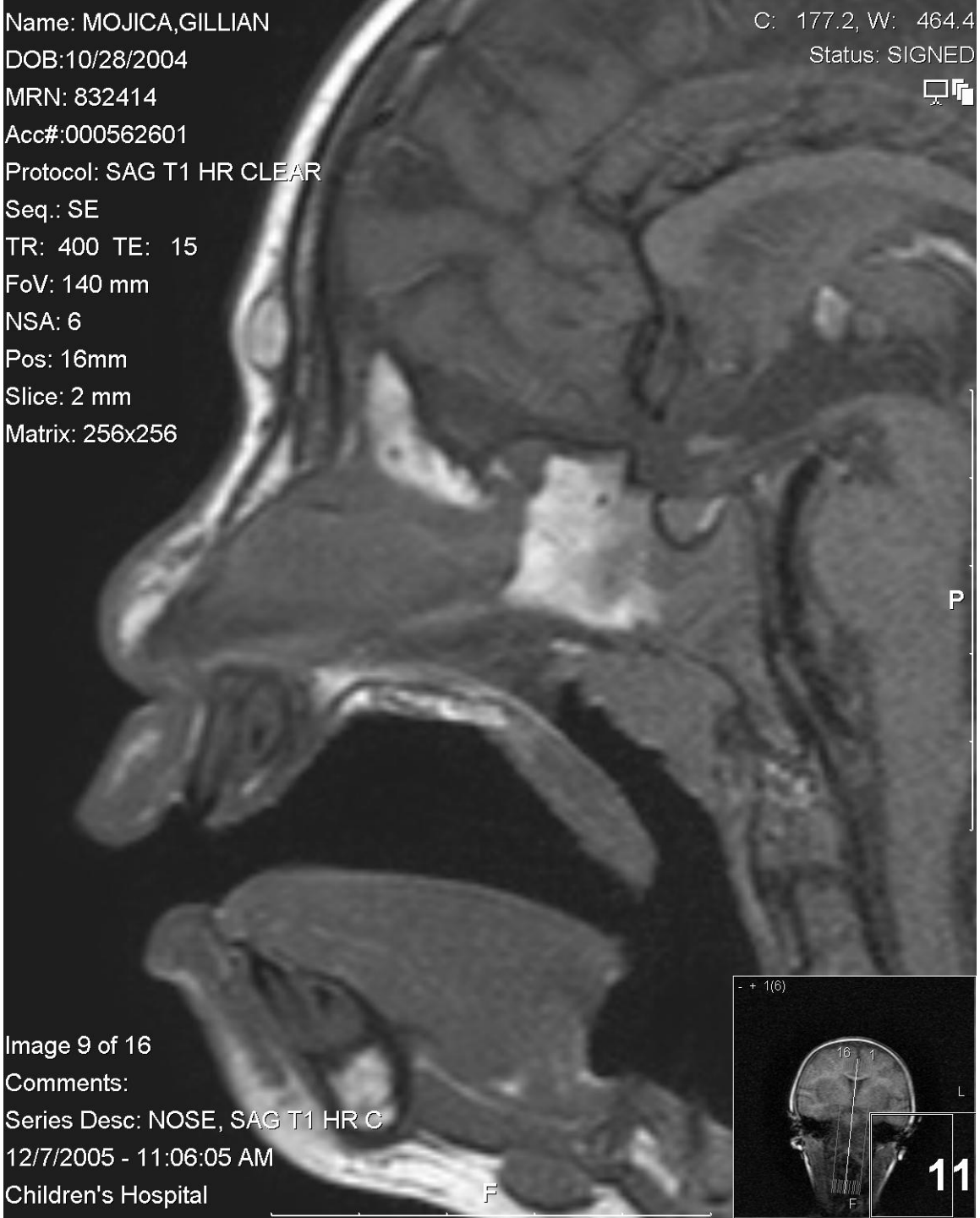
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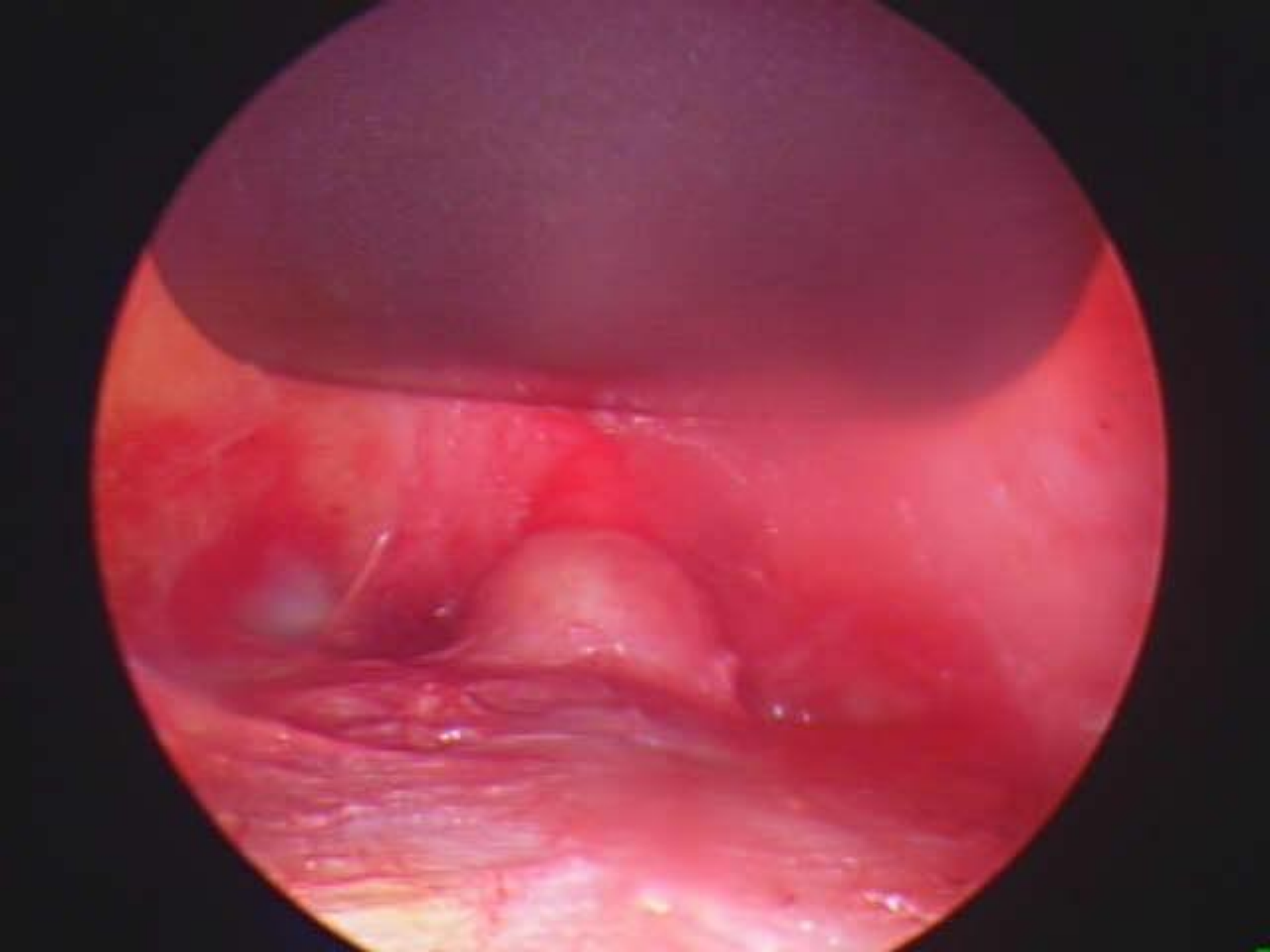
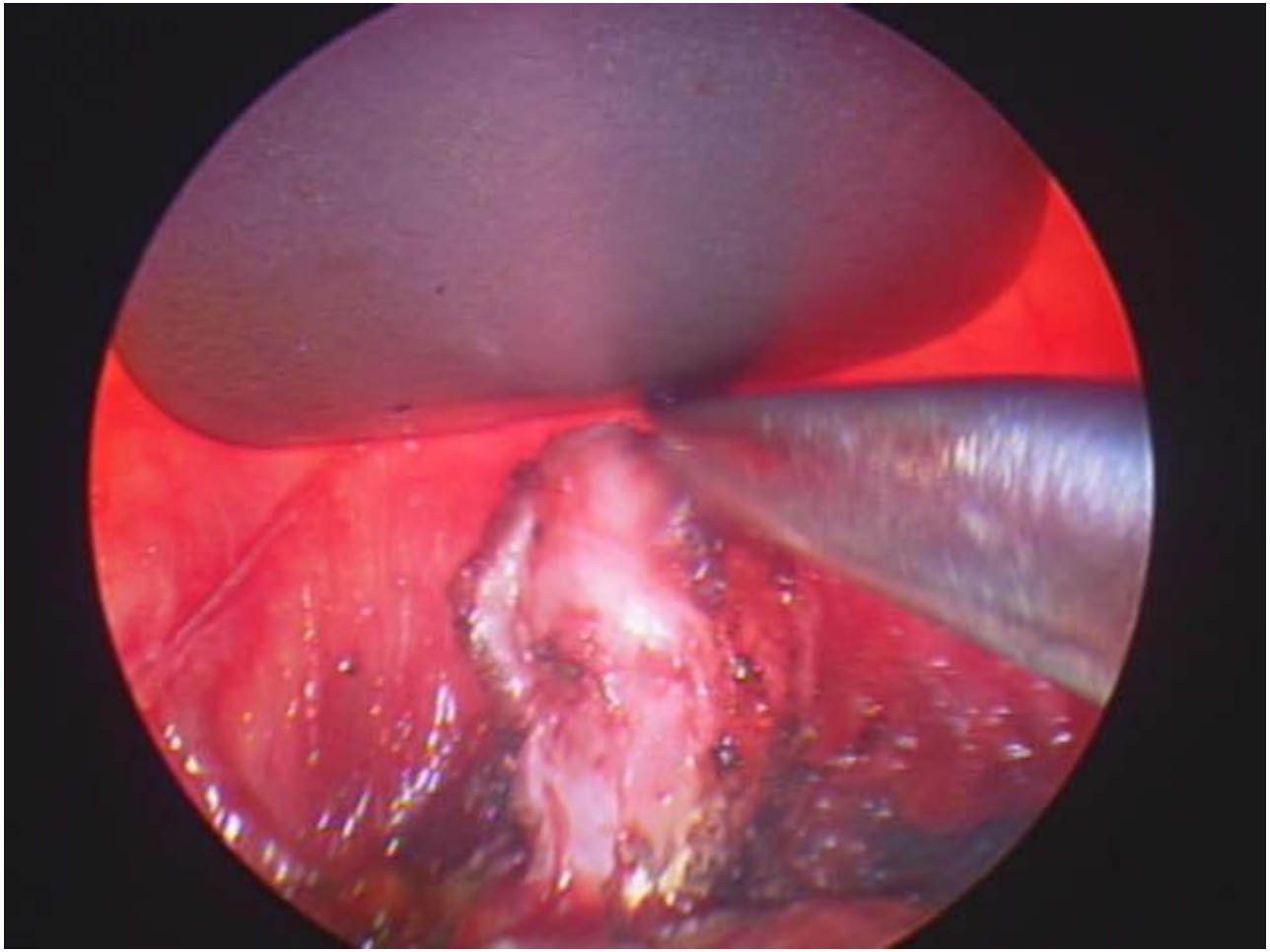
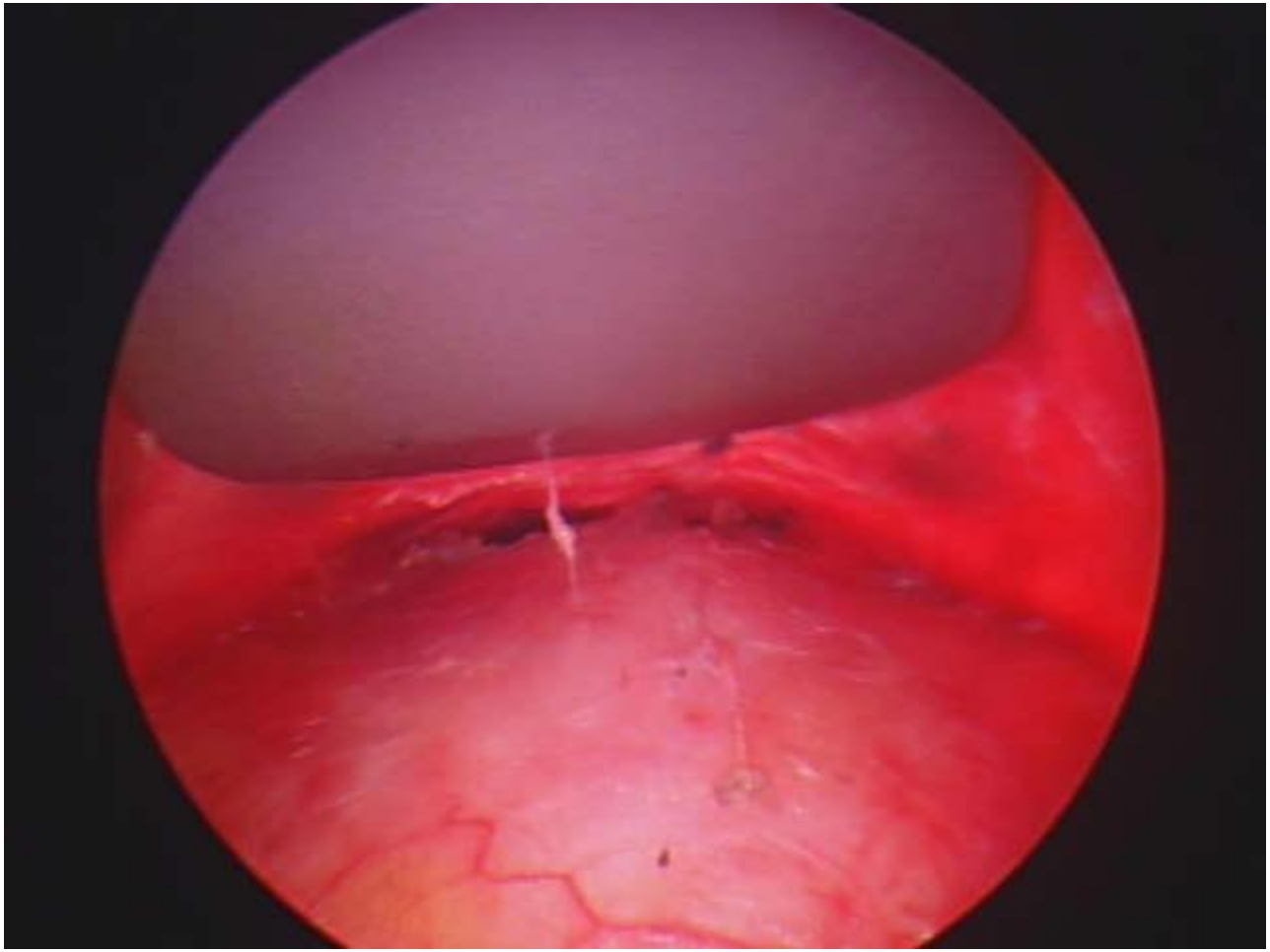
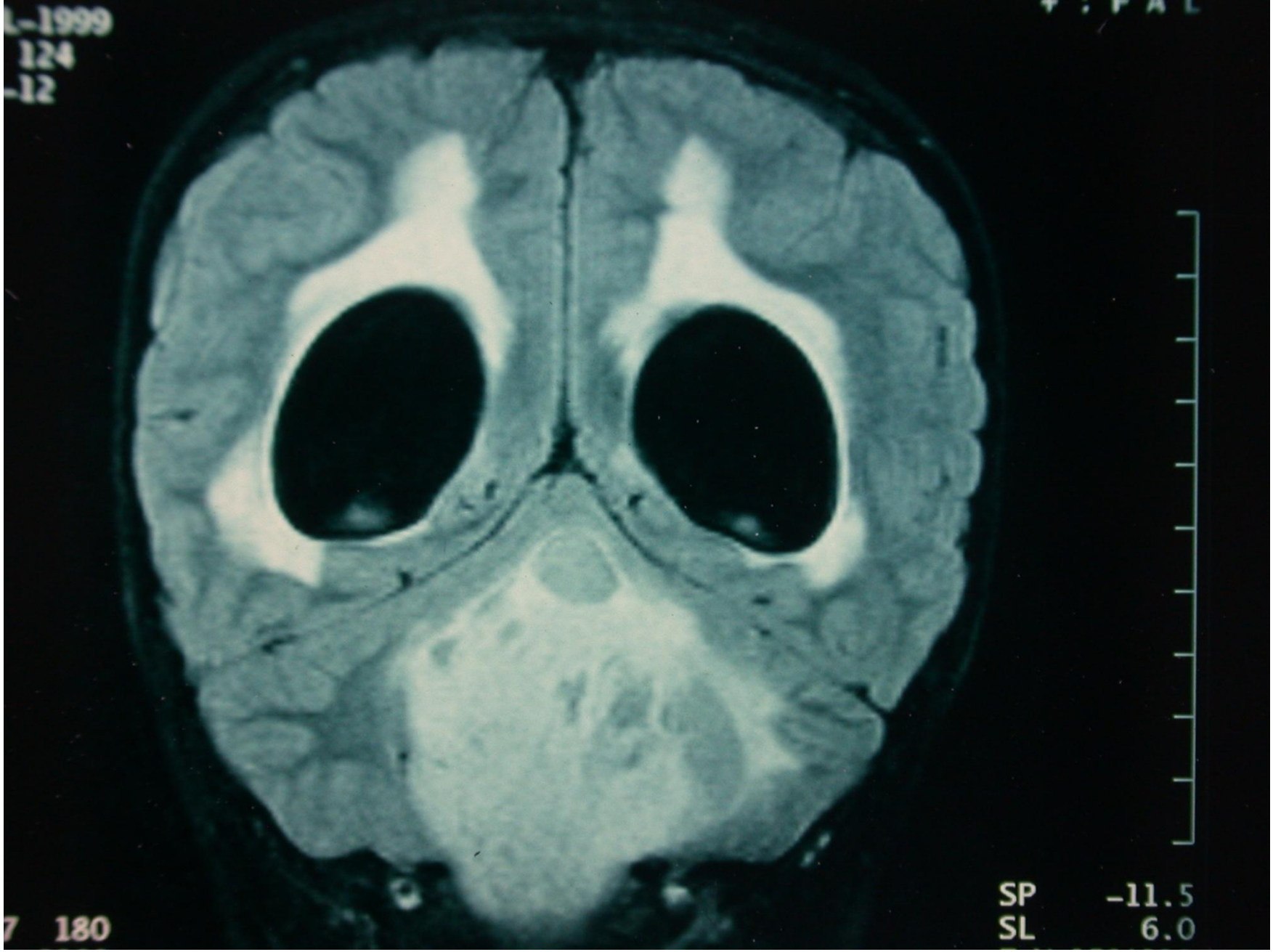
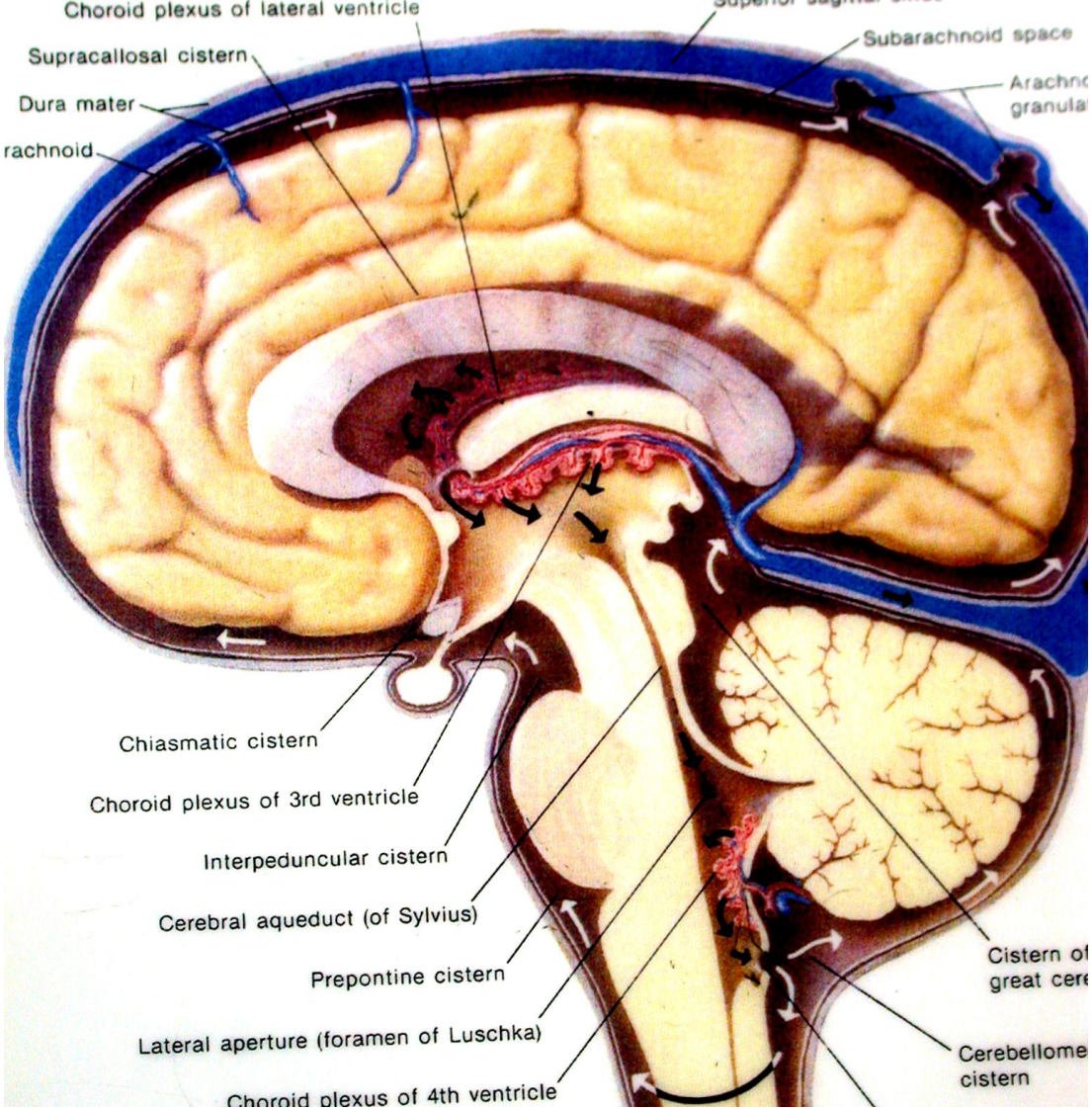







SP -11.5
SL 6.0



Flow: Lat vent - foramen of Monroe - IIIrd vent- aqueduct of Sylvius - IV vent - Luschka & Magendie - subarachnoid space

Hydrocephalus: Mismatch of CSF production and absorption

Ventriculomegaly: Large ventricles

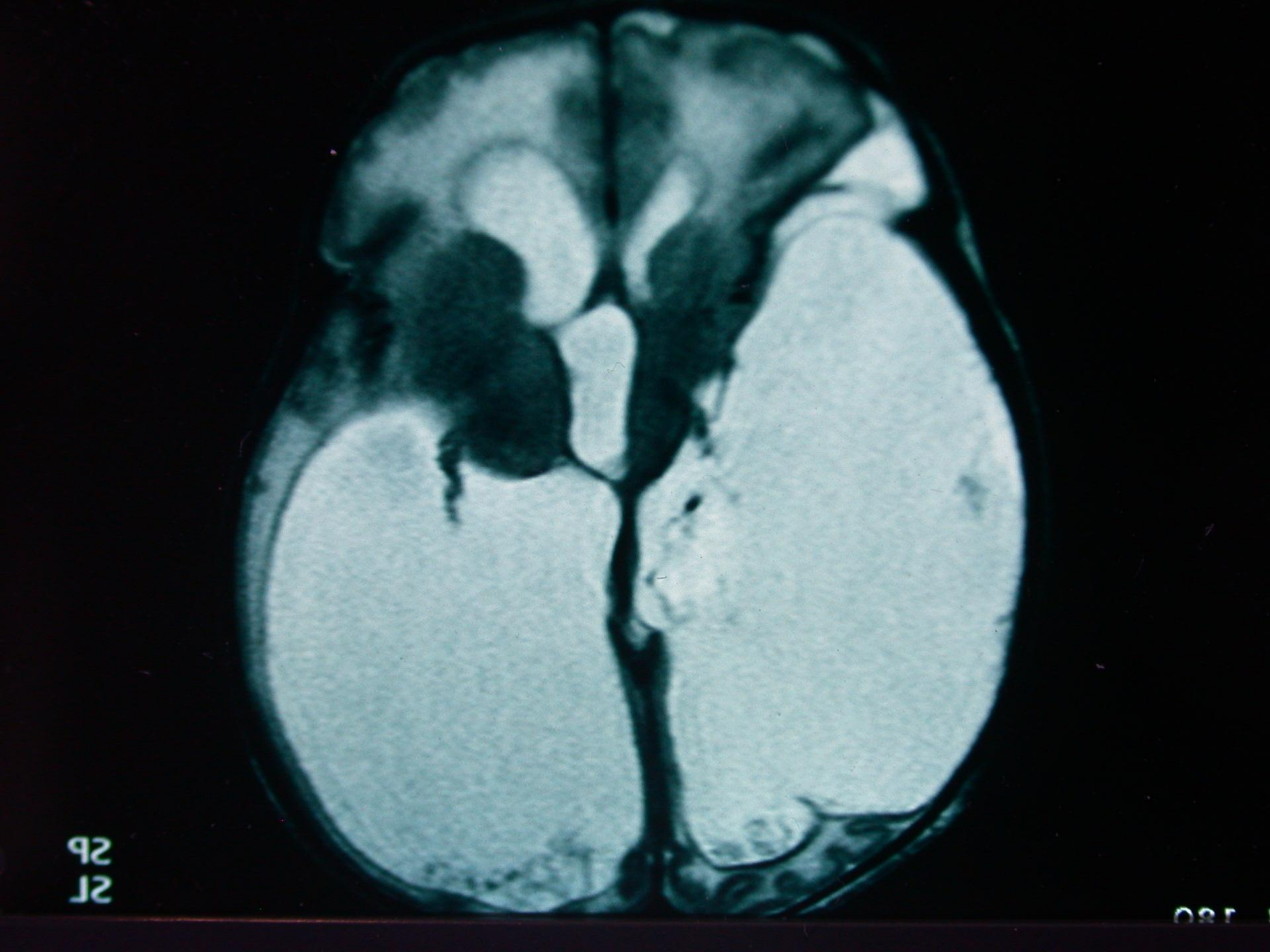
Etiology of Hydrocephalus

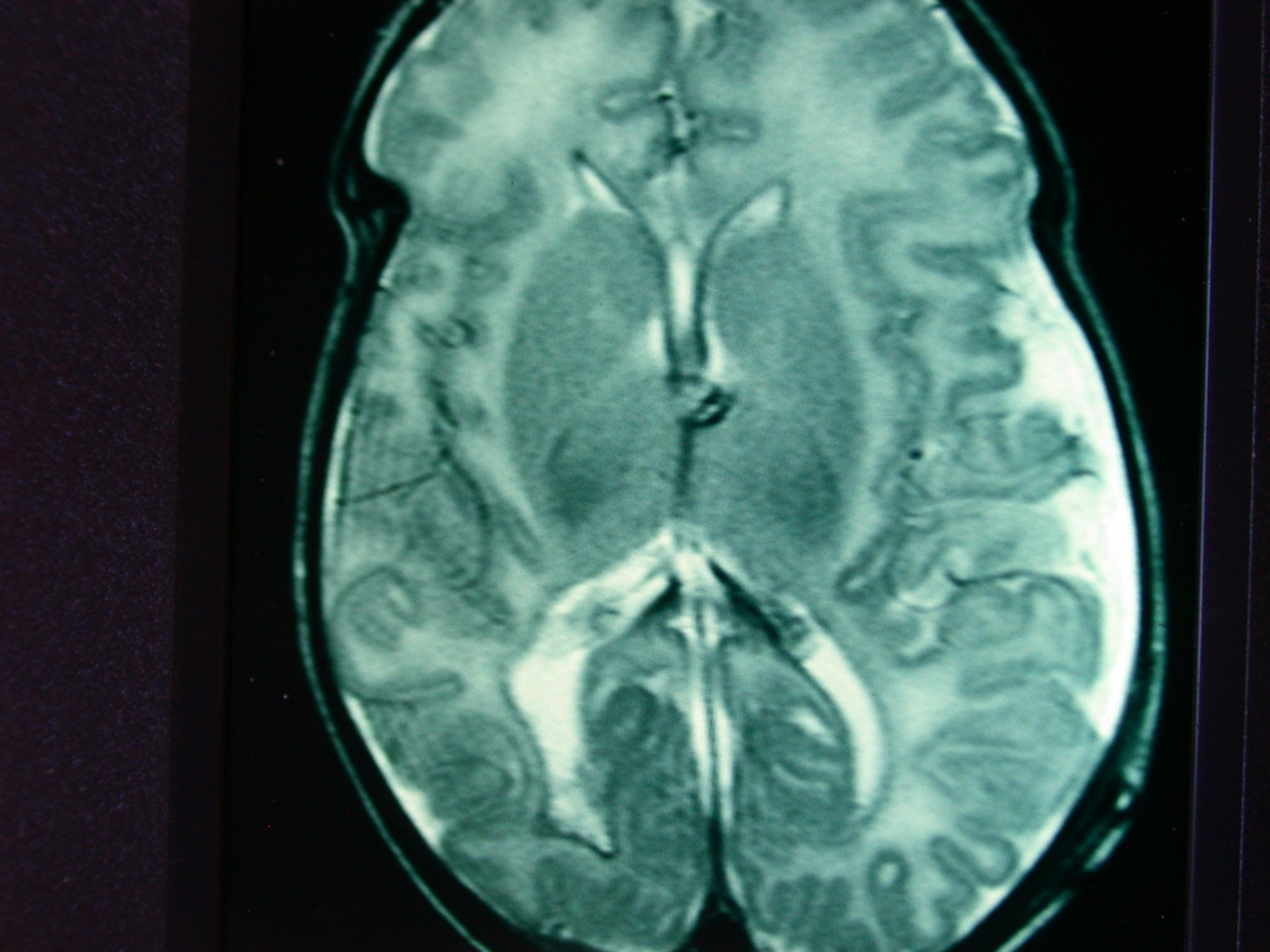
- Congenital
  - Chiari II (myelomingocele) 85%
  - Aqueductal Stenosis
  - Dandy Walker malformation
- Acquired
  - infectious
  - post-hemorrhagic - IVH: 20-50%
  - tumor
  - post-operative


1.0
04:14:52
Mag =
FL:
ROT:
P A
L R
SE
TR:500
TE:20
EC:1/1 16kHz
HEAD
FOV:20x20
5.0thk/1.0sp
16/03:16

Clinical Characteristics

Newborns	Infants
Full Fontanelle	Enlarging HC
Sunsetting eyes	IV nerve palsy
Split Sutures	Papilledema
A&Bs	Irritability
Macrocephaly	Emesis





Outcome with shunts

Natural history of untreated hydrocephalus

Mortality	**70%**
Disability	**75%**
Mental Retardation	**>50%**

Jansen J, Acta Neurol Scand 1985
Foltz EL, J Neurosurg 1963
Laurence KH, Arch Dis Chil 1965

Outcome of shunted hydrocephalus

Mortality	**<15%**
IQ>80	**50%**
	(verbal IQ > performance IQ)
Palliative	

Hirsch JF, Child's Nerv Syst 1994

Prognostic variables of shunted hydrocephalus

- **Etiology**
- **Age at Diagnosis**
- **Degree of Ventriculomegaly**
- **Age at Treatment**

Outcome of shunted hydrocephalus

Etiology	IQ> 80
Chiari II	70%[1-3]
Aqueductal Stenosis	50-65%[4,5]
Dandy-Walker	30-50%[6,7]
IVH	~Grade & lesion

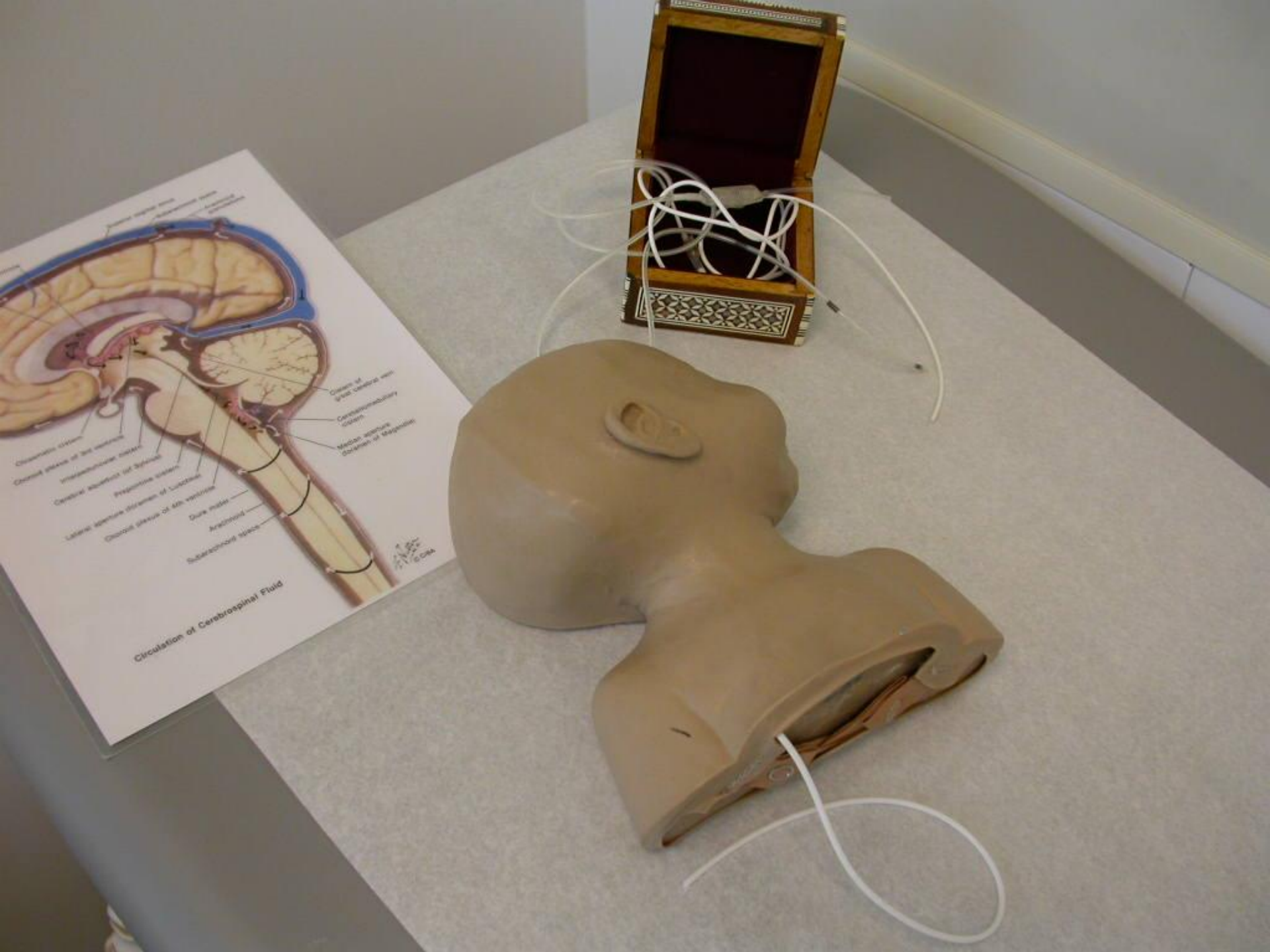
1 Hemmer R, Arch Psych Nerv (German) 1981
2 McCullough DC, J Neurosurg 1982
3 Raimondi AJ, Am J Dis Child 1974
4 Villani R, Child's Nerv Syst 1995
5 Guiffre R, J Neurosurg Sci 1986
6 Hirsch JF, J Neurosurg 1984
7 Sawaya R, J Neurosurg 1981

Fetal hydrocephalus: AW> 20mm for greater than 2 months leads to uniformly poor outcome

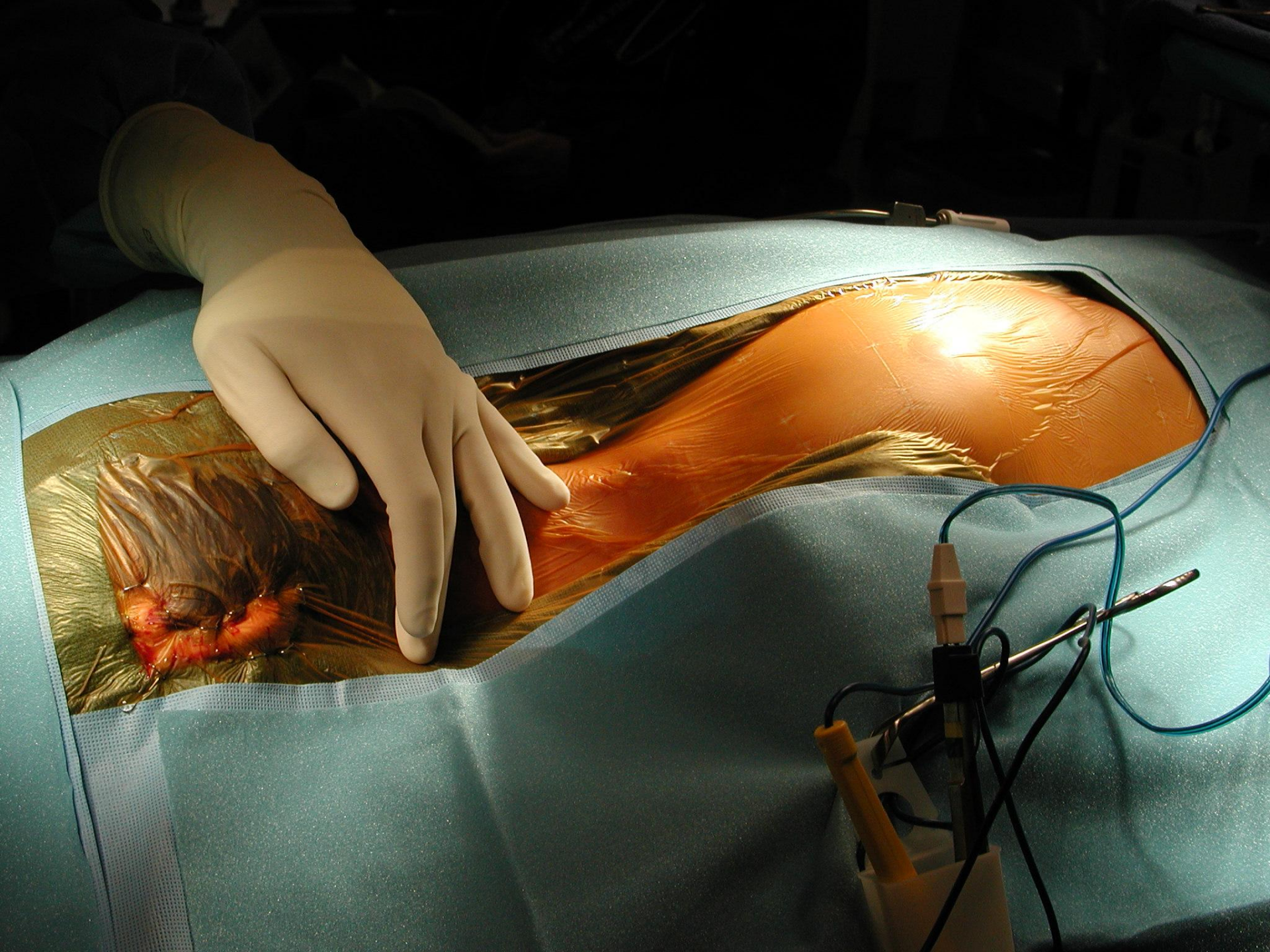
-Rapidly progressing fetal hydrocephalus, early delivery and shunting may be considered after 32 weeks (C-section)

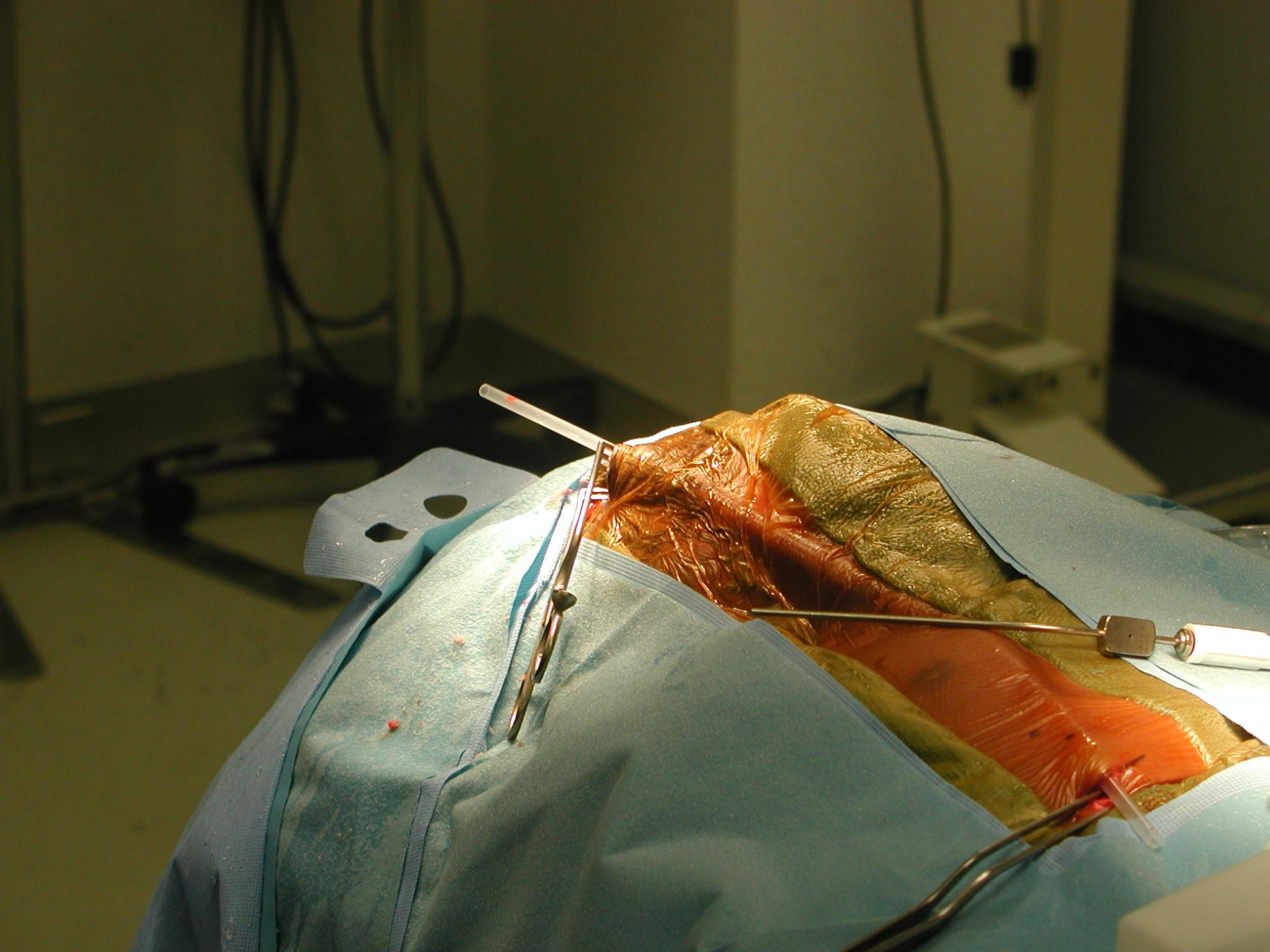
- **Age at Treatment**

For infants with overt hydrocephalus, clinical experience points to a critical limit of age 2-5 month for shunting to achieve a good outcome


Circulation of Cerebrospinal Fluid


OR7
VP shunt in progress...
Please keep out!
Time Out:
1. Patient
2. Procedure
3. Site
4. Side
Thank YOU all!
PLEASE
DO NOT ENTER
NEUROSURGERY
HARDWARE
IMPLEMENTATION
IN PROGRESS





1. **No traffic**
2. **IV abx**
3. **IT Vanco**
4. **Abx irrgation (Baci/Kefzol)**
5. **Triple prep**

2010: Infection rate 1.3%!

Implications of a shunt

- Lifetime dependence

Shunt Malfunction

- 30-40% failure rate in 1st year[1]
- @ 4-6 revisions / 20yrs[1]
- independent of shunt type, 50% in 2 years[2]

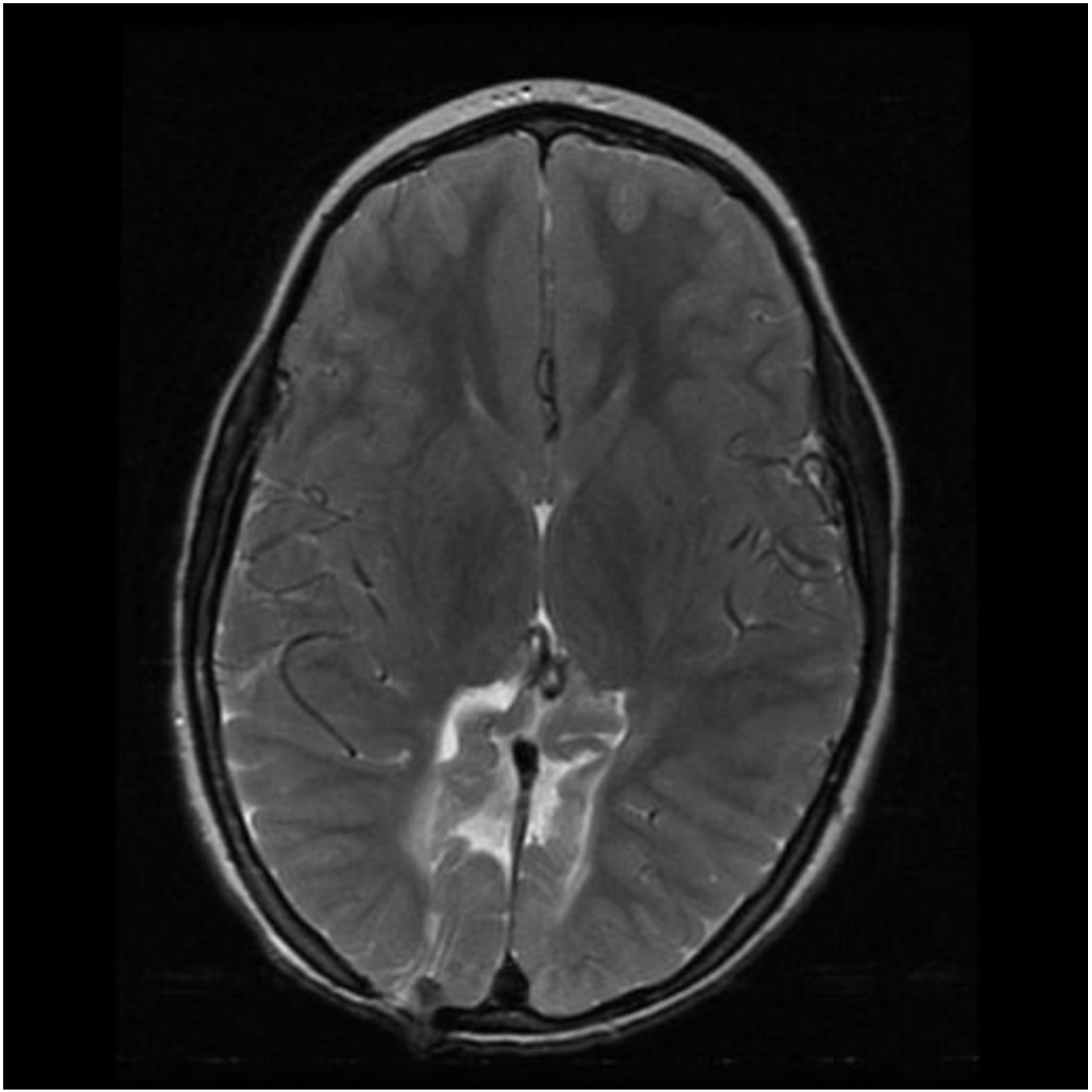
Proximal Shunt Malfunction

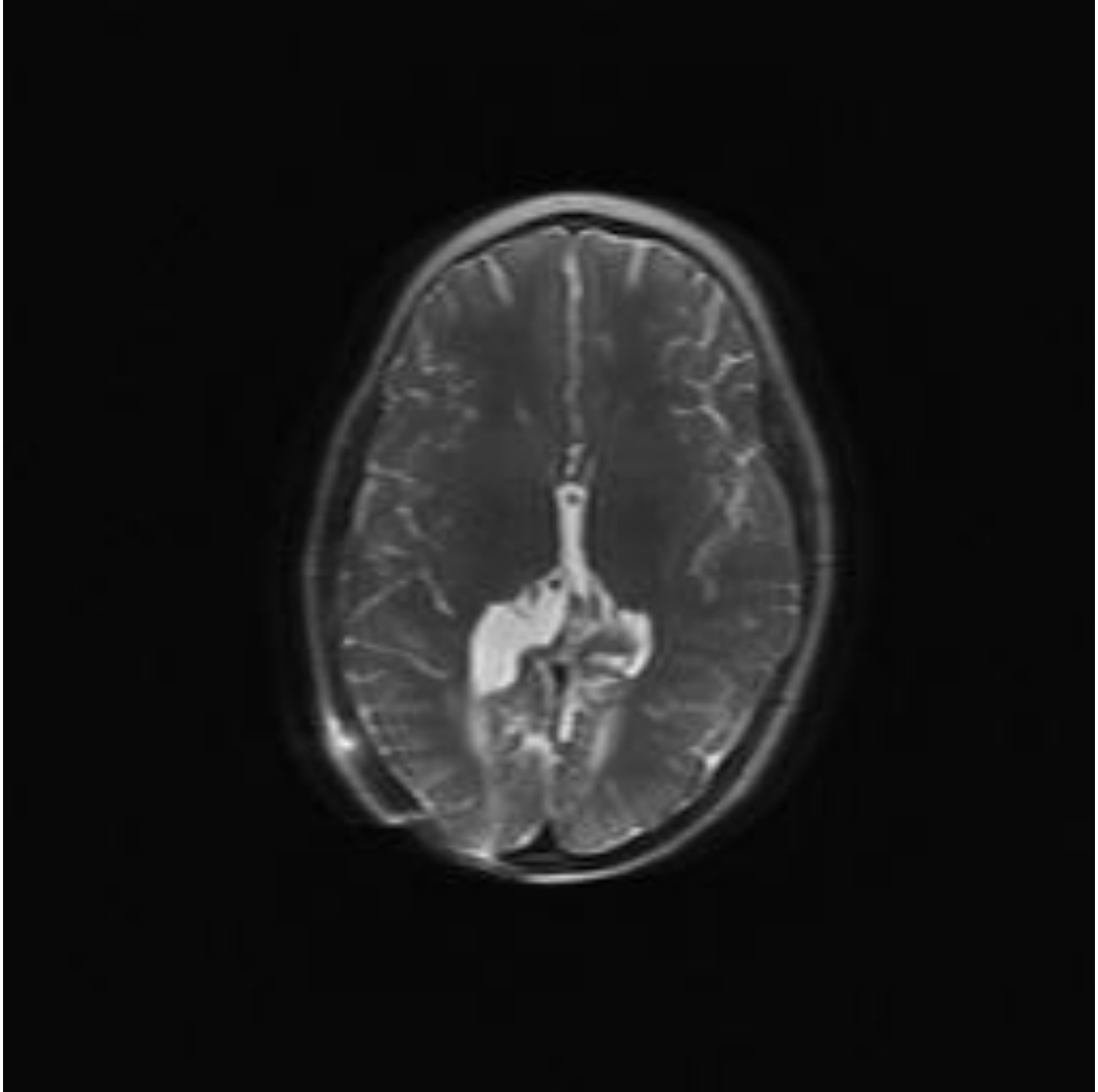
- choroid plexus / ventricular surface:
  OVERDRAINAGE - siphoning, one way valve
- too short
- poor positioning

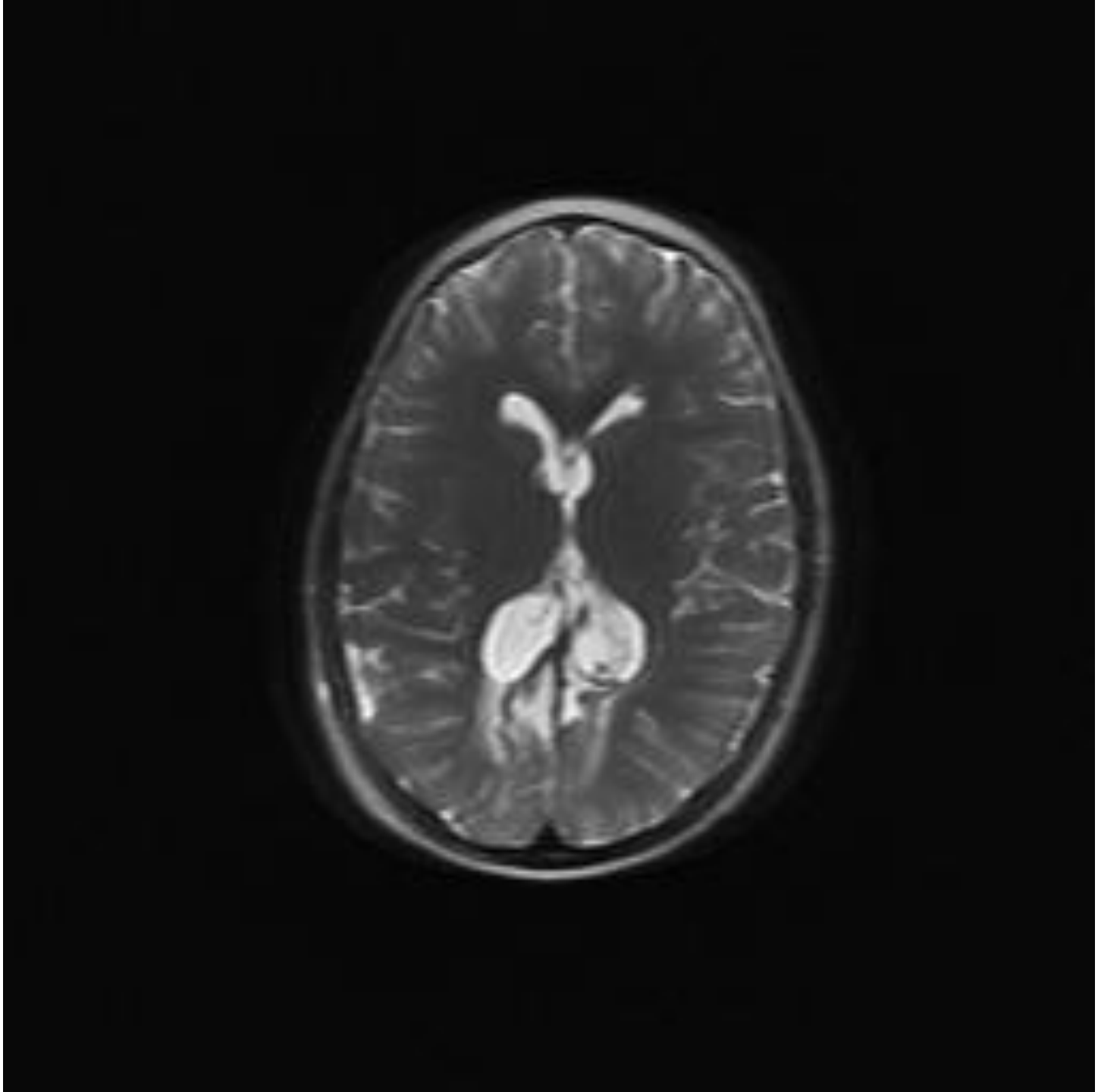
(Left) Do not remove the valve from the sterile packaging. Turn sterile package face down so that the translucent tray and valve are facing up. Position the Locator Tool above the valve so that the Locator Tool's blue flow direction arrow is aligned and centered with the direction of CSF flow through the valve.

(Right) Keeping the Locator Tool in position, set the Indicator Tool into the Locator Tool while aligning the red bands on the tools and rotating the Indicator Tool as necessary until it settles into place. Record current performance level setting.

NOTE: All valves are preset to



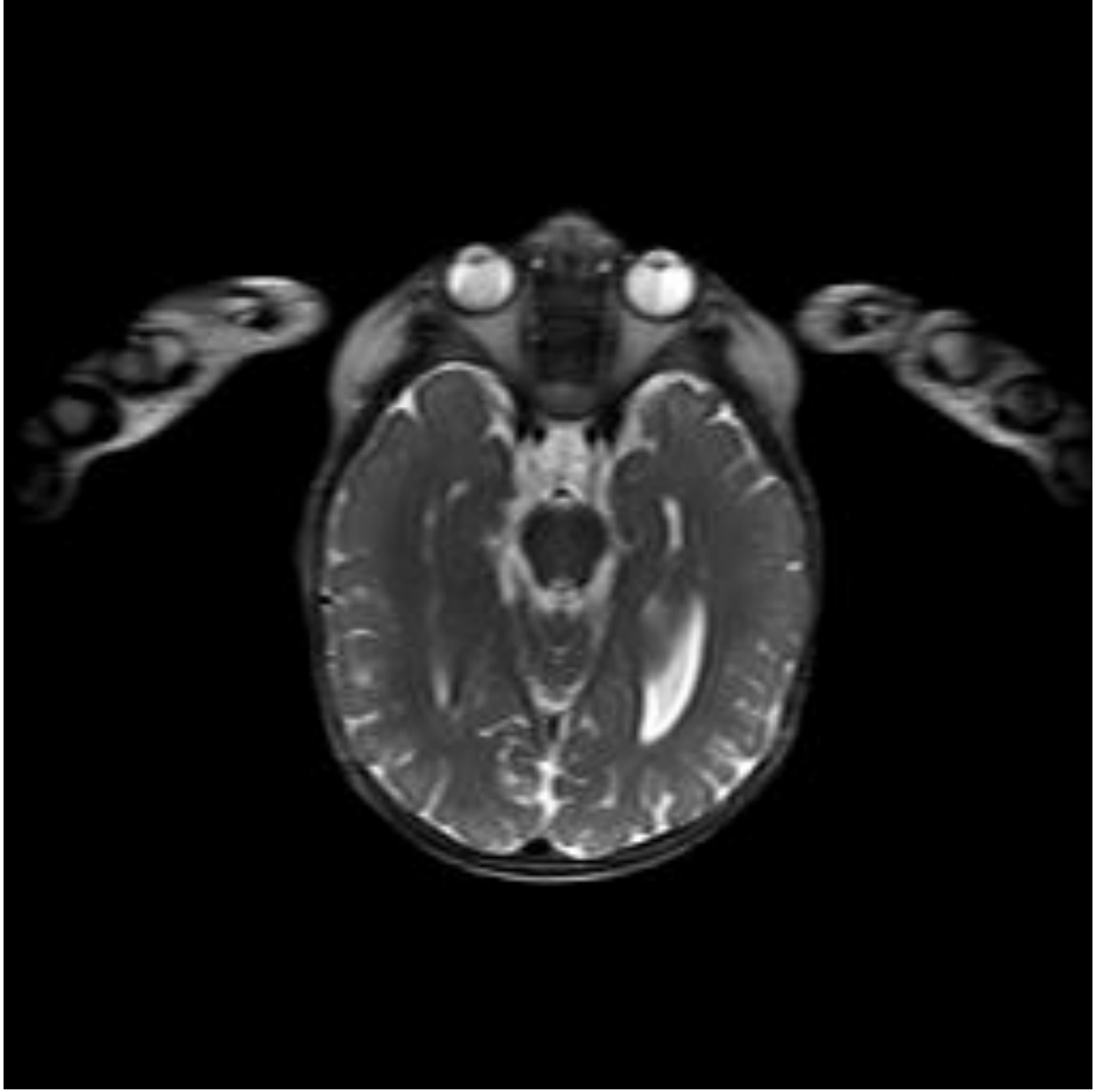




Adjustable Shunts +
Intraoperative Imaging+
Computer Navigation

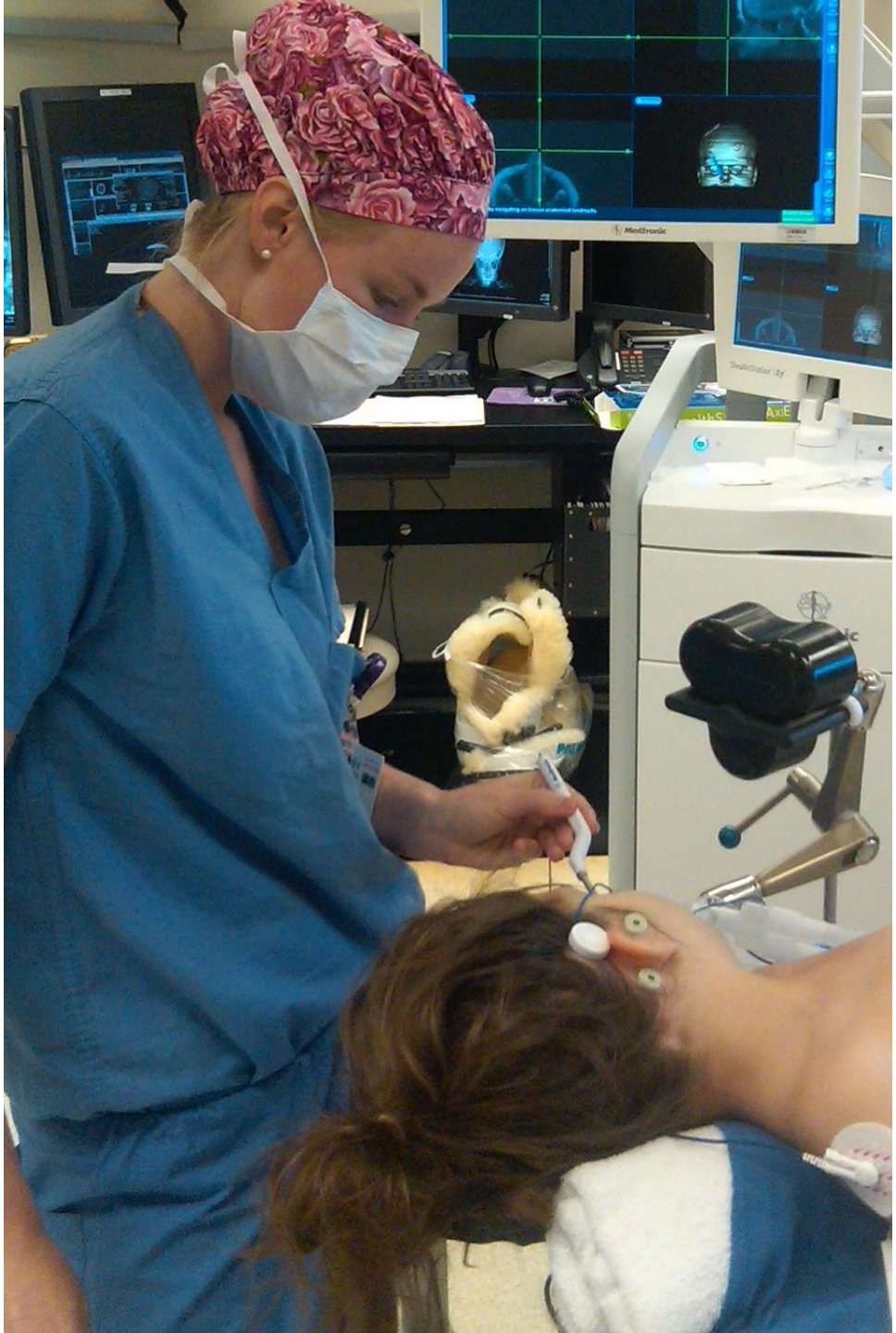
Shunt Revision:
2001: N=128 (240)

2010: N=47 (400+)



No more CT scans!!!

“quick MRI”: no sedation, no radiation!!


Medtronic

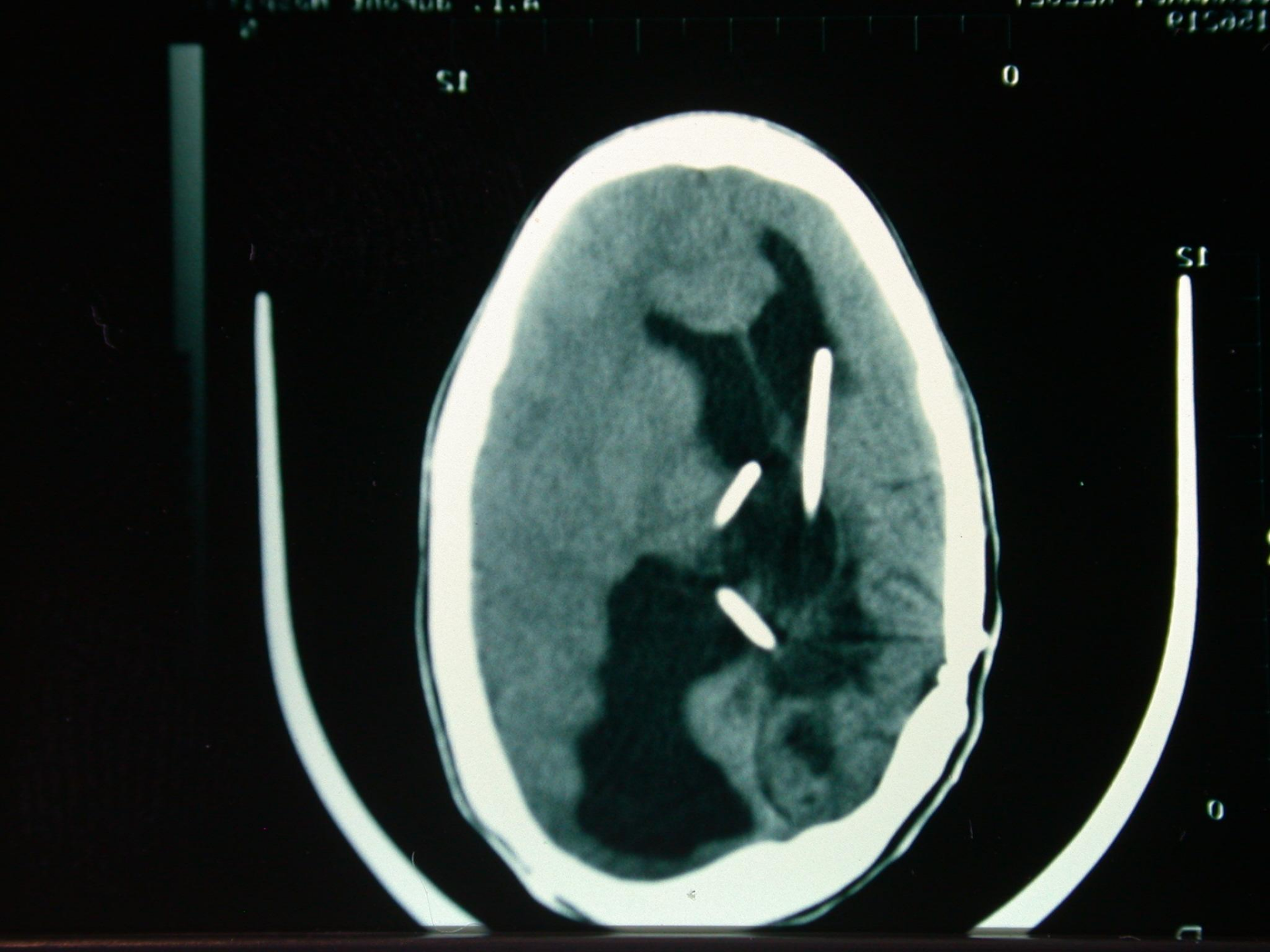
- Endoscopic fenestration:

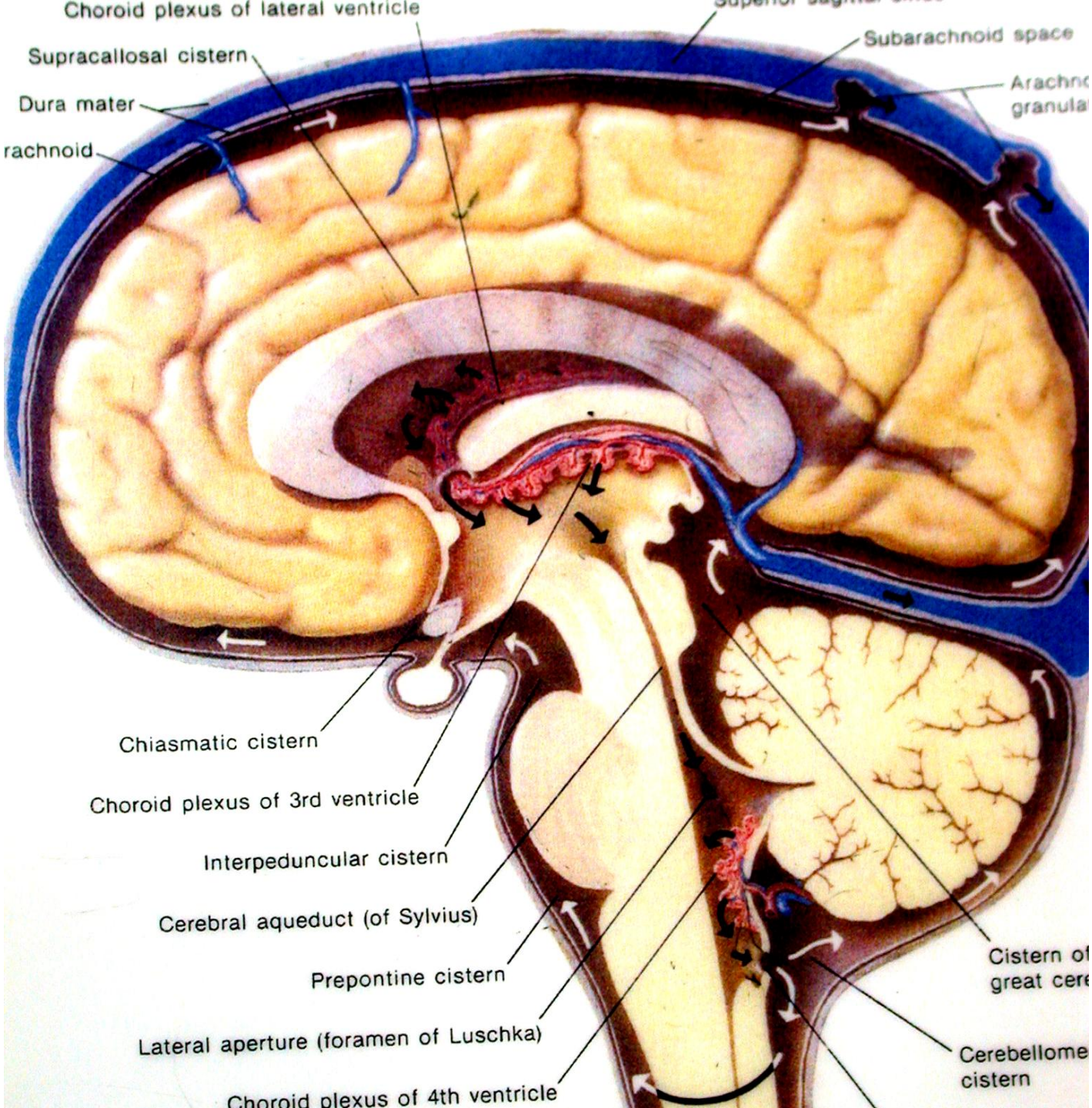
- large instrumentation
  not ideally suited for neonatal brain

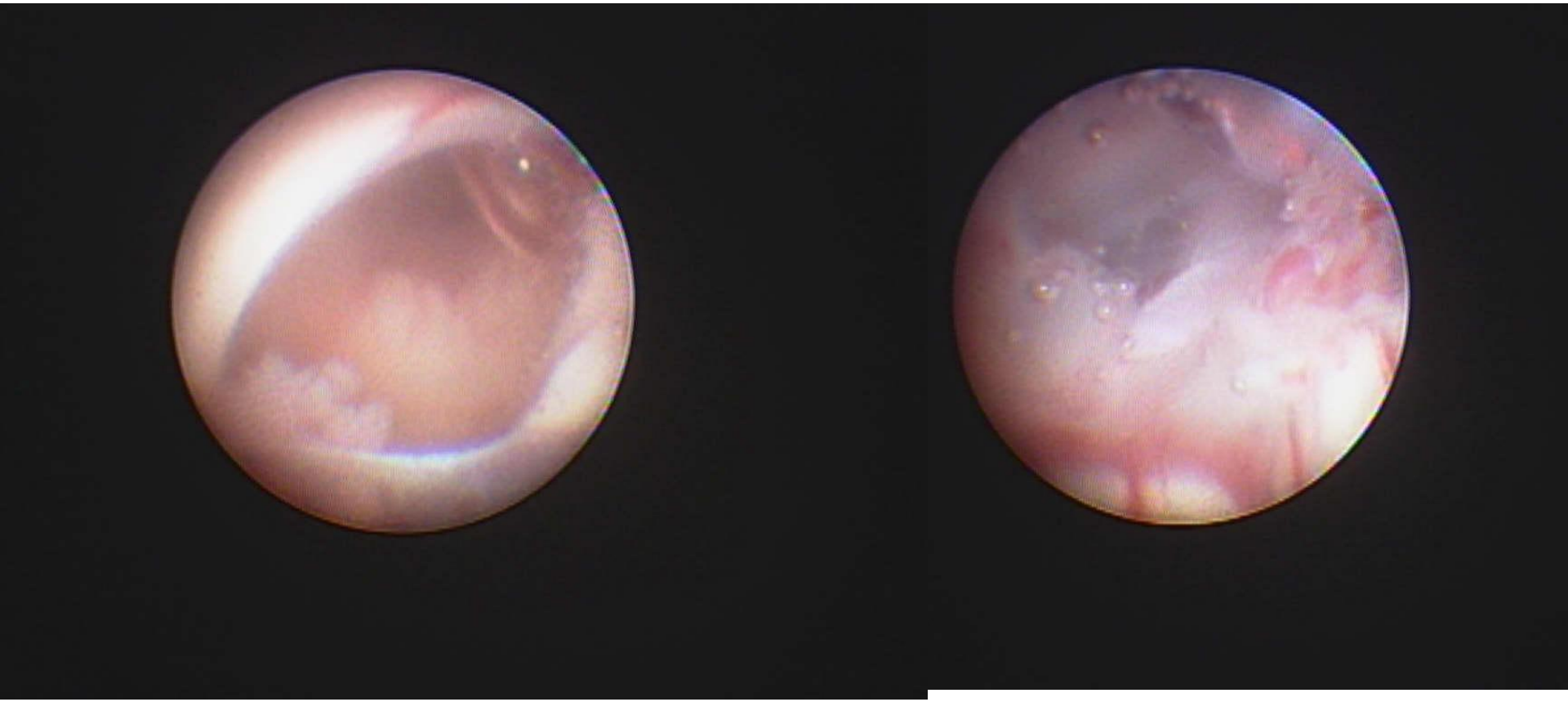
- Endoscopic 3rd ventriculostomy

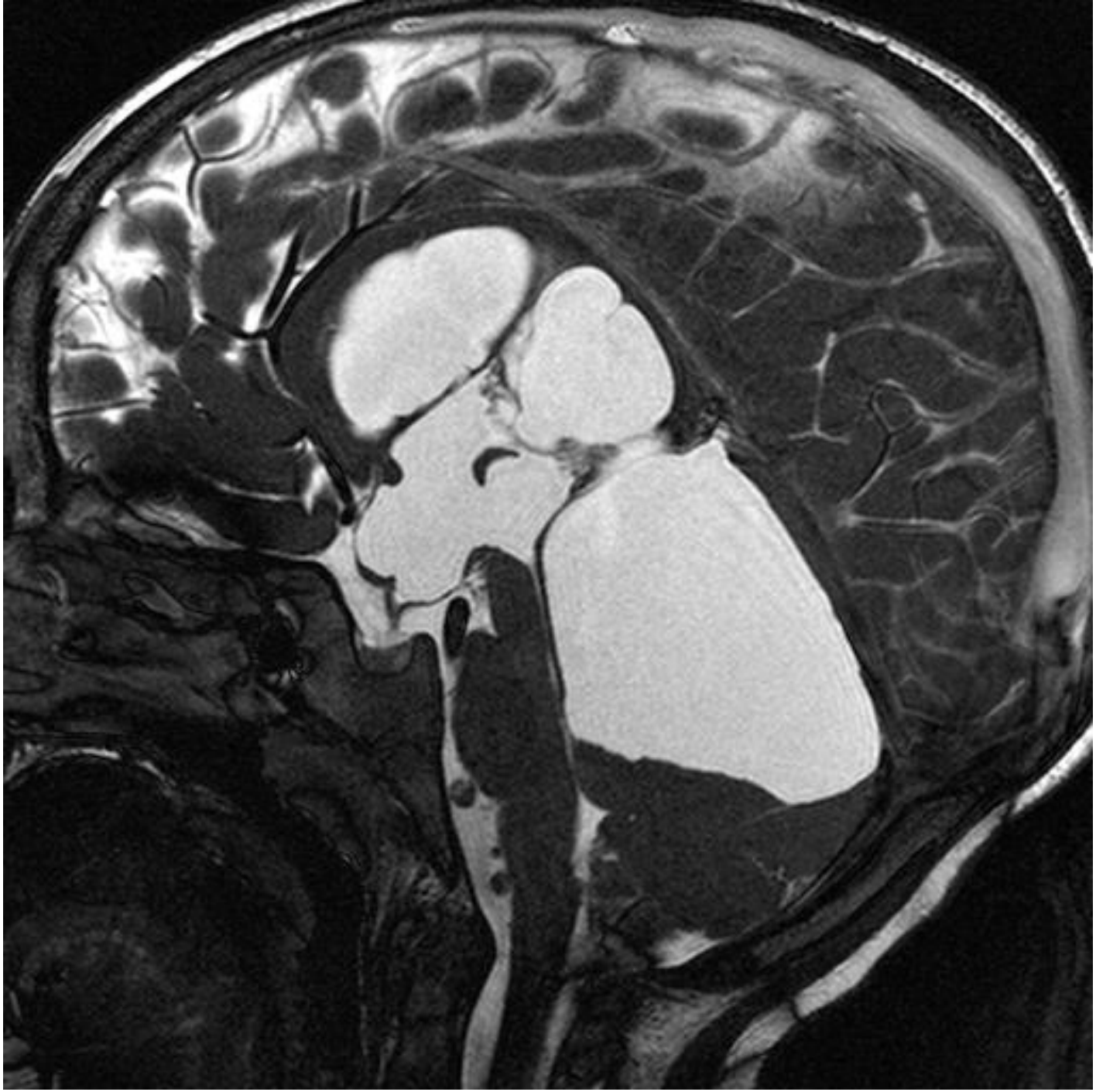
- obstructive hydrocephalus
- relies on well developed CSF circulation,
  high failure rate <2yo

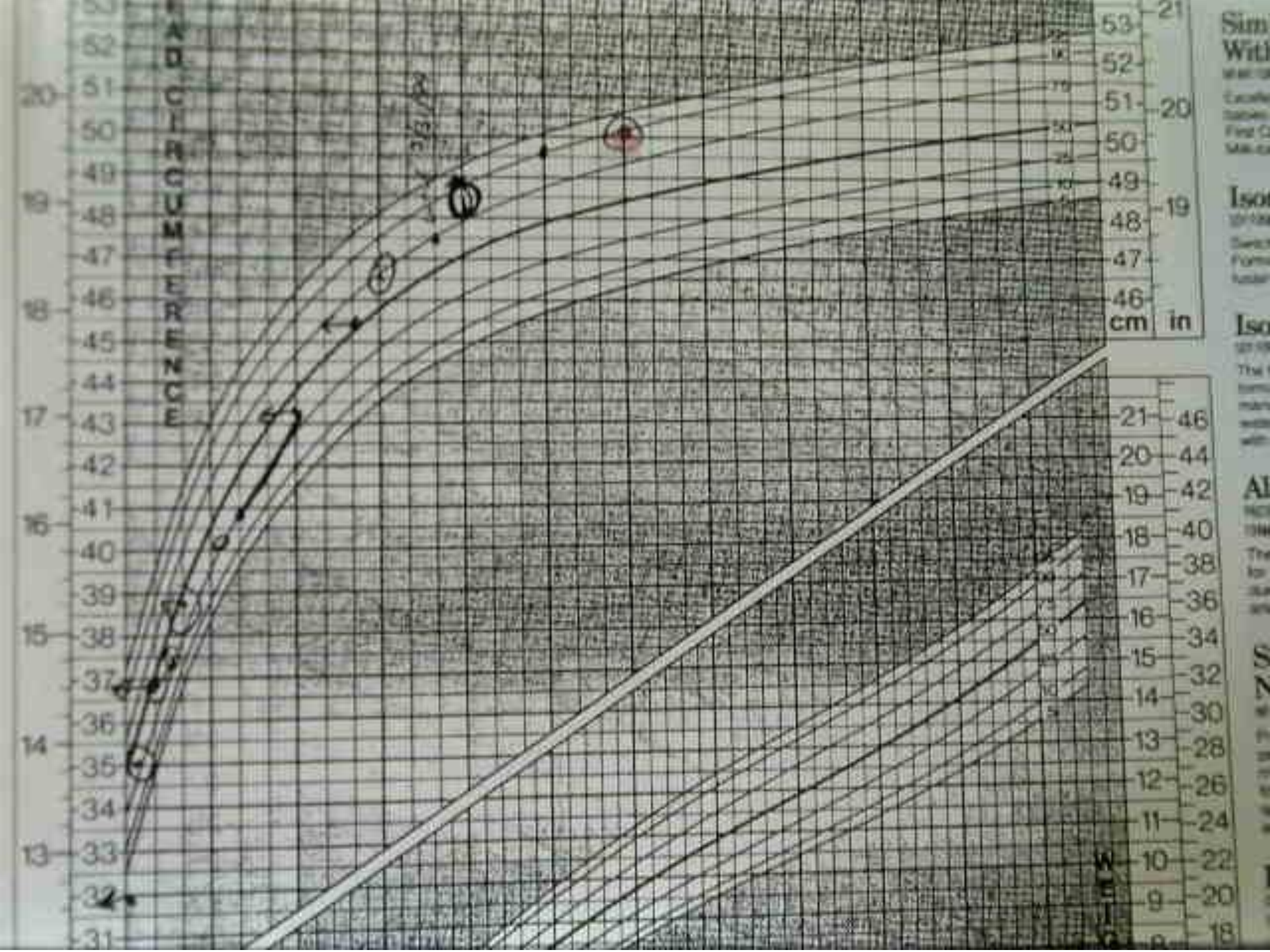

S70
LULA.


15
0
15
0


Choroid plexus of lateral ventricle
Supracallosal cistern
Dura mater
rachnoid
Subarachnoid space
Arachno
granula
Chiasmatic cistern
Choroid plexus of 3rd ventricle
Interpeduncular cistern
Cerebral aqueduct (of Sylvius)
Prepontine cistern
Lateral aperture (foramen of Luschka)
Choroid plexus of 4th ventricle
Cistern of
great cere
Cerebellome
cistern






HEAD CIRCUMFERENCE
cm
in
WEIG

Benign External Hydrocephalus*

Presentation: Macrocephaly

Imaging: Prominent SA spaces with mild ventriculomegaly

Resolves by 12-24 mo

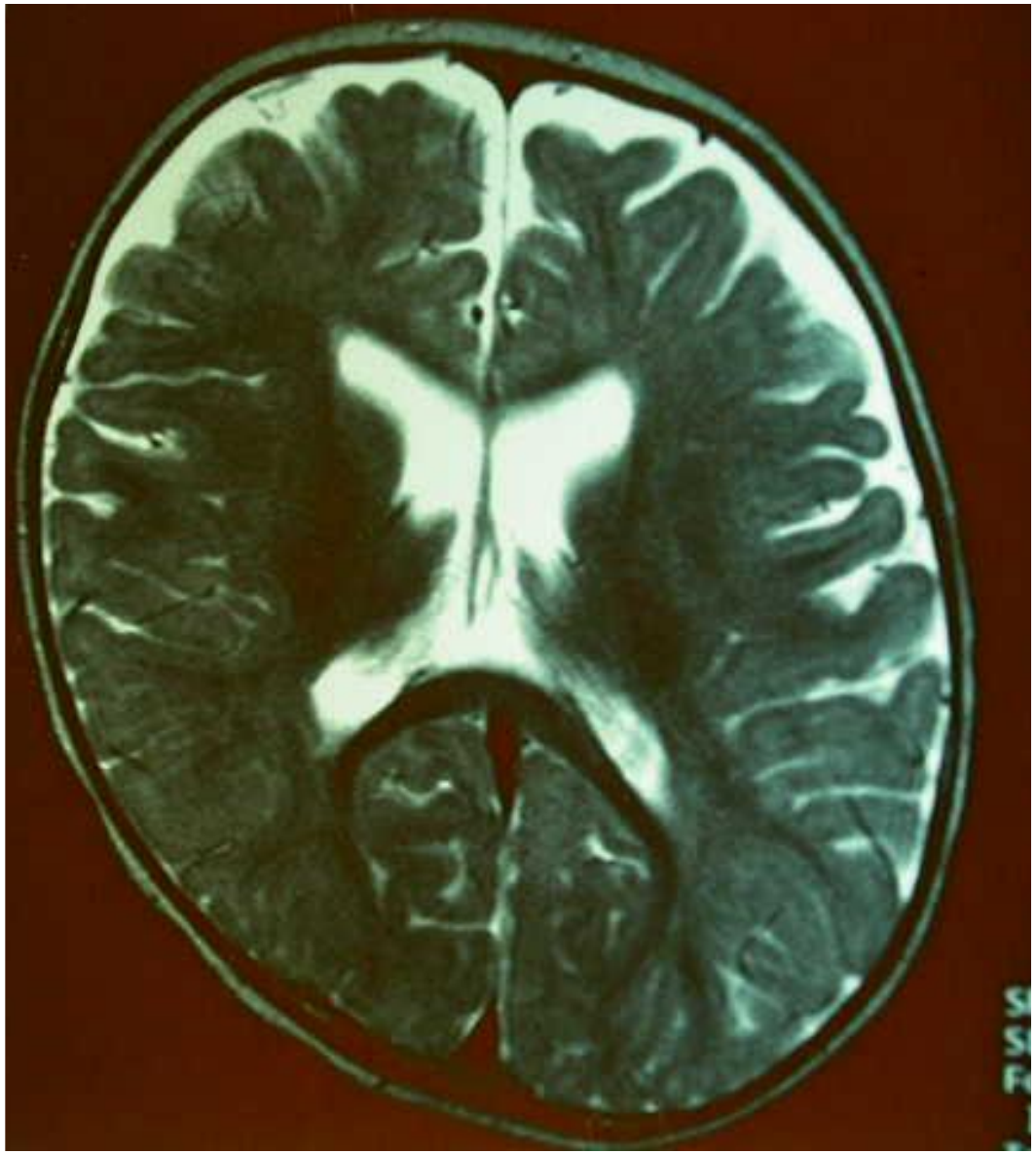
Developmentally normal (40% interim motor delay)

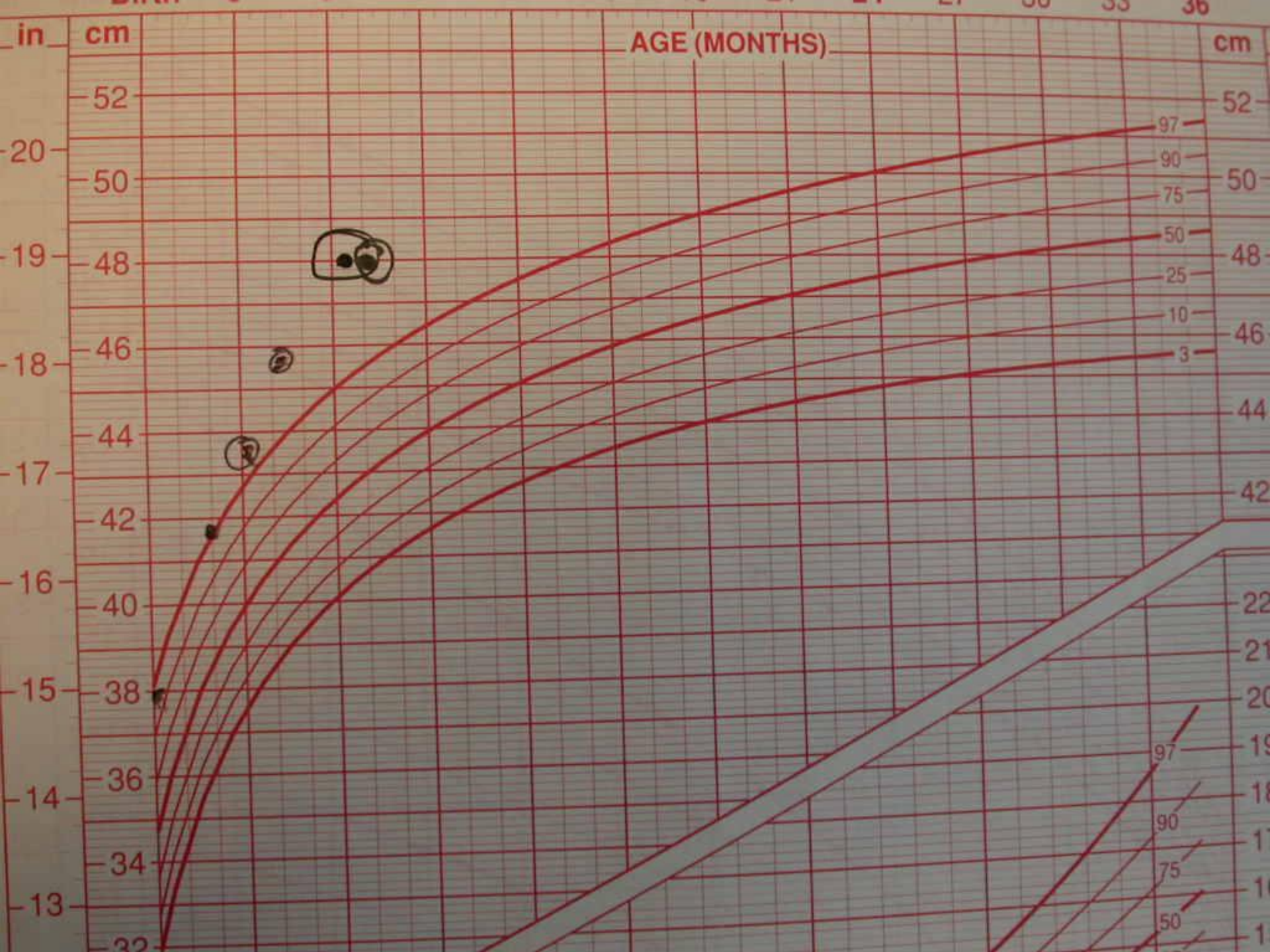
Associated with positional plagiocephaly

88% had family history of macrocephaly

Do not Shunt

*Alvarez L, Pediatrics 1986

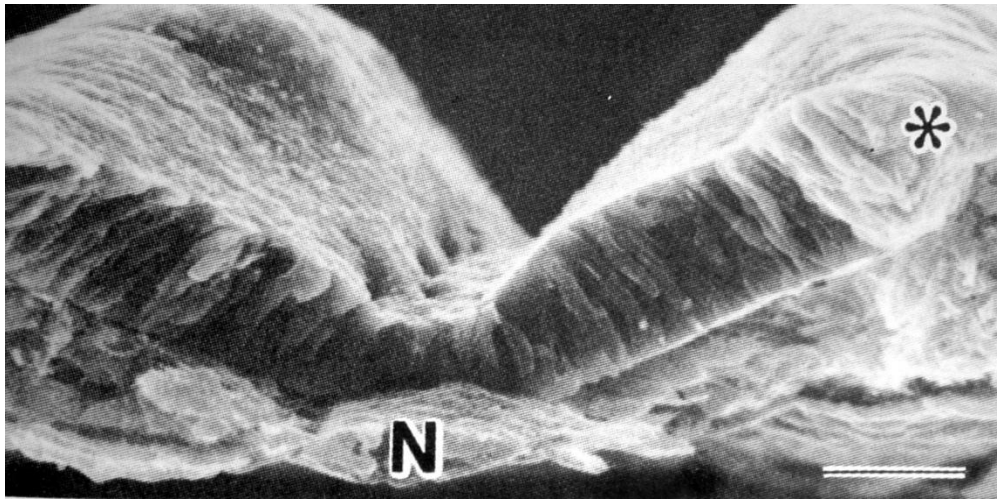



in
cm
AGE (MONTHS)
cm
52
20
50
19
48
46
18
44
17
42
16
40
15
38
36
14
34
13
97
90
75
50
25
10
3
22
21
20
19
18
97
90
75
50

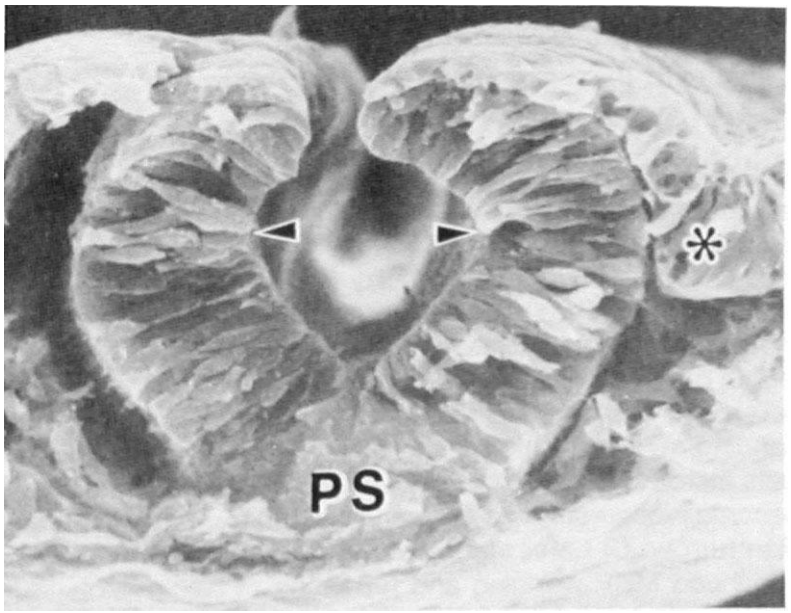

1.0
04:14:52
Mag =
FL:
ROT:
P A
L R
SE
TR:500
TE:20
EC:1/1 16kHz
HEAD
FOV:20x20
5.0thk/1.0sp
16/03:16

Parietal bossing

Primary Neurolation - (C1- S2)



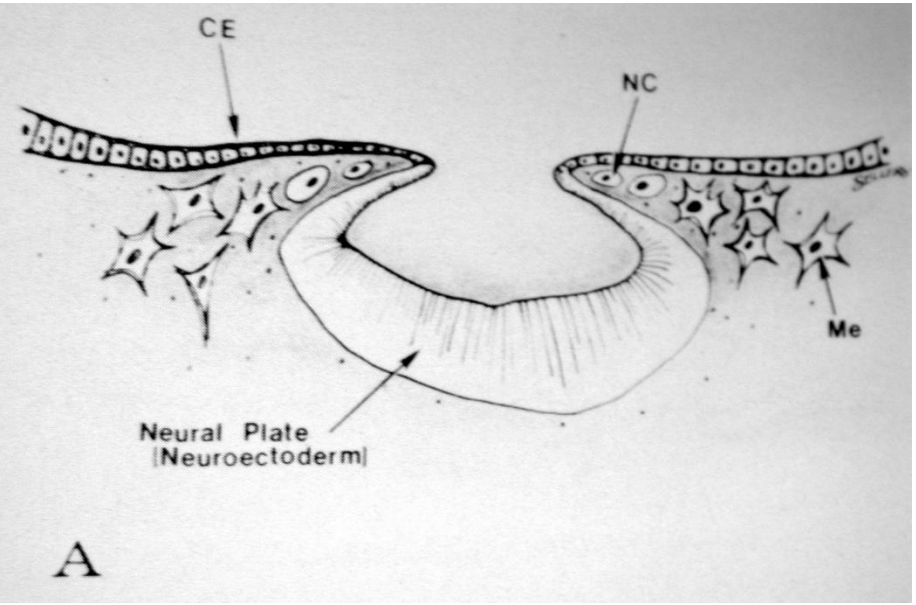
(SEM) stage 8 chick embryo



Abnormal Dorsal Midline Neural Development: conceptual classification

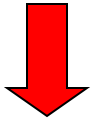
Abnormal Primary Neurulation

Failure of Neural Tube Closure - Neural Tube Defects: spina bifida aperta / myelomeningocle


CE
NC
Me
Neural Plate
(Neuroectoderm)
A

Tethered spinal cord

- Defective dorsal midline formation
(*spina bifida, myelodysplasia, spinal dysraphism*)

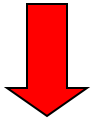


- Allows inelastic mesenchymal elements to fuse with the spinal cord at the caudal level of malformation

- Tethers the spinal cord during rapid spinal column growth

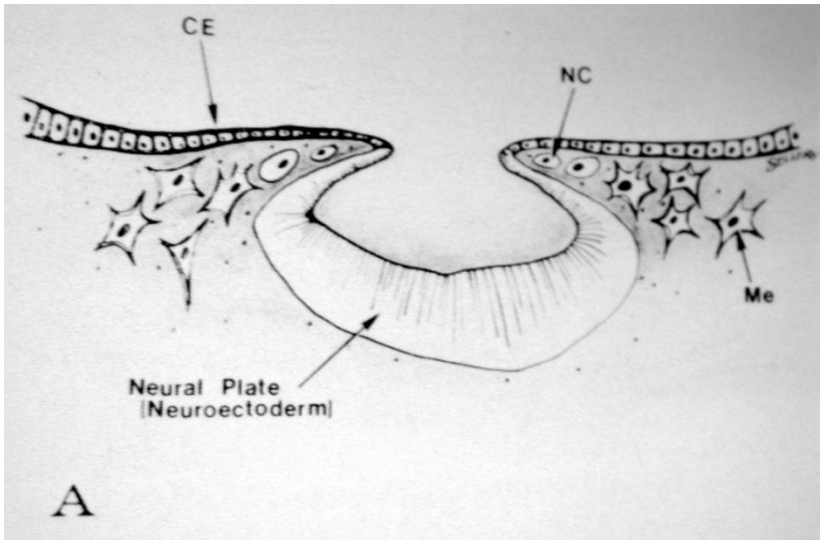
Tethered spinal cord

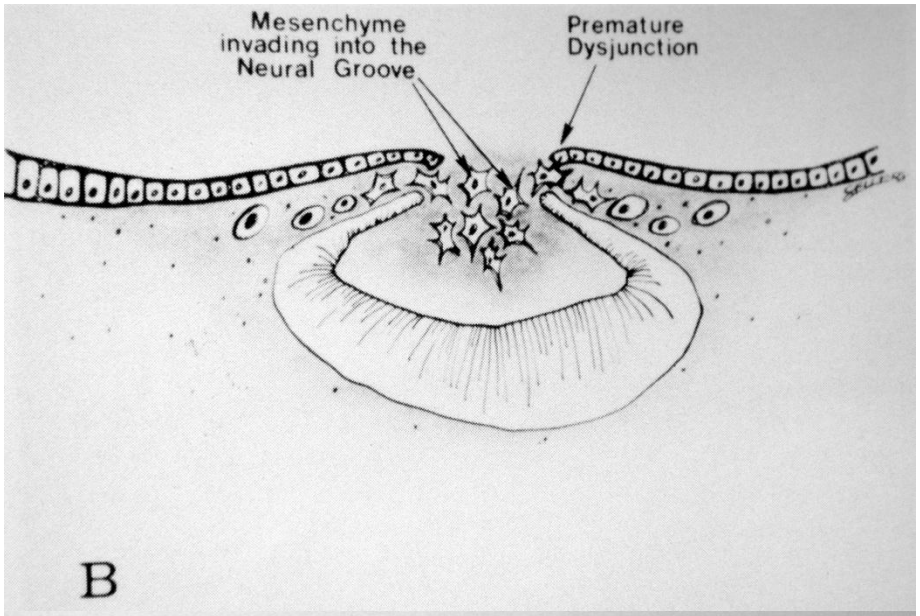
Stretched spinal cord, conus below L2

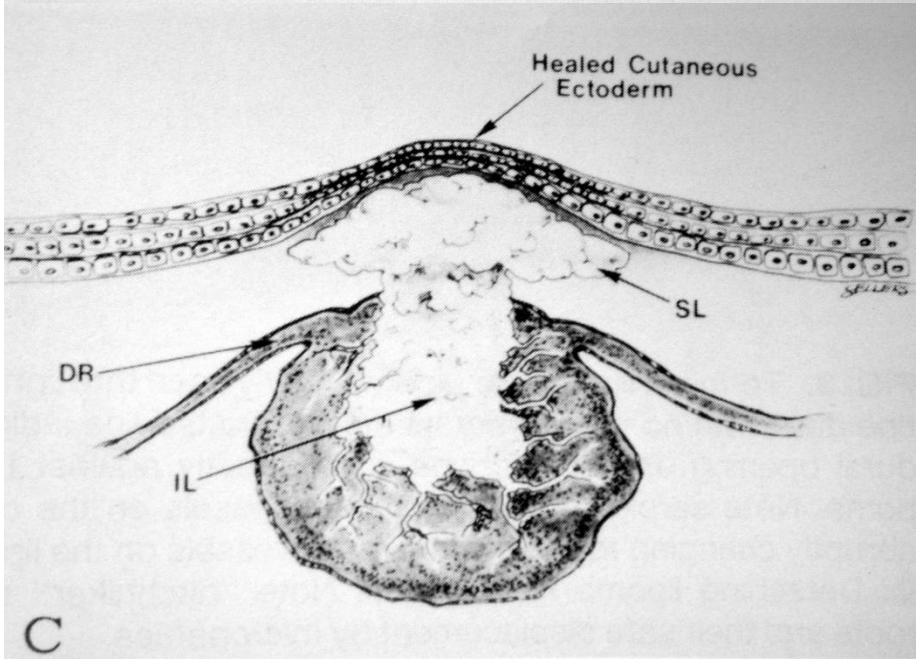


Altered blood flow, stretched neuronal membrane, neuronal and interneuron degeneration

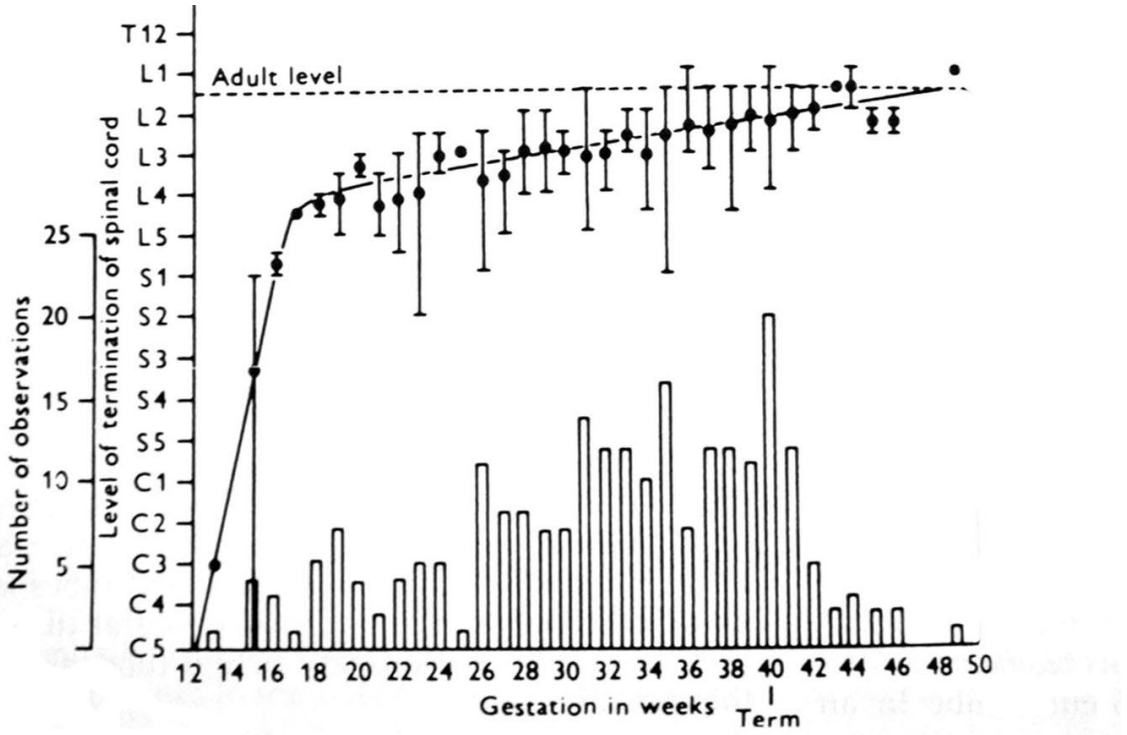
Progressive neurological deficits


CE
NC
Me
Neural Plate
(Neuroectoderm)
A


Mesenchyme
invading into the
Neural Groove
Premature
Dysjunction
B


Healed Cutaneous
Ectoderm
SL
DR
IL
C

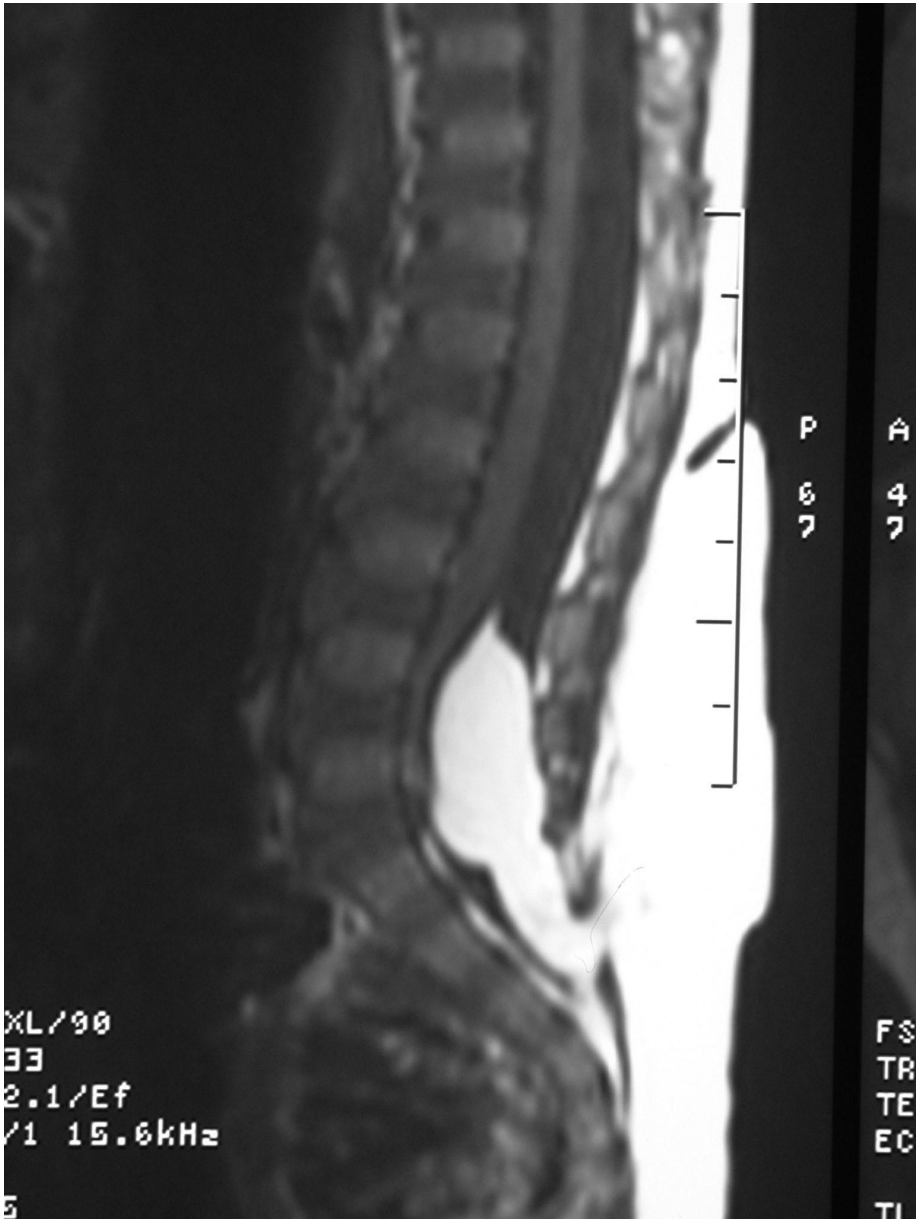
Ascent of the Conus Medullaris

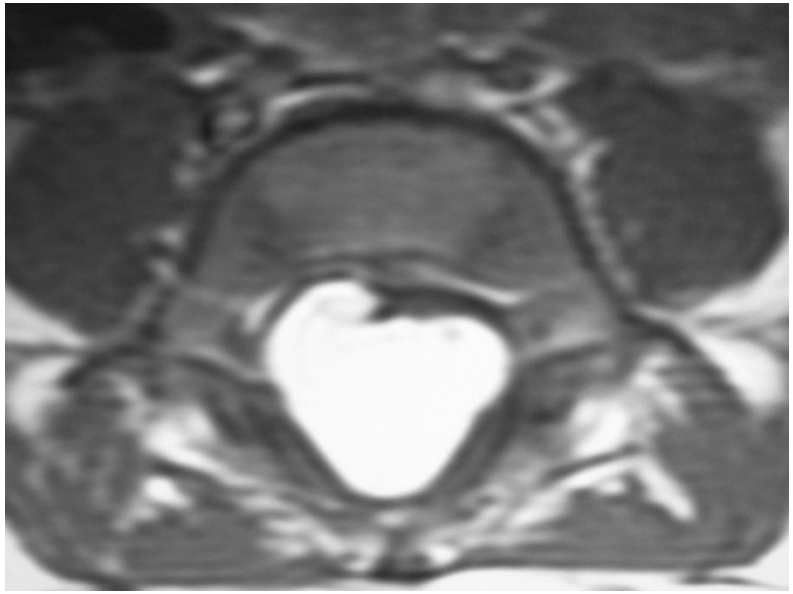


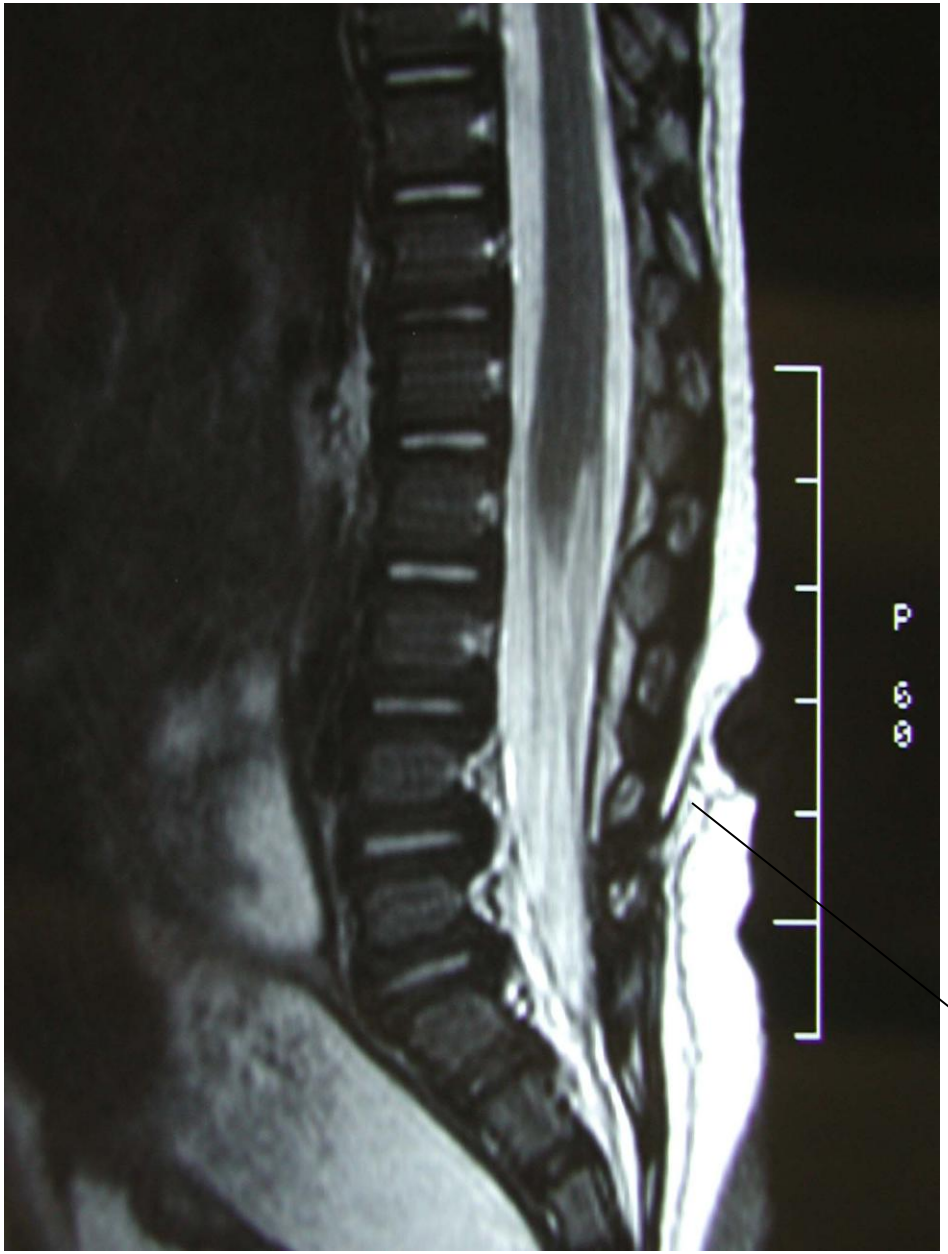
Tip of conus at birth: L2-3 interspace

Tip of conus >2months of age: **L1-2** interspace

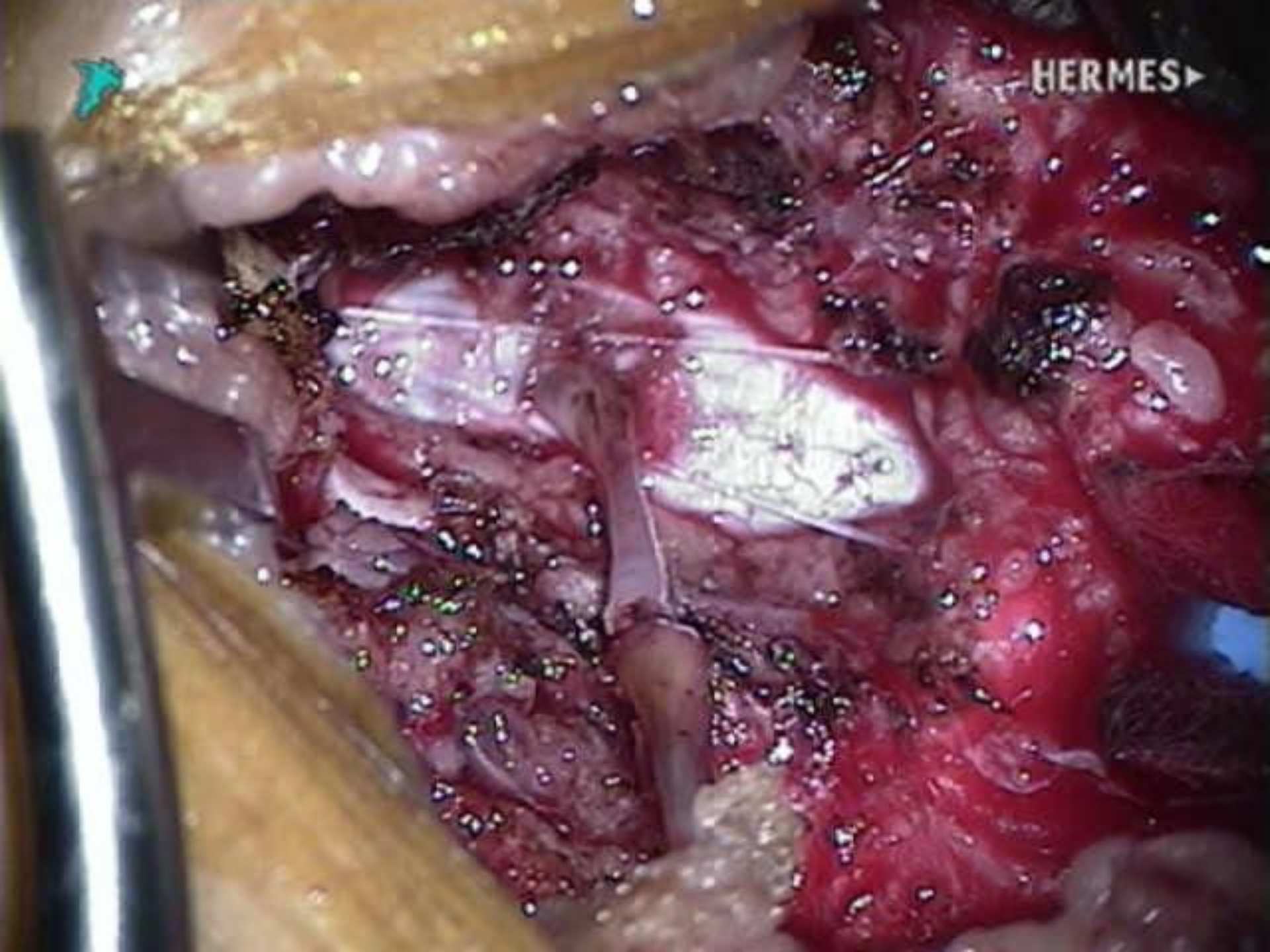
- *Tip of the conus **at or below L2-3** suggests spinal cord is tethered*

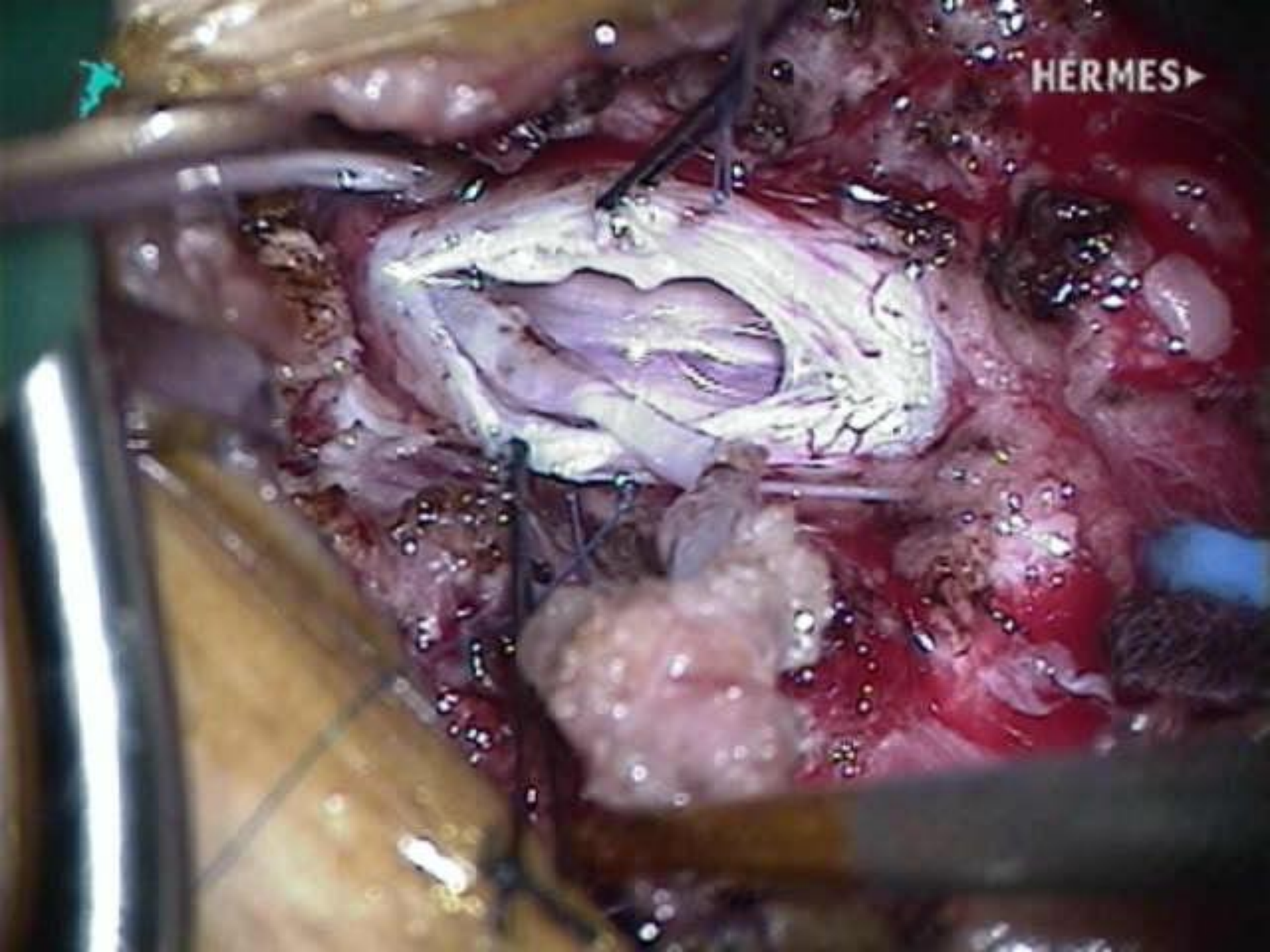

P A
XL/90
33
2.1/Ef
/1 15.6kHz
FS
TR
TE
EC

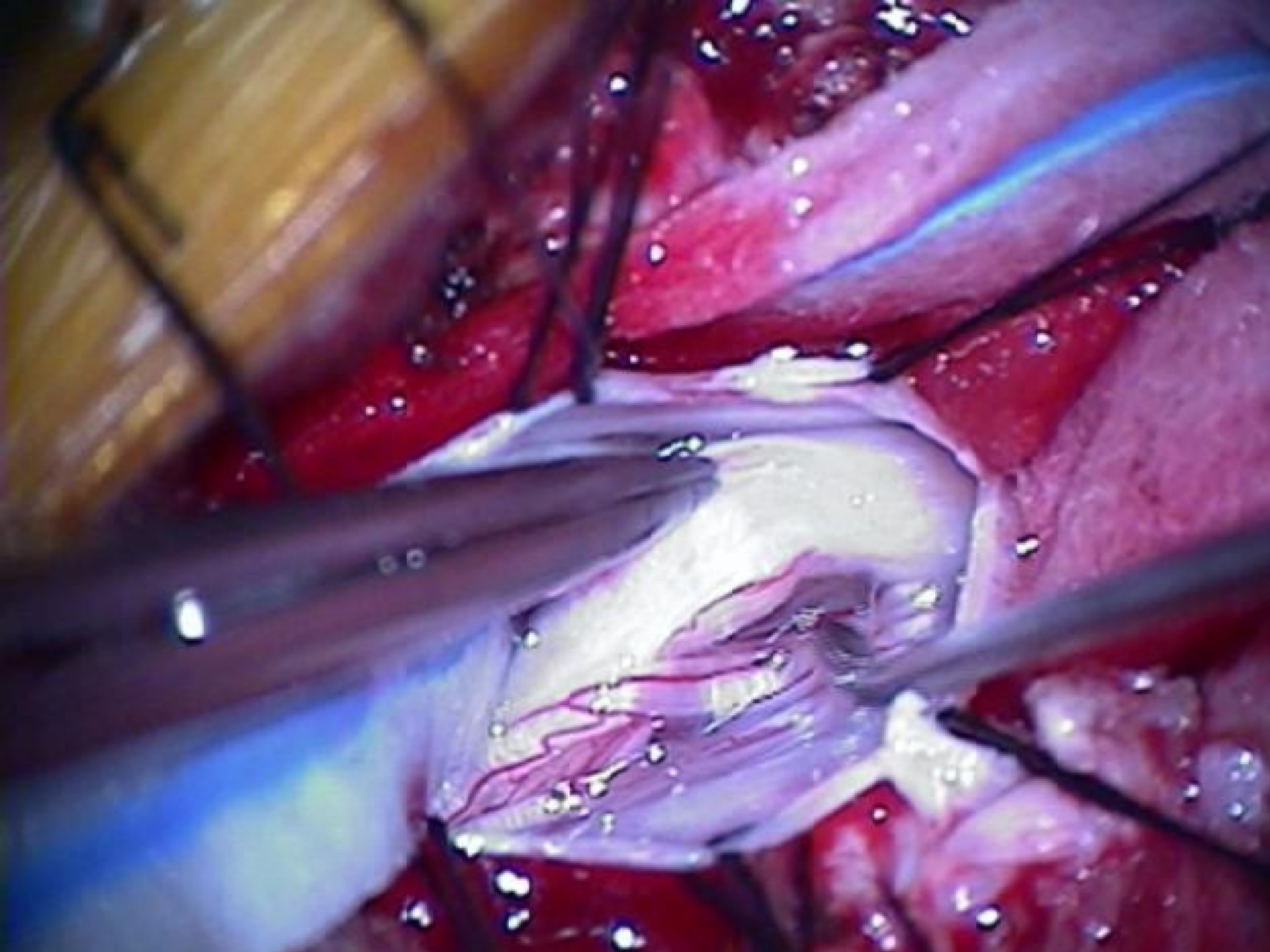


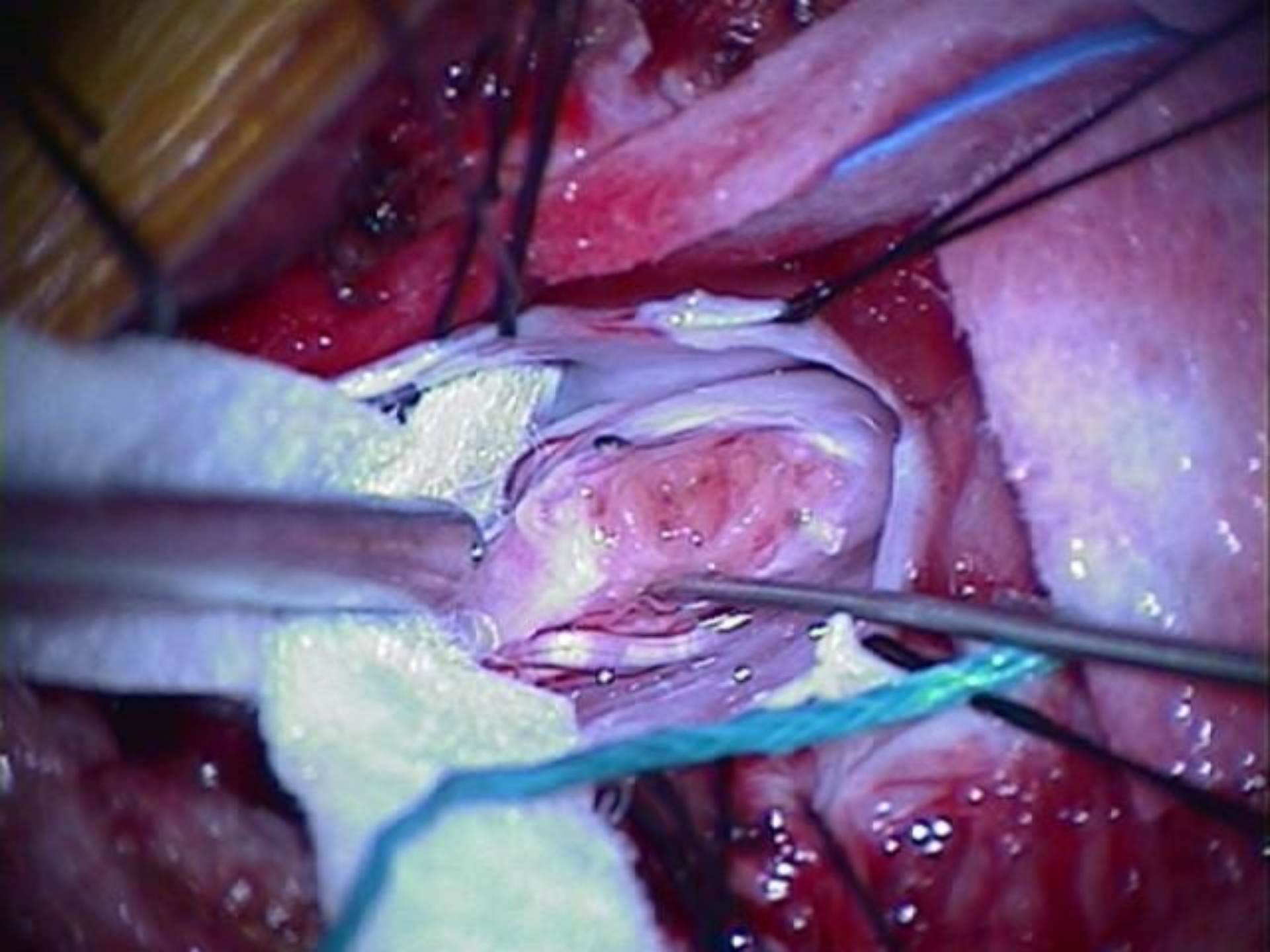


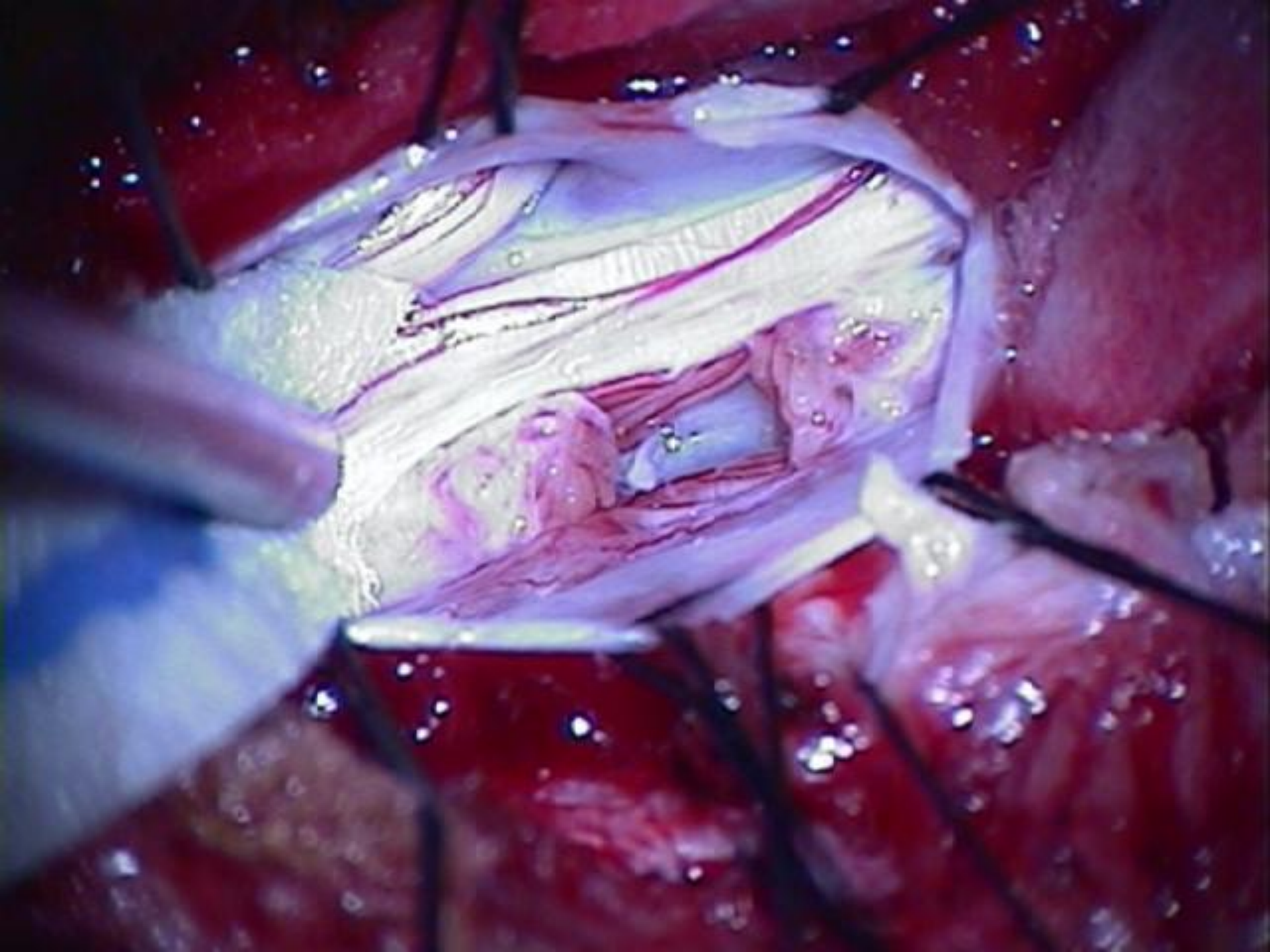
Subcutaneous tract


HERMES


HERMES







Tethered spinal cord
Diagnosis

80-90% have cutaneous manifestations

MRI screening for high risk patients with cutaneous manifestations and those patients with associated caudal abnormalities

Tethered spinal cord

Cutaneous Manifestations

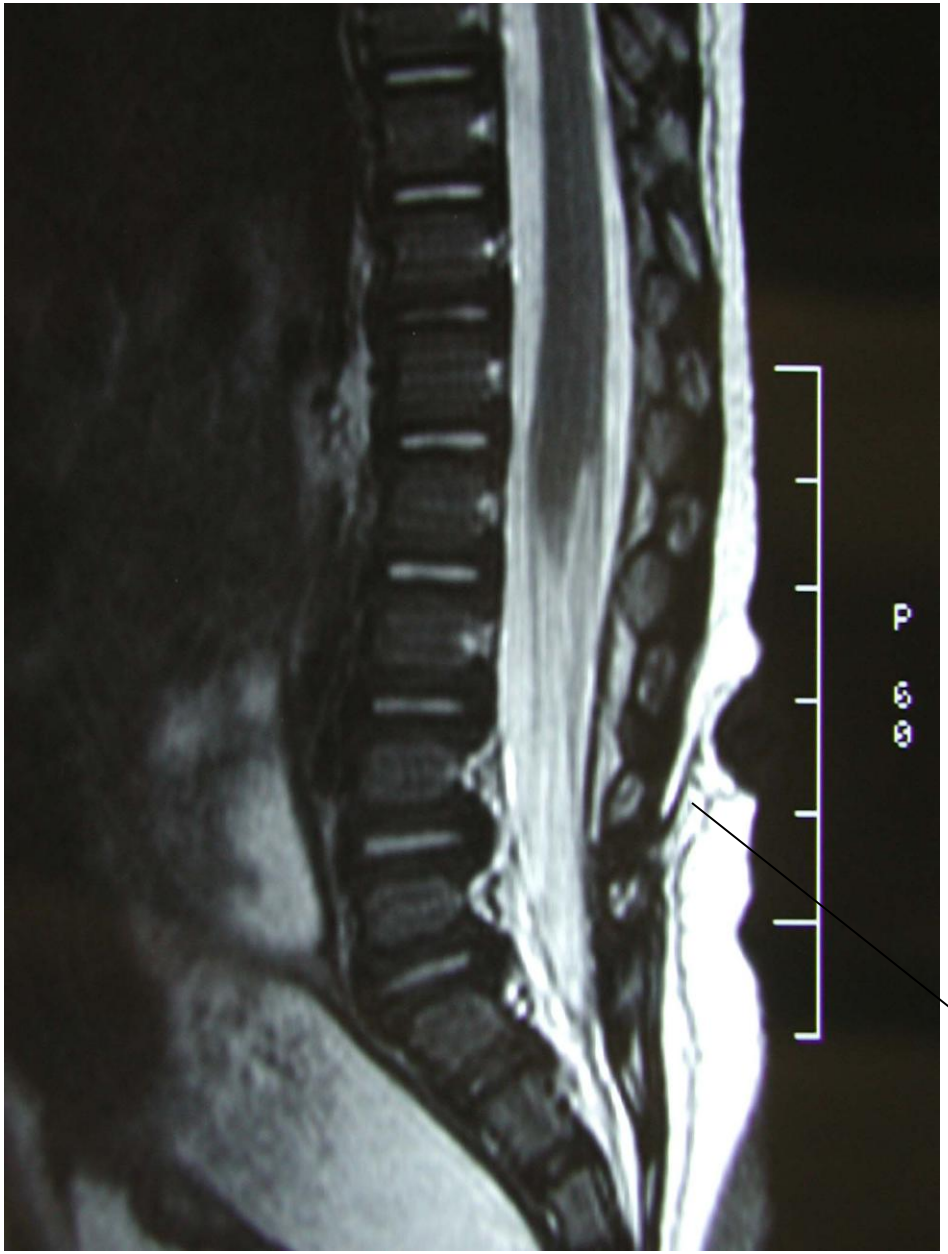
1. Dimple above the crease
2. Capillary Hemangioma / dystrophic skin
3 Subcutaneous Lipoma
4. Hair Tuft
5. Asymmetrical Crease
6. Midline Appendage

Tethered spinal cord
Cutaneous Manifestations

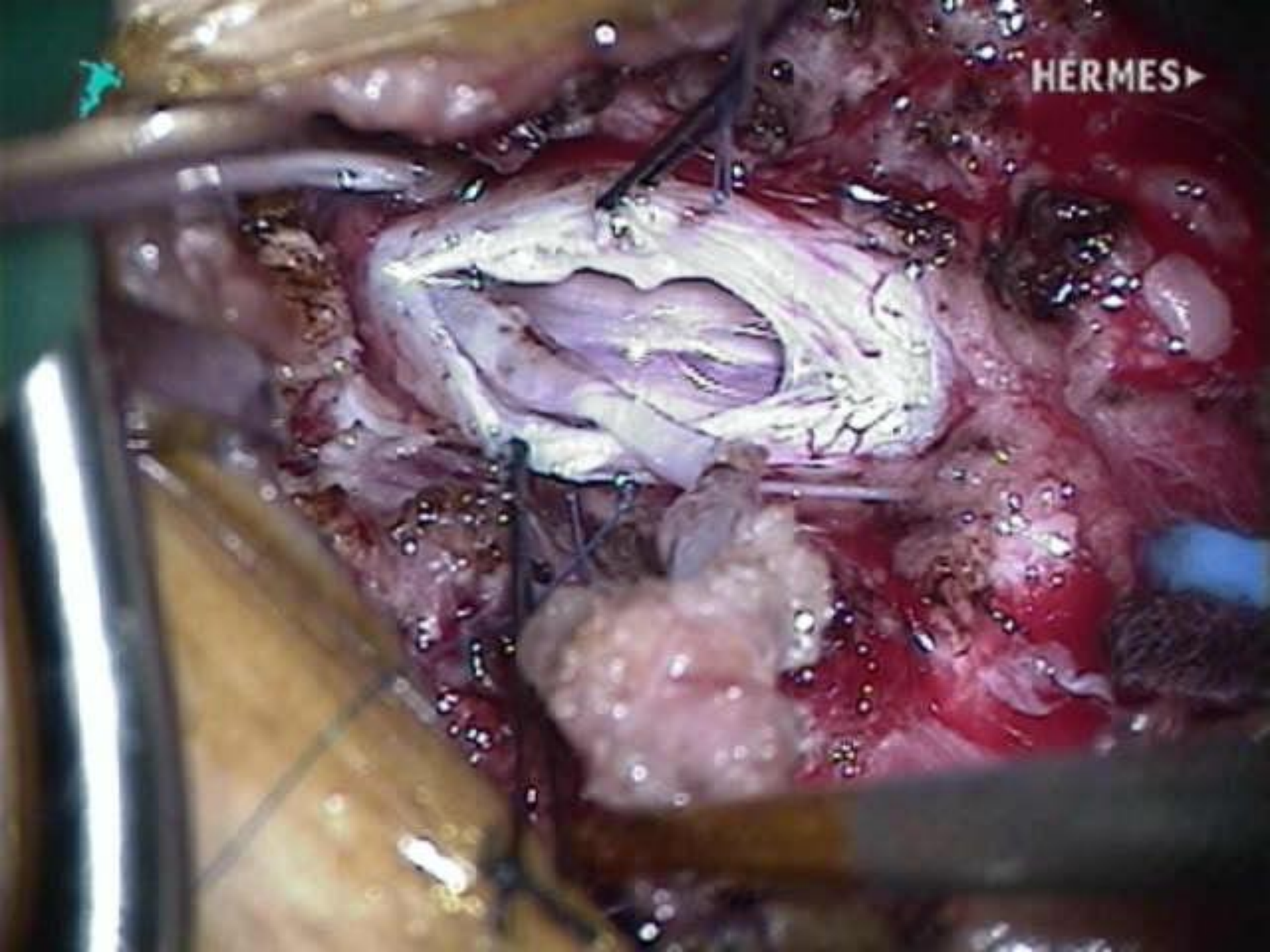
1. Dimples that represent tethered spinal cord from a dermal sinus tract is above the intergluteal cleft (S2)

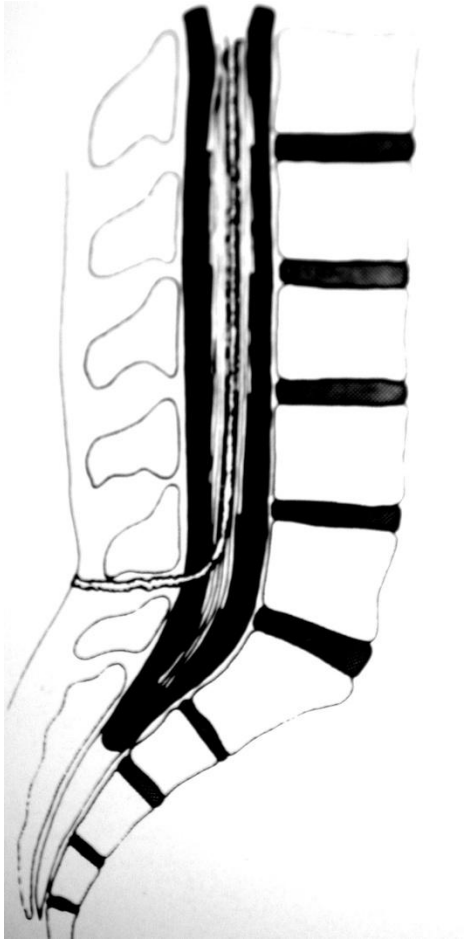
Dimples

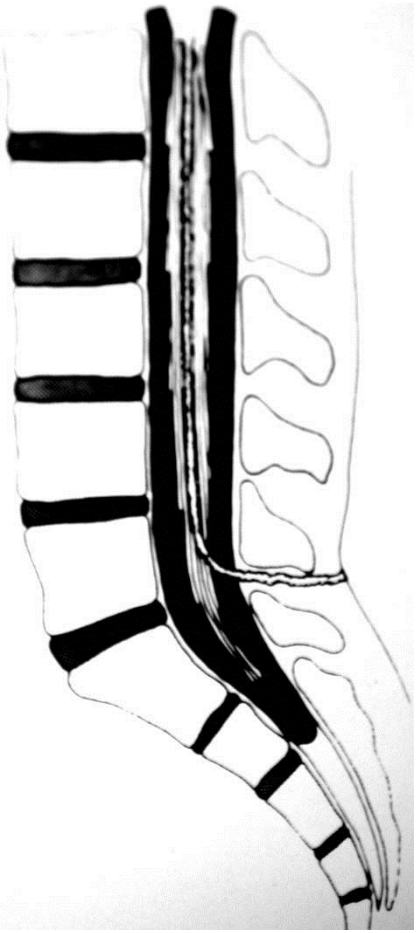
- Shallow or deep
- Frequently associated with dystrophic skin, hemangioma



Subcutaneous tract

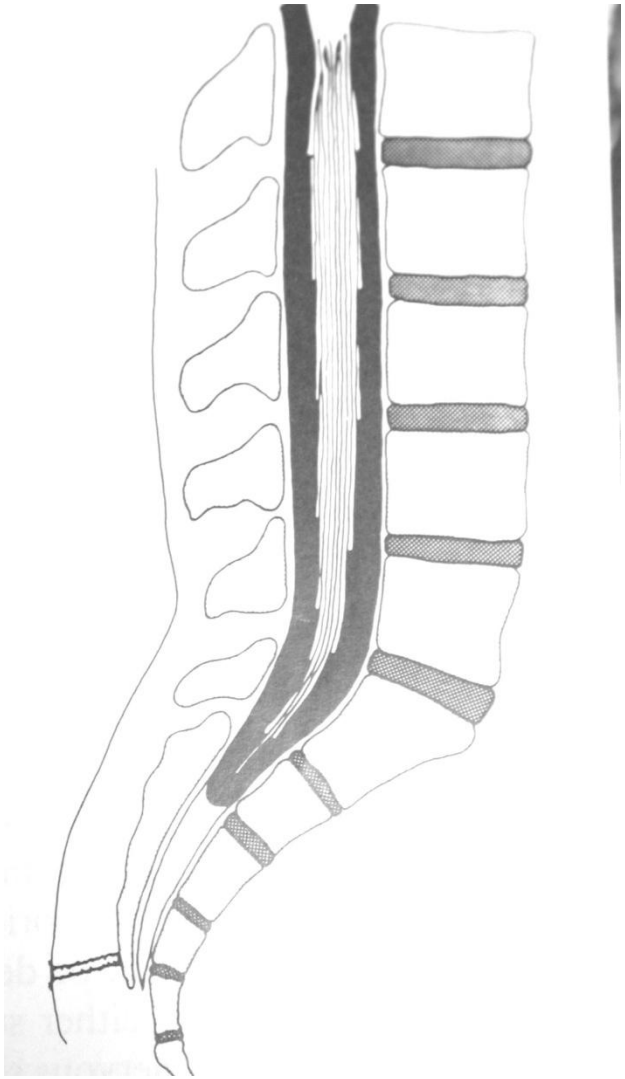

HERMES





Dermal sinus tract: tethering lesion
mass lesion
source of infection
(epidural abscess/meningitis)

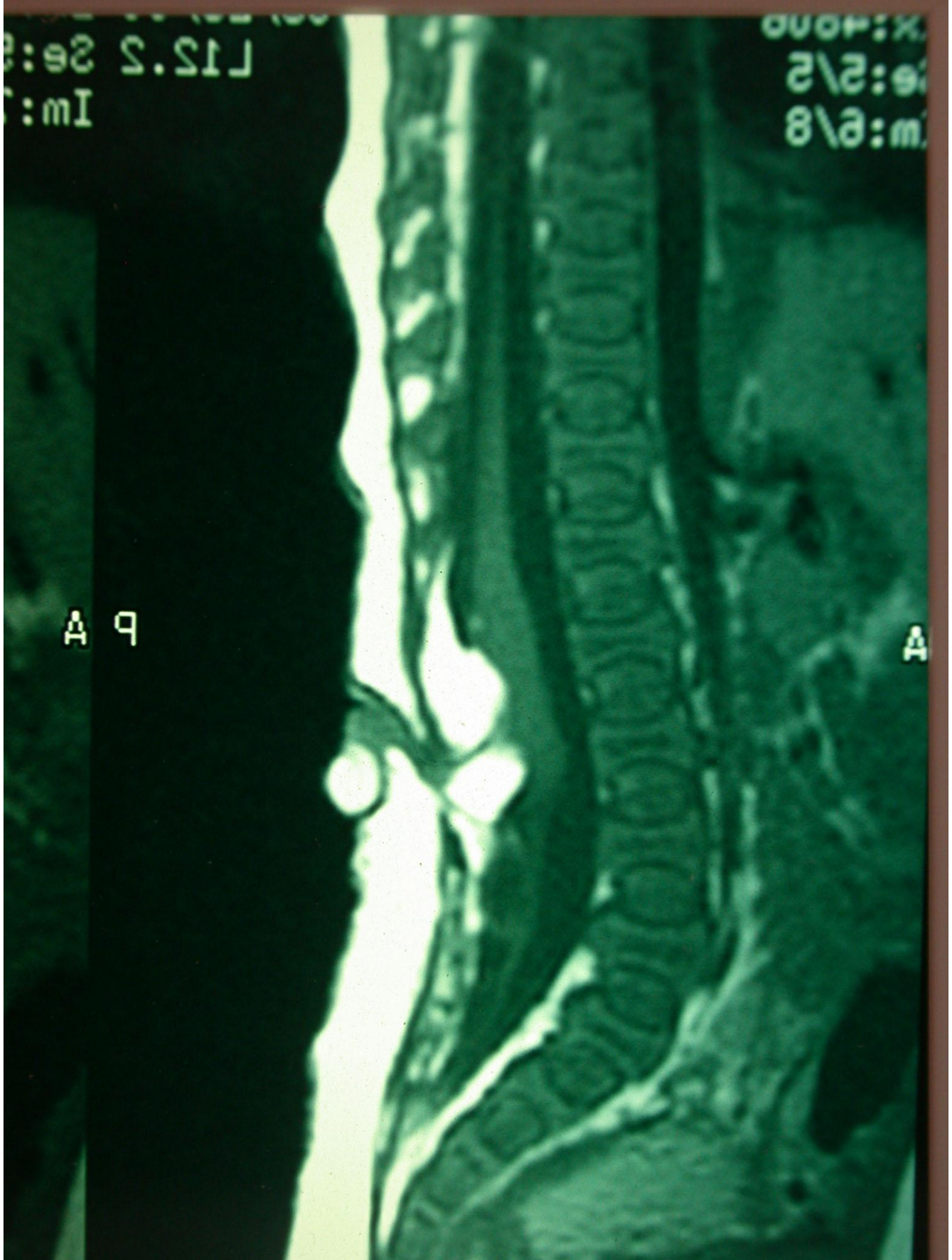
Dimple in a straight crease= normal



Sacral dimple:
-in the crease
-near the tip of the coccyx
-does not extend into the spine
-2% of infants

Dimples above the crease= not normal

Not normal


L12.2
A
P
A

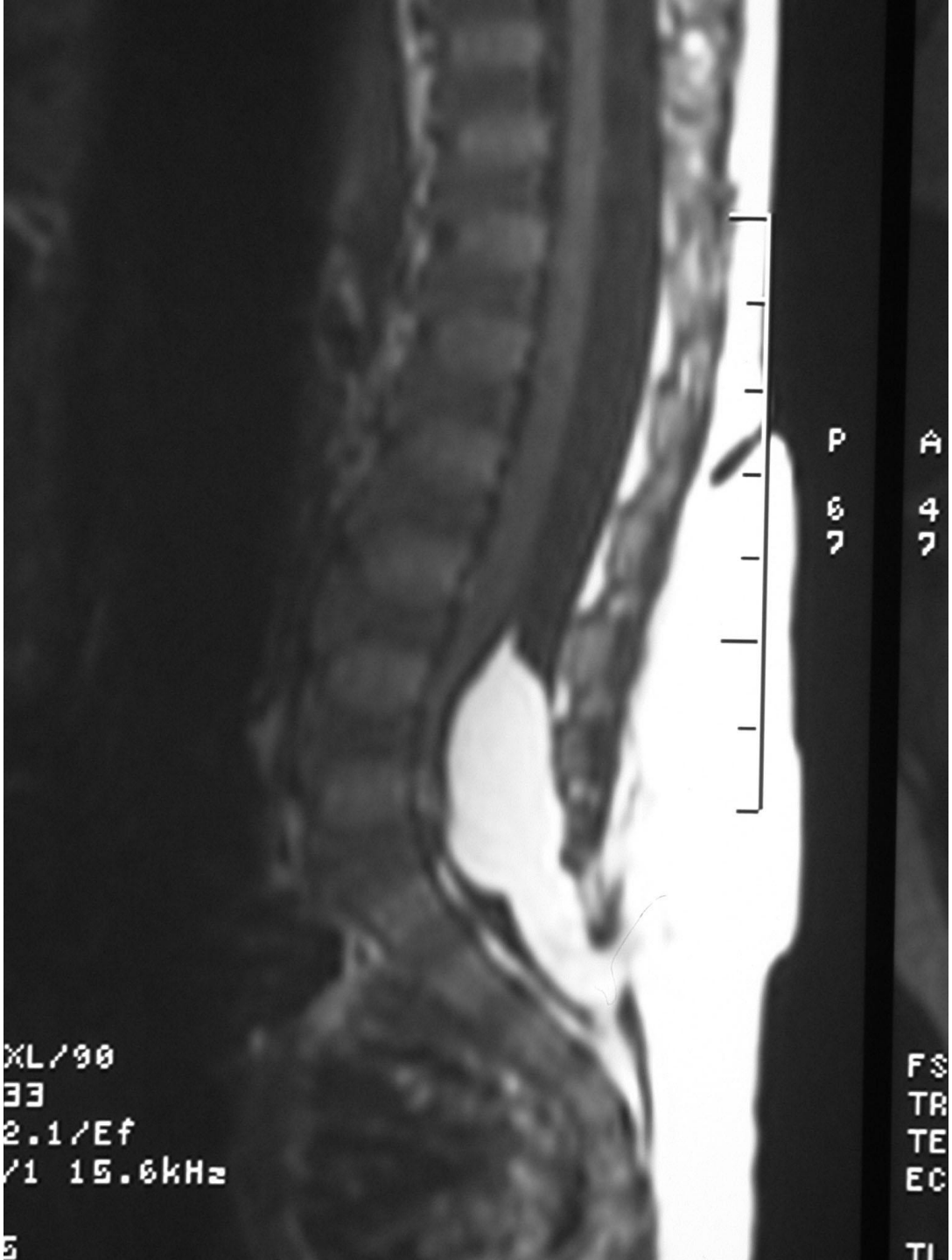
Lumbar lesions=not normal

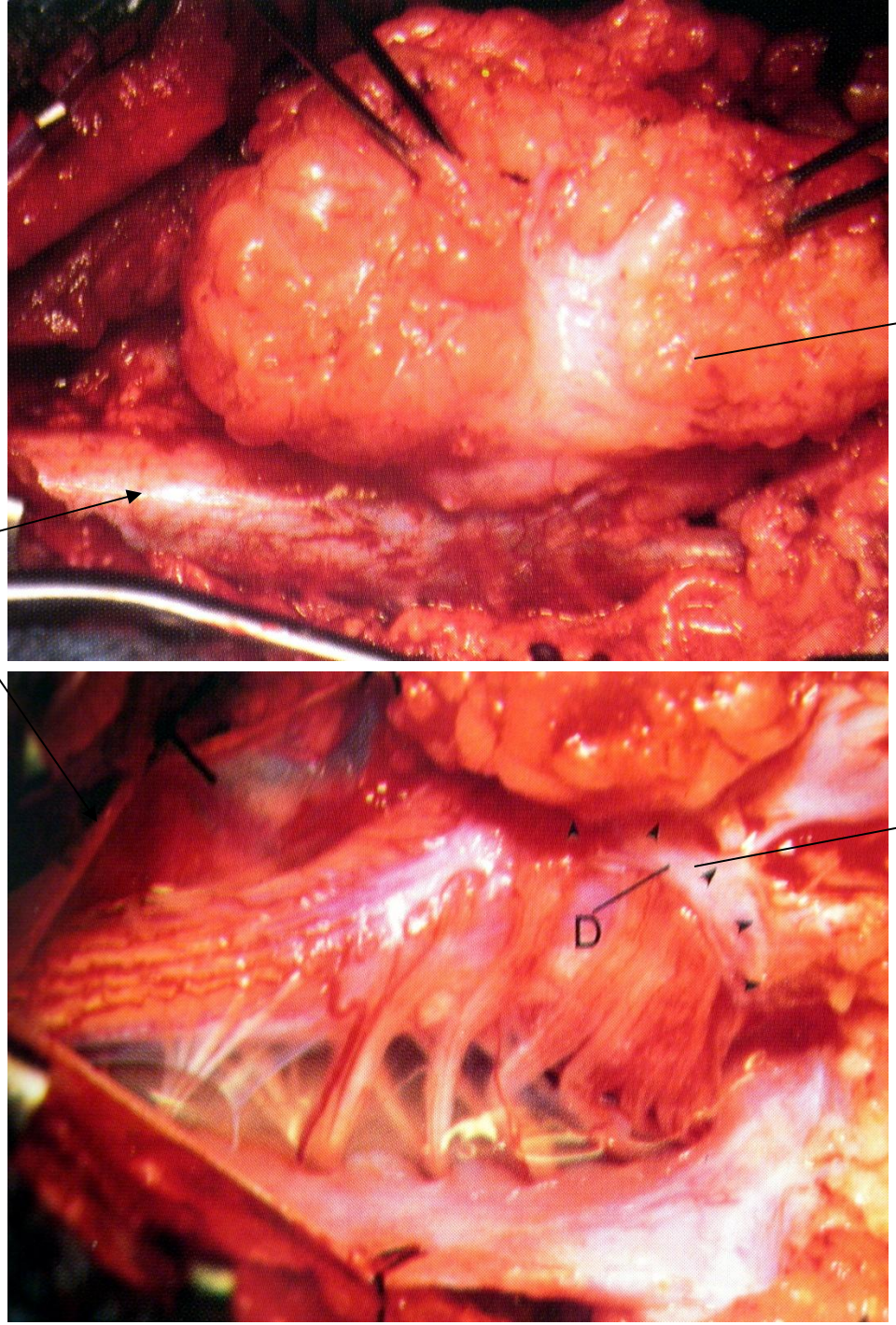

P

Smooth capillary hemangiomas may be normal

Not just a bump

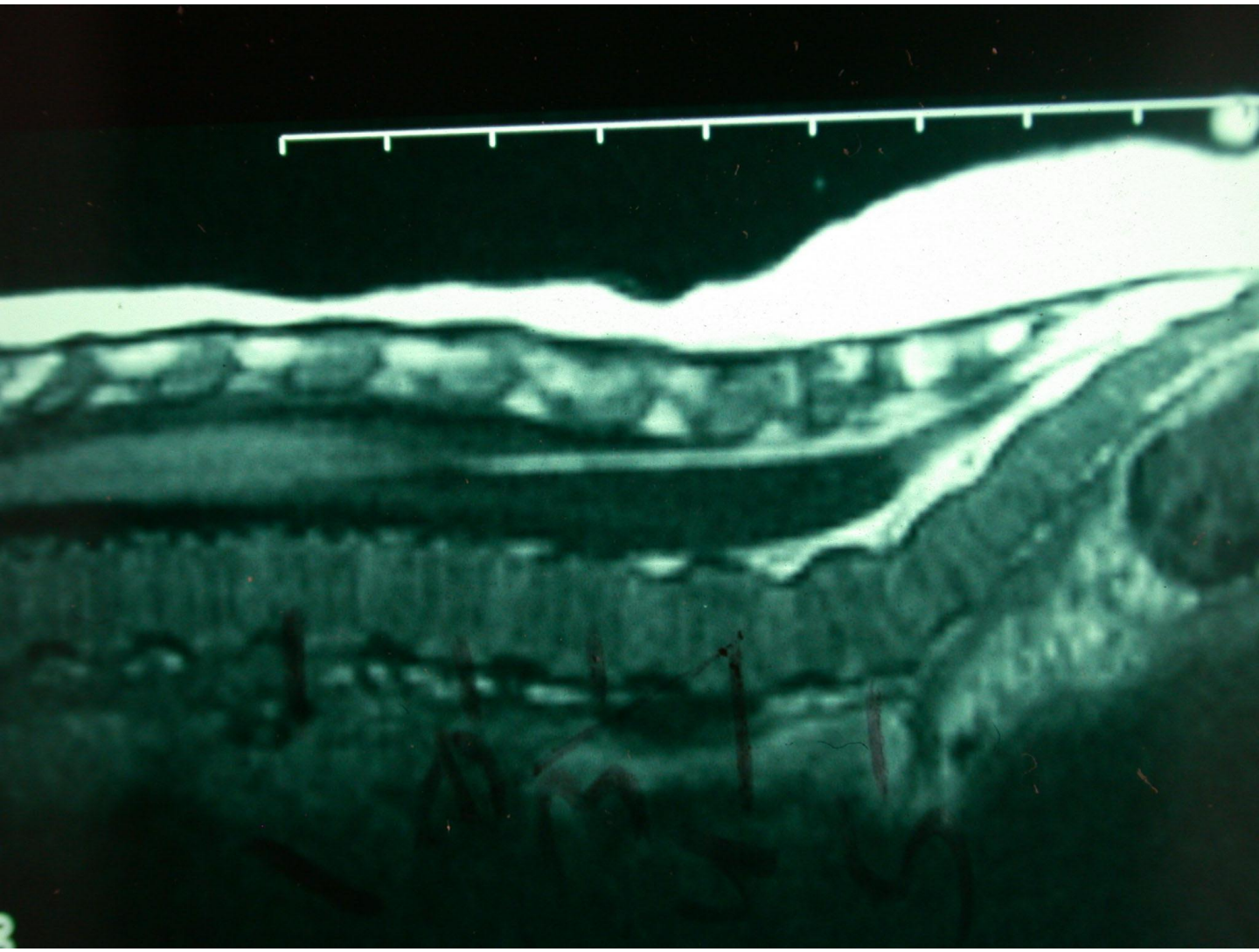
Like wise……


P A
6 4
7 7
XL/90
33
2.1/Ef
/1 15.6kHz
FS
TR
TE
EC
TI


lipoma
Dura
Tethered spinal cord
D

This hair is too long

Minor crease deviation @15% tethered cords, needs screening



Not just a skin tag…

Tethered spinal cord
Associated caudal lesions

MRI recommended

- Sacral agenesis
- Imperforate anus (54%)
- Cloacal exstrophy, VATER
- Urinary tract anomalies
- Genital duct anomalies

Tethered spinal cord
Management

MRI: 3 months of age

Surgery:

-Generally, tethered cords should be untethered
 6-12 months of age: relatively low risk,
 no transfusions, 3 days hospitalization
- Routine neurophysiological monitoring

Pediatric Brain Tumors:

-Almost never present with headaches alone
-Tend to be midline, and large
-Biology determined by both histology *and* location
developing molecular characterization
-Most are curable; in many others long term control
achieved through combination of surgery, chemotherapy and radiation
-Long term sequelae requiring requiring comprehensive pediatric subspecialty care

Pediatric Brain Tumors:

Incidence rate: 3.9 cases per 100,000 children (0-19)

@2500 new cases in the United States 2000[1]

1. Central Brain Tumor Registry of the United States (CBTRUS)

Site of Origin

(1038 Pediatric CNS Tumors)

Cerebrum (30%)
Posterior Fossa (37%)
Ventricular (10%)
Optic Nerve/ Chiasm (9%)
Sellar/Parasellar/Pituitary (7%)
Spinal Cord (4%)
Pineal (2%)

Presentation: Symptoms*

(supratentorial / infratentorial)

Headache +1: 99.1% / 99.4%
+2: 87.7% / 93.1%
+3: 64.8% / 71.3%

nausea/vomiting (71% / 86%)
seizures
speech/personality/academic performance change <6 (87% / 80%)
visual symptoms/diplopia (90% / 80%)
difficulty walking/balance (65% / 92%)
motor weakness
bladder symptoms
neck pain
back pain
failure to thrive

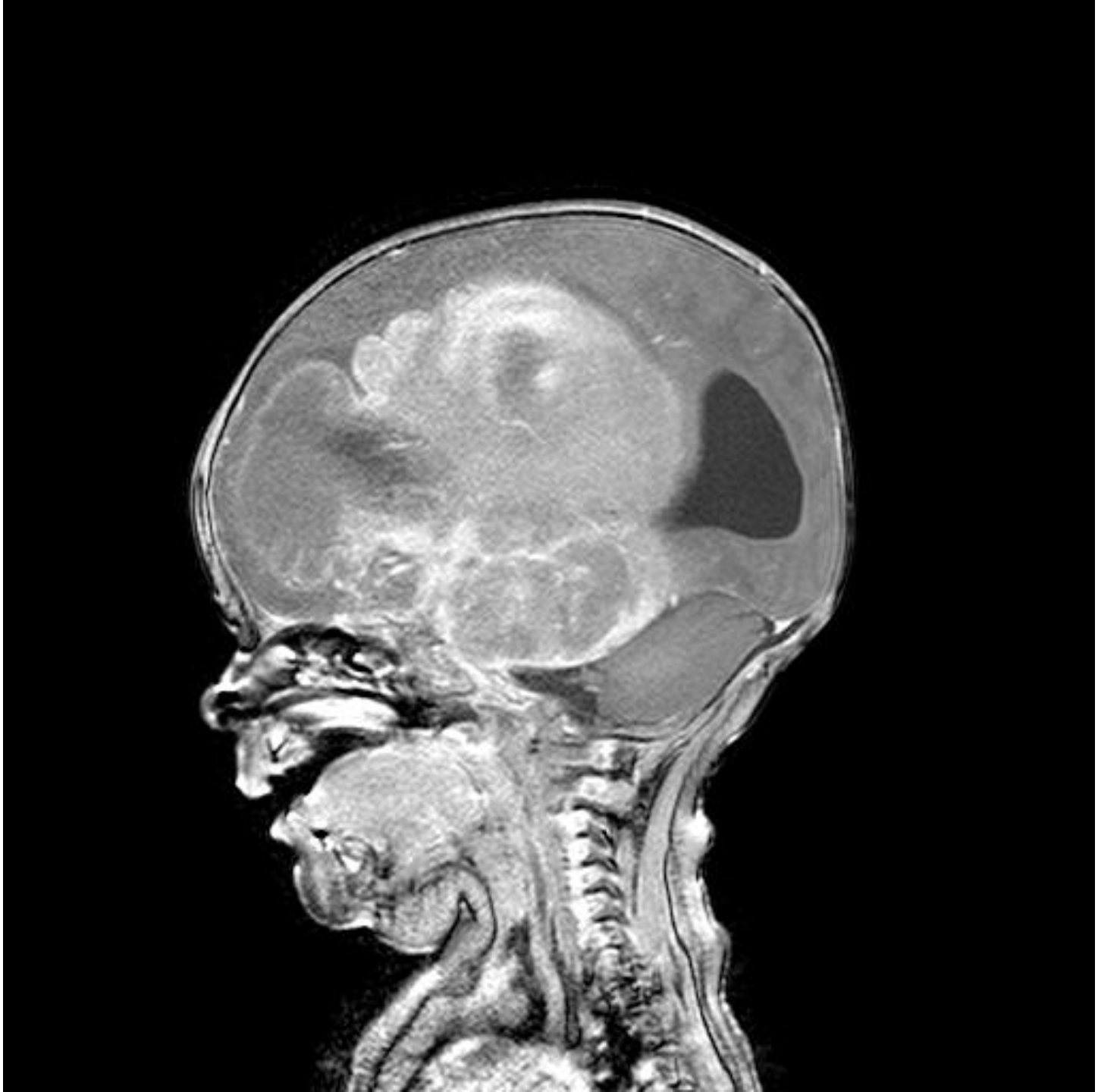
Presentation: Symptoms*
(supratentorial / infratentorial)

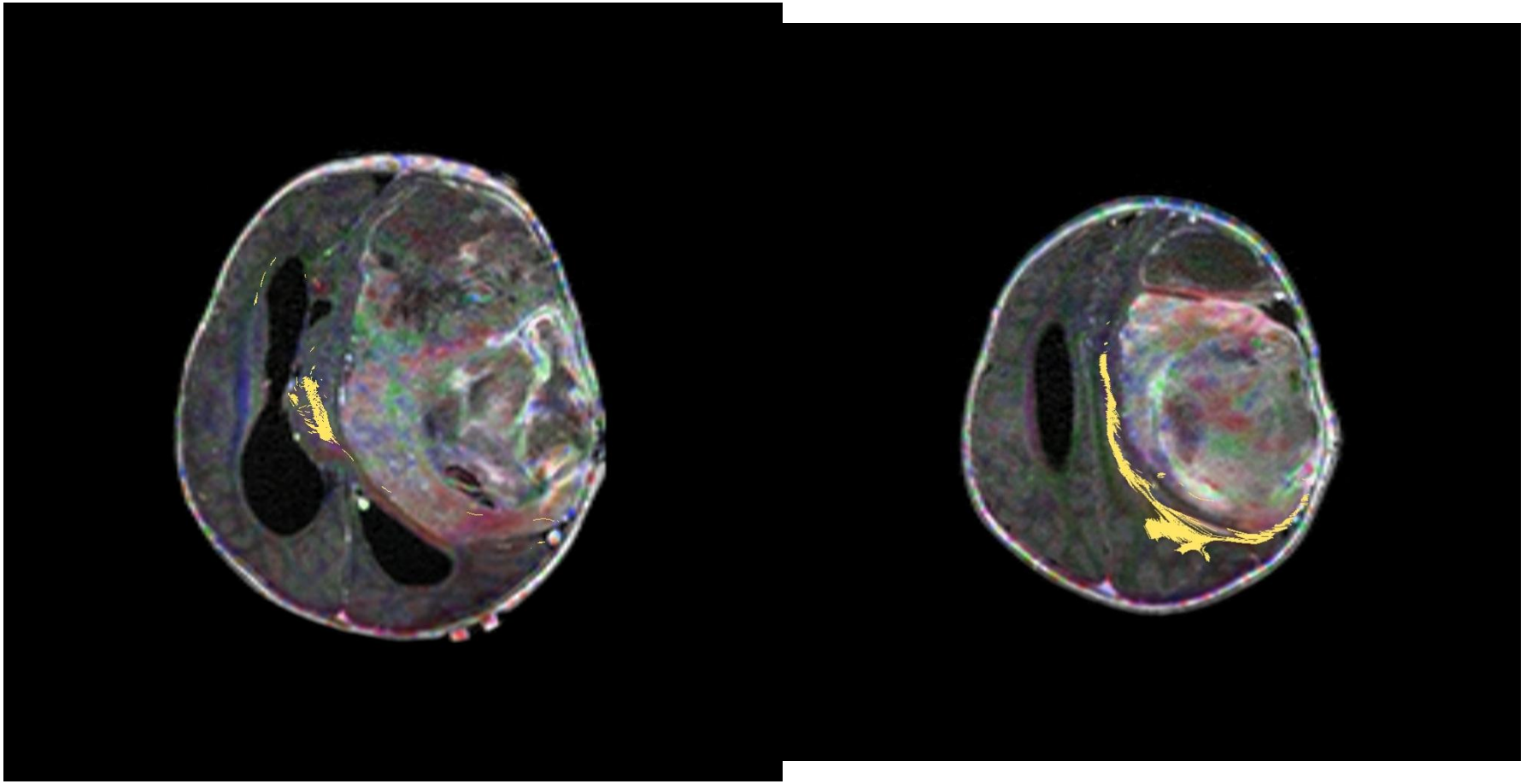
Headache +1: 97.7 / 99.0%
+2: 90.8 / 97.2%
+3: 82.6 / 92.5 %

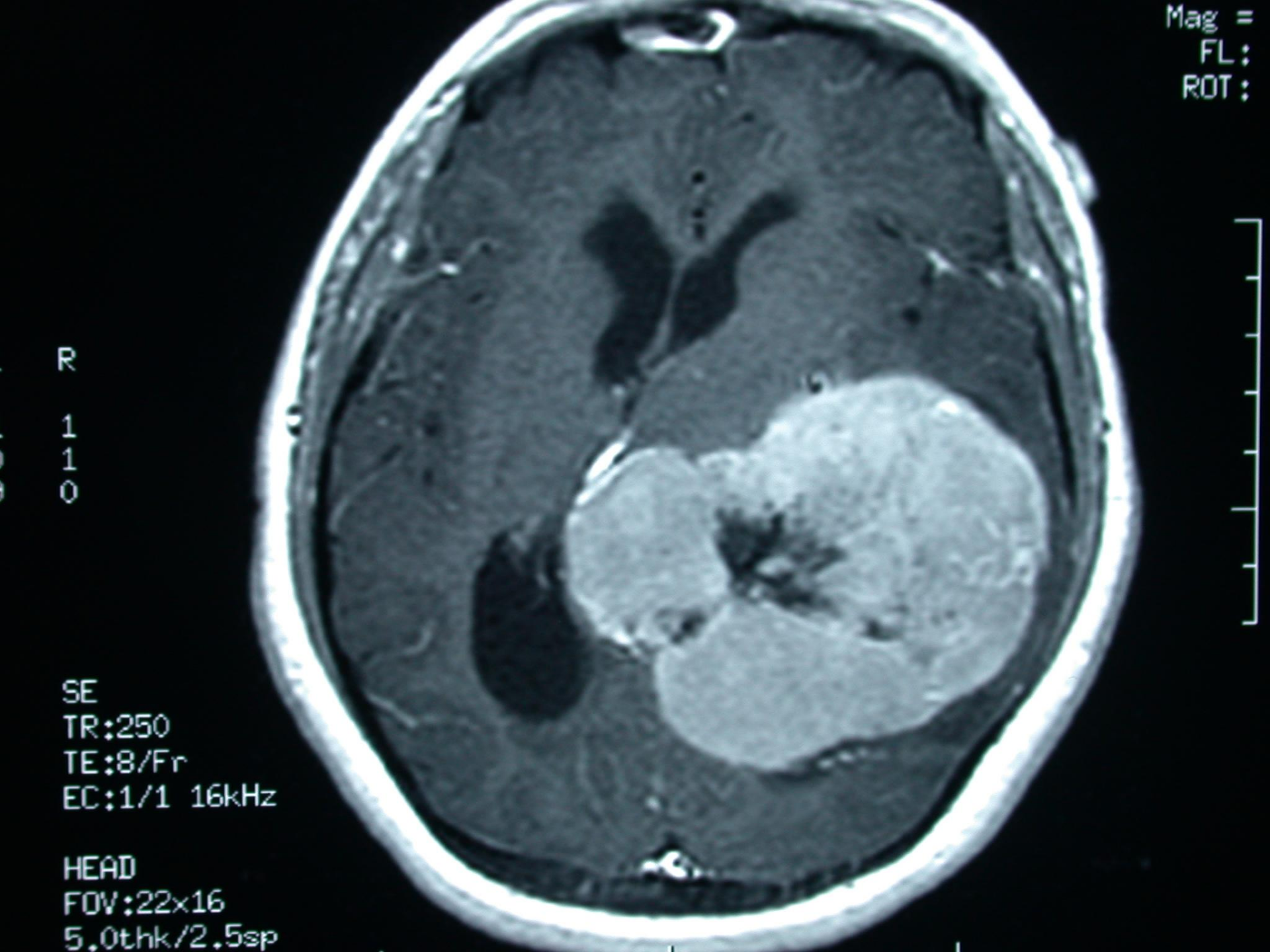
confusion/stupor
head tilt
lethargy
paresis
ataxia
papilledema (64%/80%)
visual field defect >4 (55%/9%)
tense fontanel

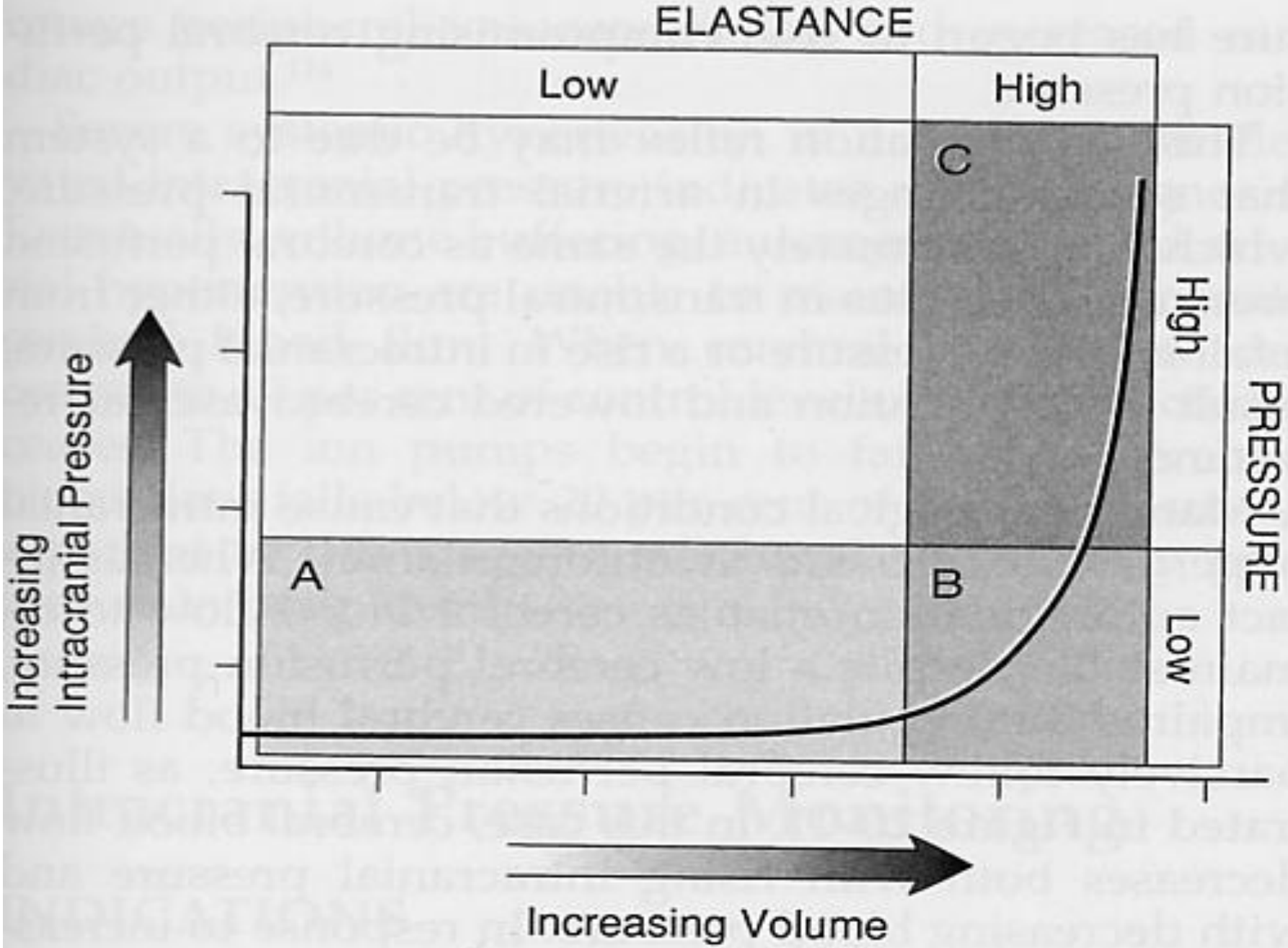
coma
irritability
stiff neck
abnormal reflexes
hypesthesia >3
decreased visual acuity
CN palsy: VI, VII

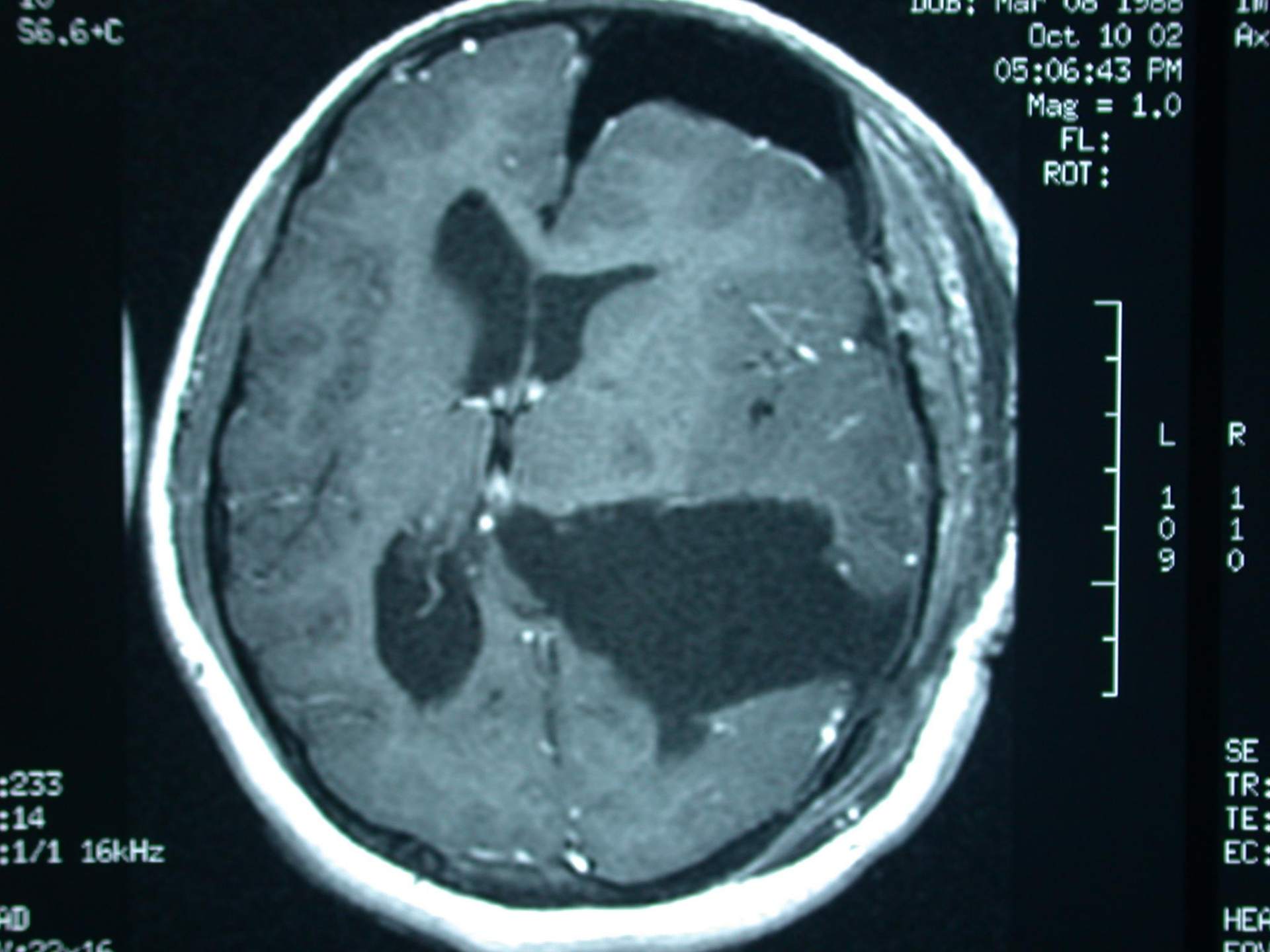
*The epidemiology of headache among children with brain tumor, *J Neuro-oncology* 10: 31-46, 1991






Mag =
FL:
ROT:
R
1
1
0
SE
TR:250
TE:8/Fr
EC:1/1 16kHz
HEAD
FOV:22x16
5.0thk/2.5sp


ELASTANCE
Low
High
C
A
B
High
Low
PRESSURE
Increasing
Intracranial Pressure
Increasing Volume

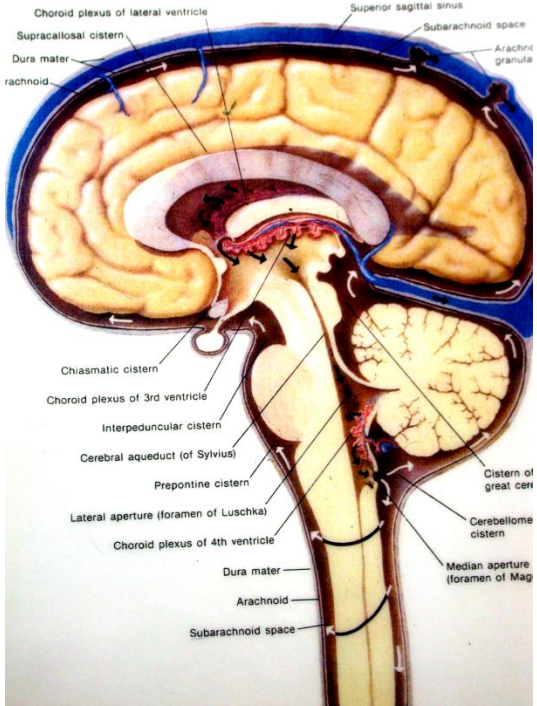

S6.6+C
DOB: Mar 08 1988
Oct 10 02
05:06:43 PM
Mag = 1.0
FL:
ROT:
L
R
1
0
9
1
1
0
:233
:14
:1/1 16kHz
AD
SE
TR:
TE:
EC:
HEA

Low Grade Gliomas

Good

JPA (may have well defined margins)

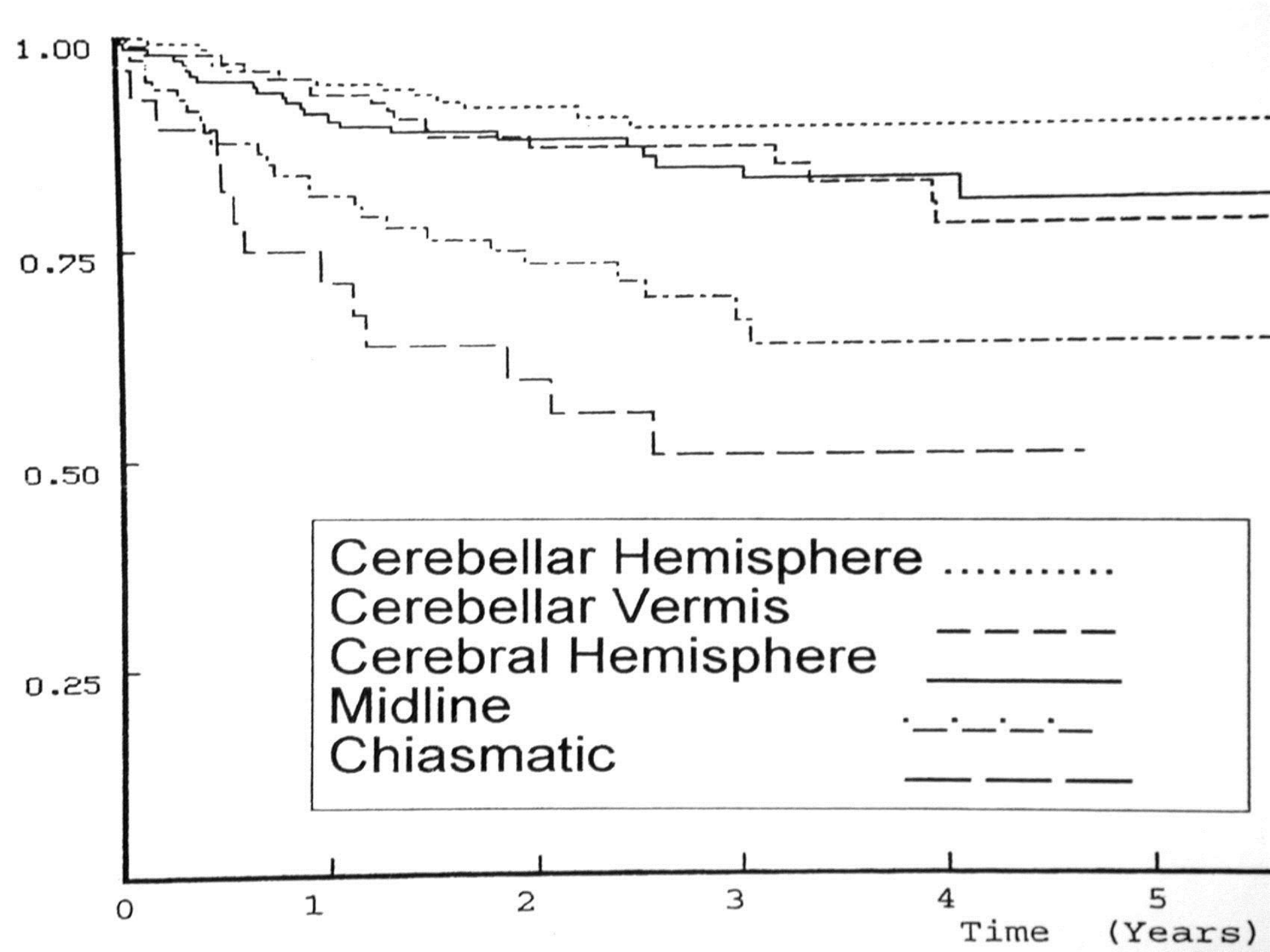
cerebellum
cerebral hemisphere
tectum
midbrain
spinal cord



Bad

Fibrillary (infiltrative)

thalamus
hypothalamus
basal ganglion
pons
optic pathway/chiasmatic

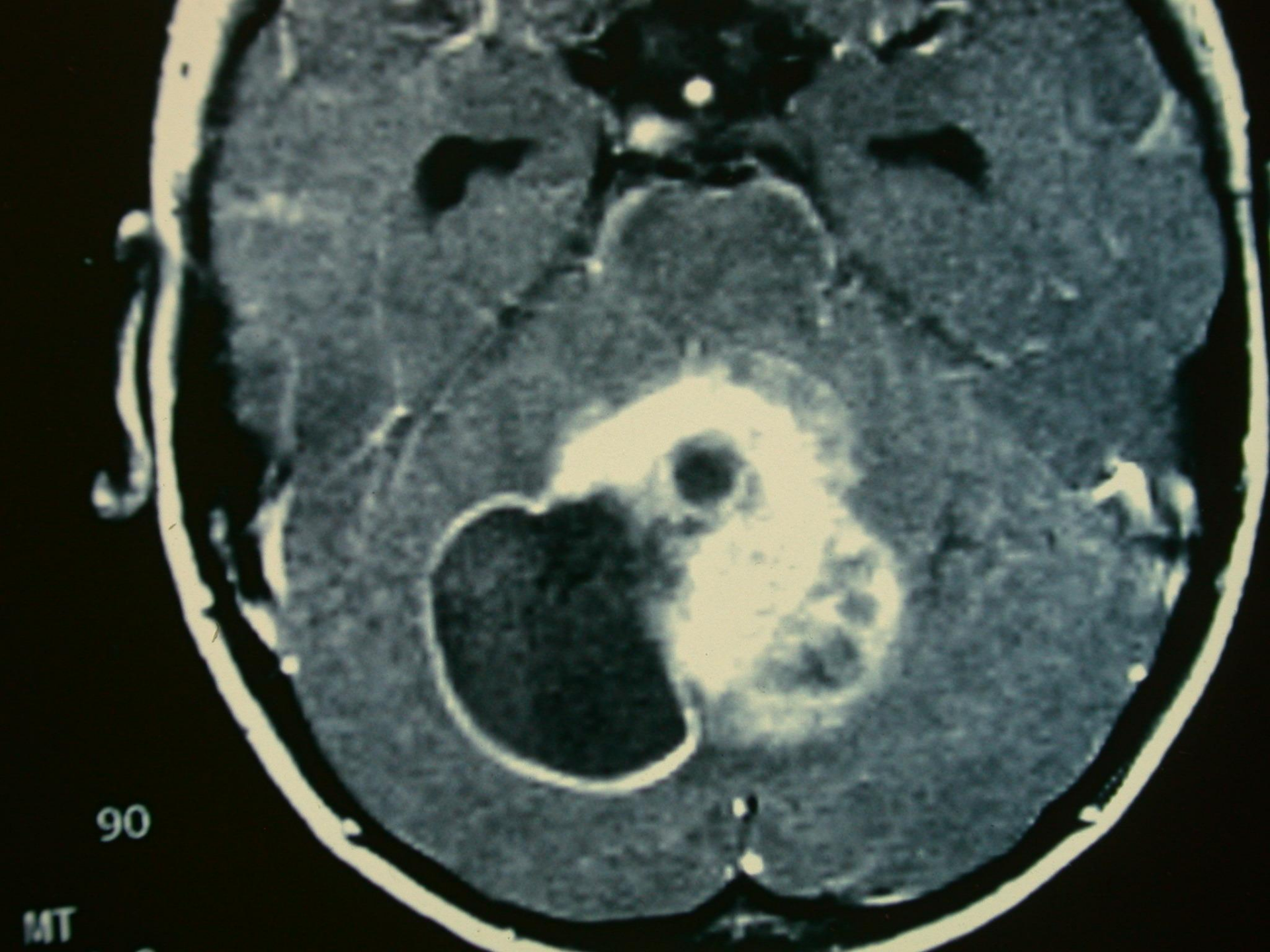

1.00
0.75
0.50
0.25
0
1
2
3
4
5
Time (Years)
Cerebellar Hemisphere
Cerebellar Vermis
Cerebral Hemisphere
Midline
Chiasmatic

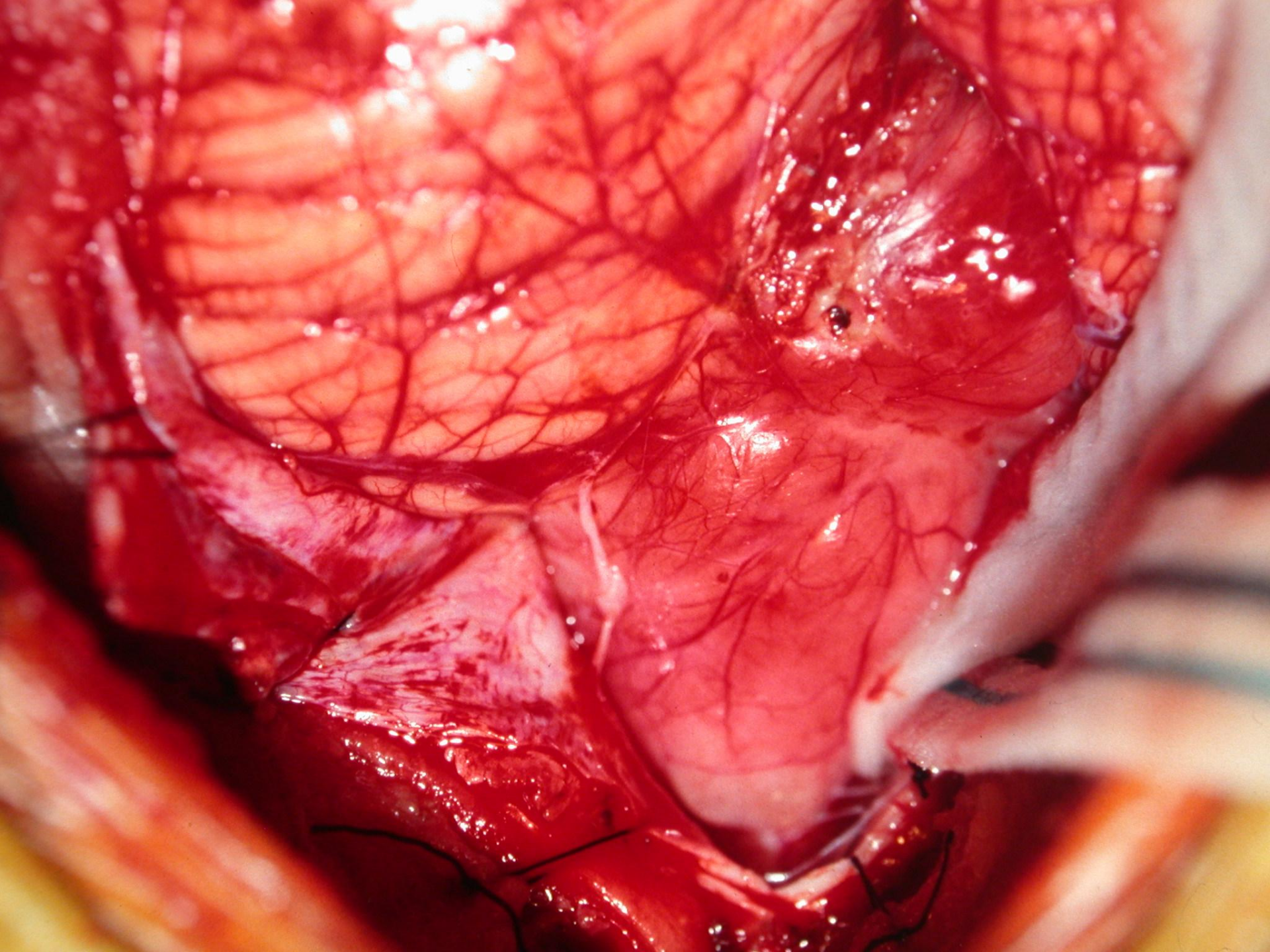
Low Grade Gliomas

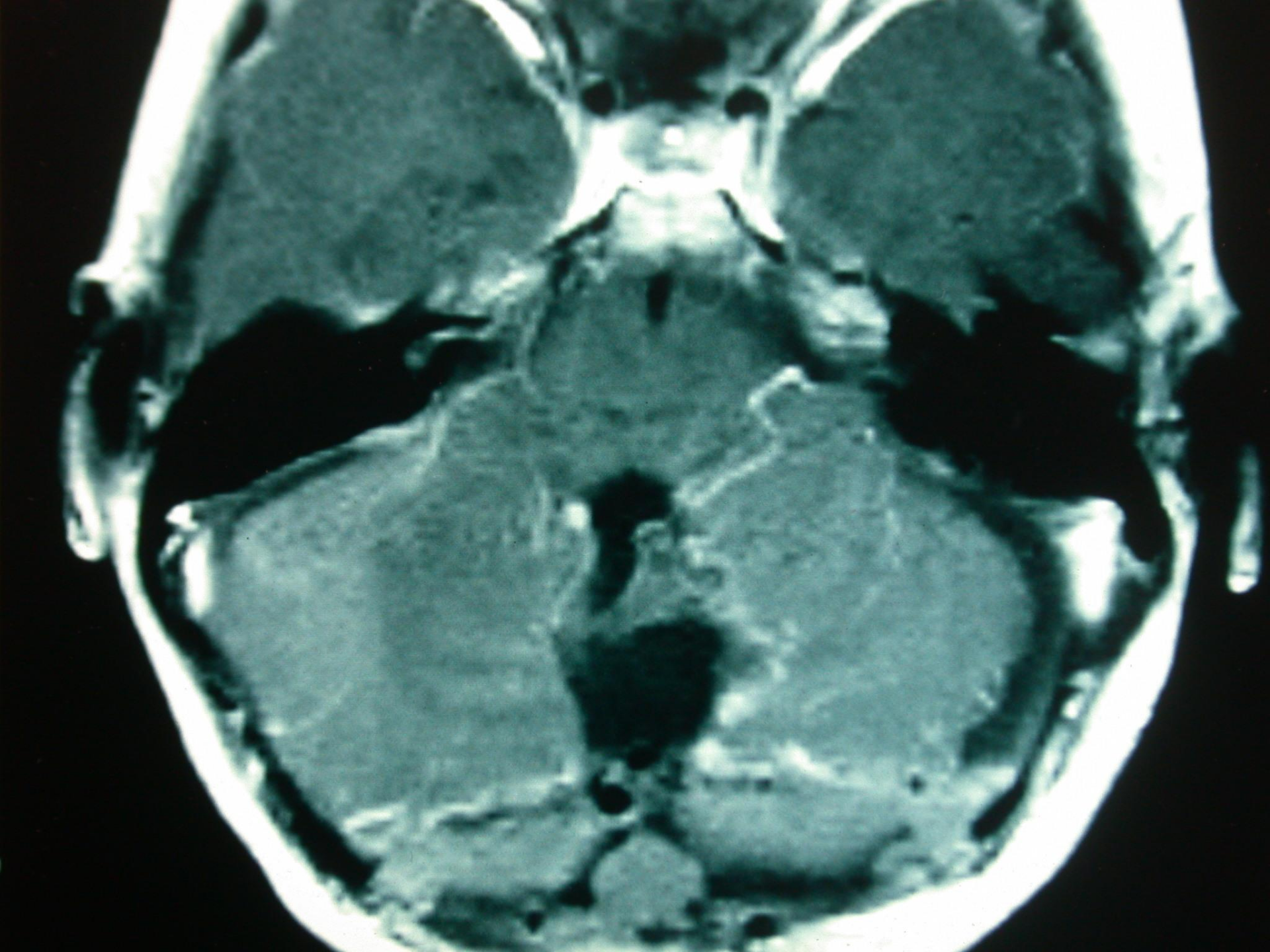
Treatment:

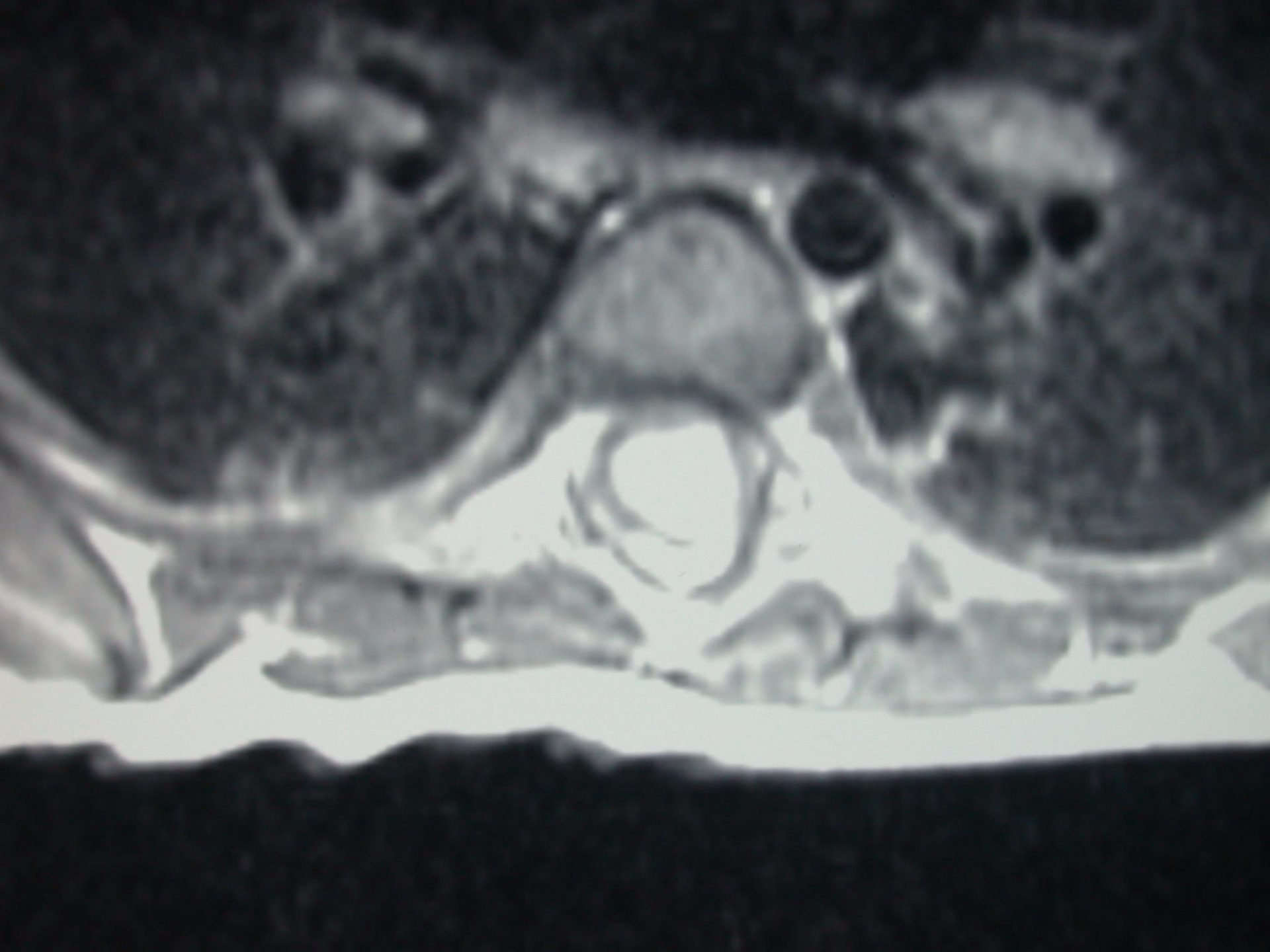
Surgery for tissue diagnosis and remove as much tumor safely as possible.

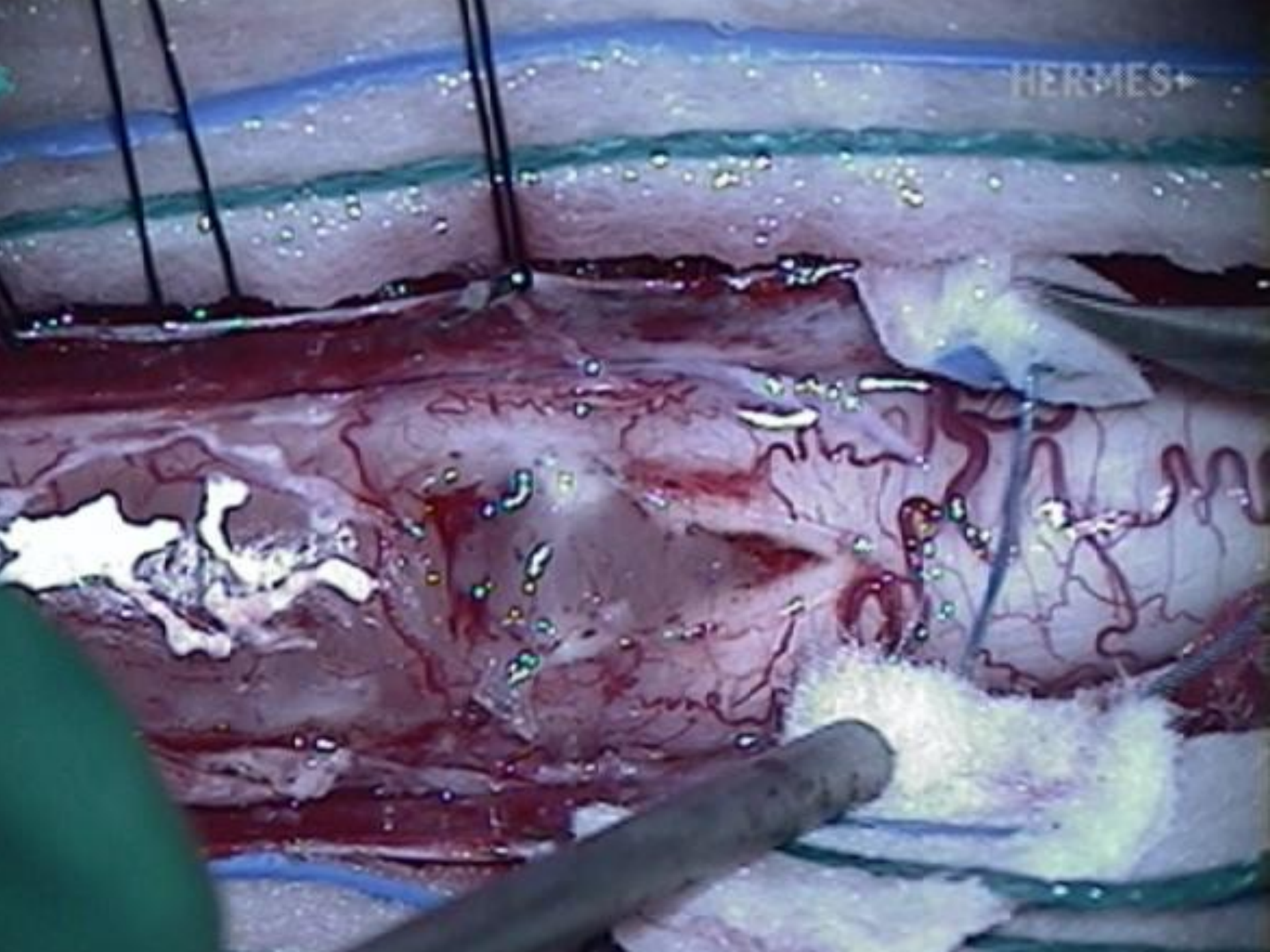
-Total resection offers long term DFS and is potentially curative (95-100% 10yr DFS for cerebellar astrocytomas)
-Resection limited by certain locations and infiltrative margins
-Radical resection >90-95% improves EFS (84% vs. 65% 2yr EFS *Wisoff, CCG9891, 726 pts 1991-1996*)
-small residual disease may be followed
-mindful that adjuvant therapy can offer long term control

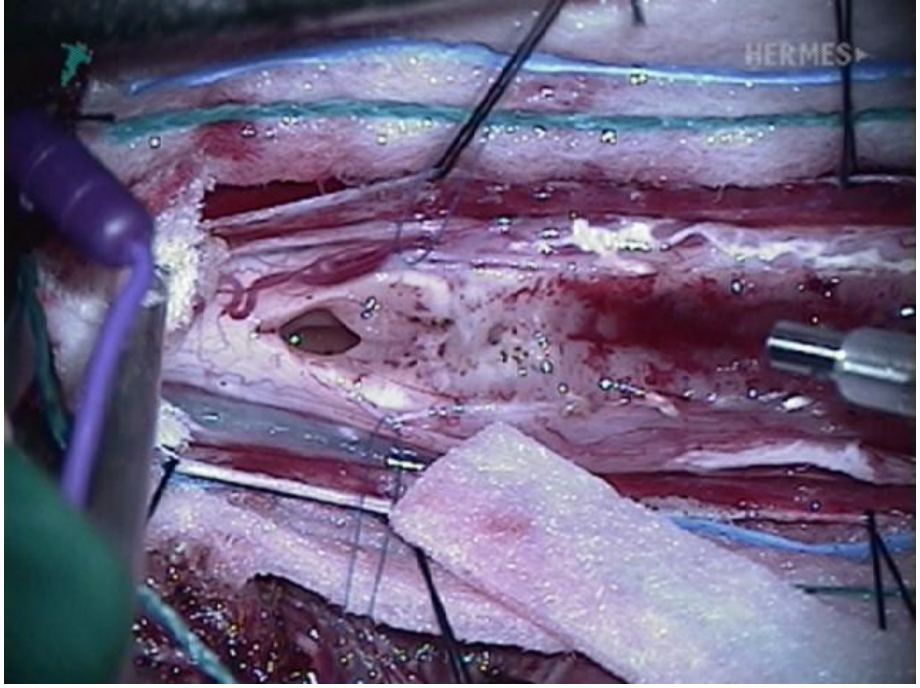
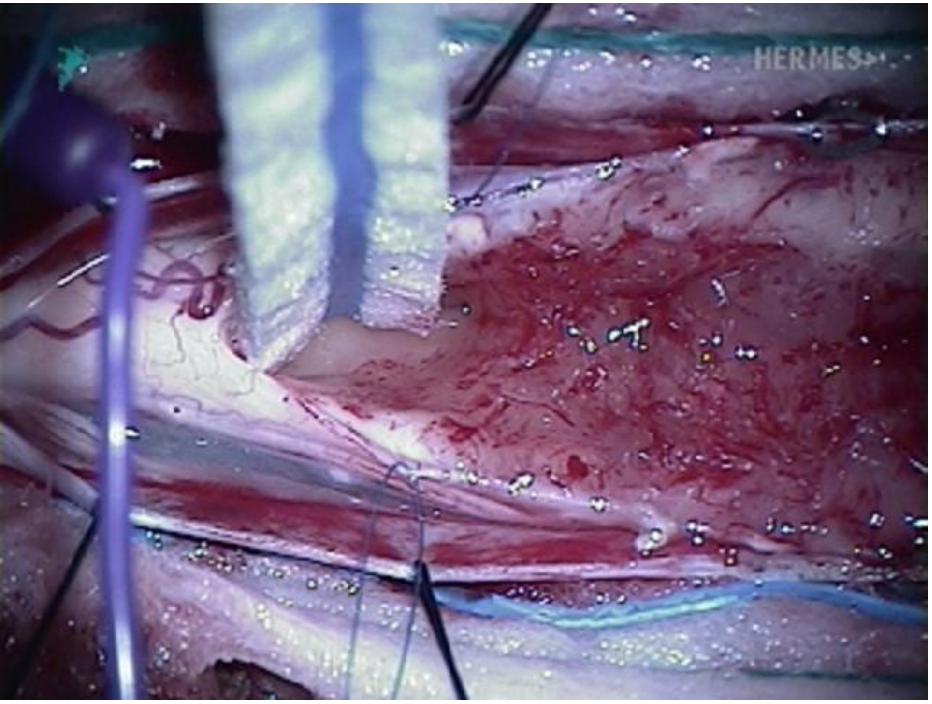

90
MT



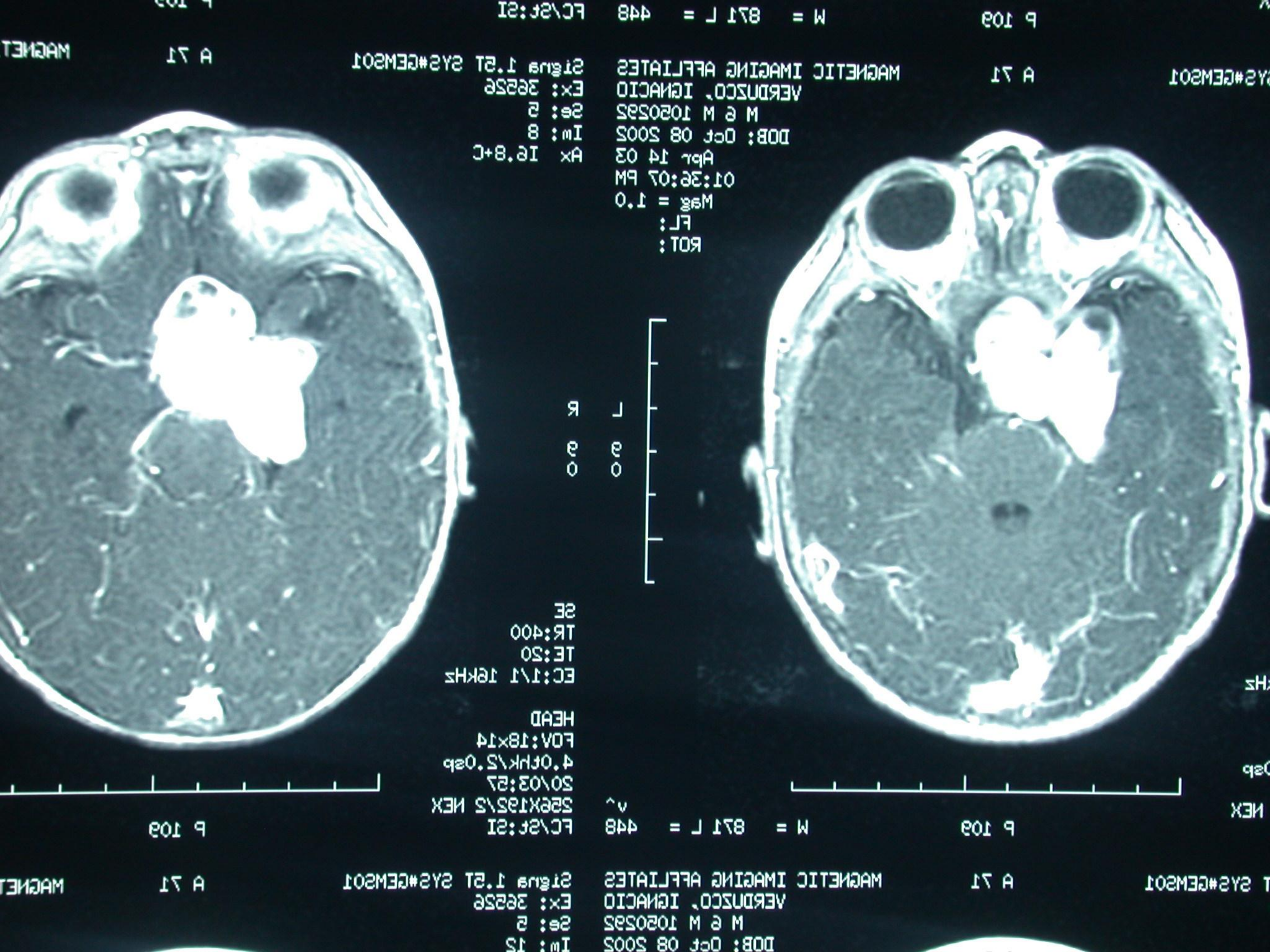


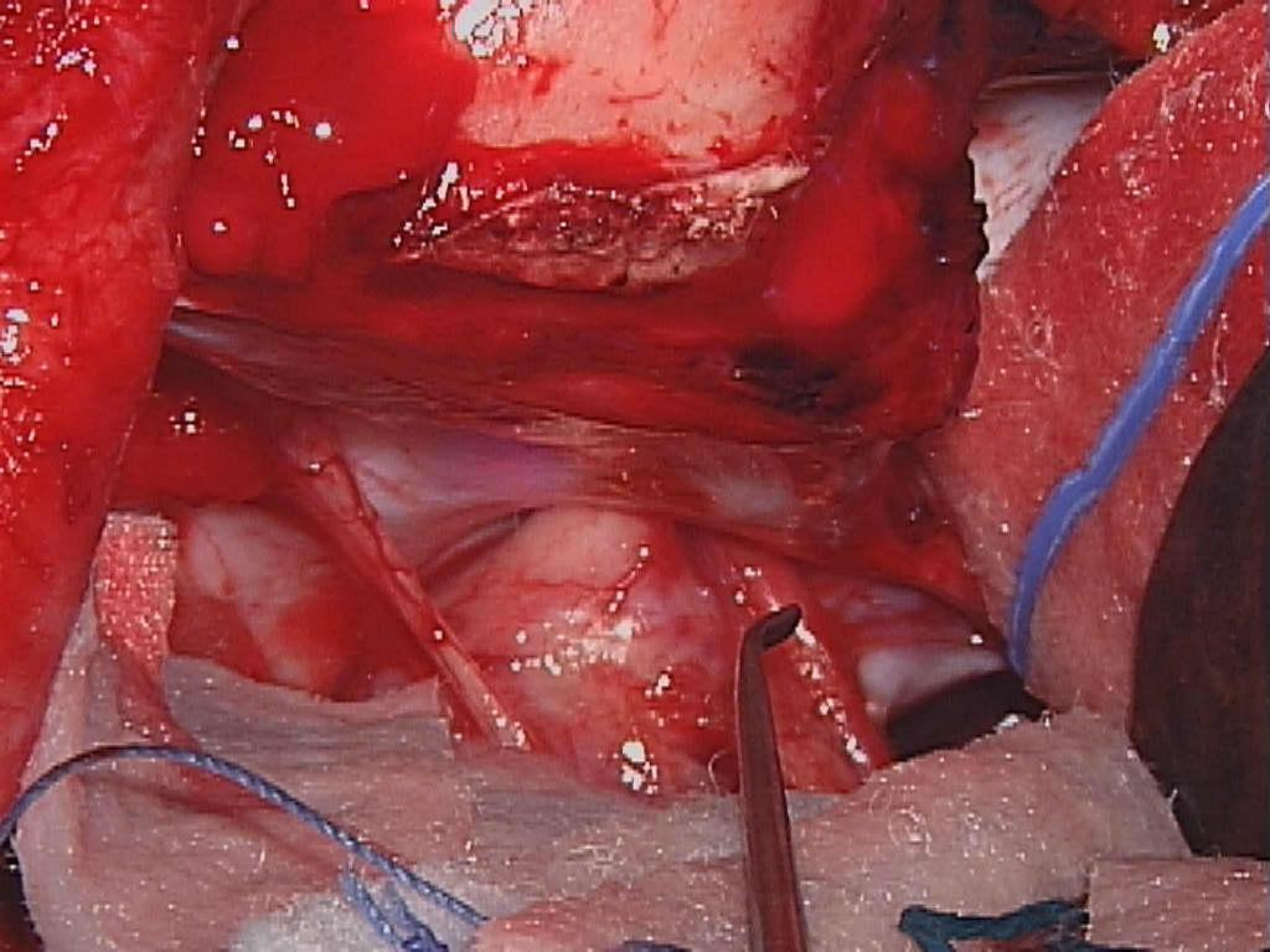


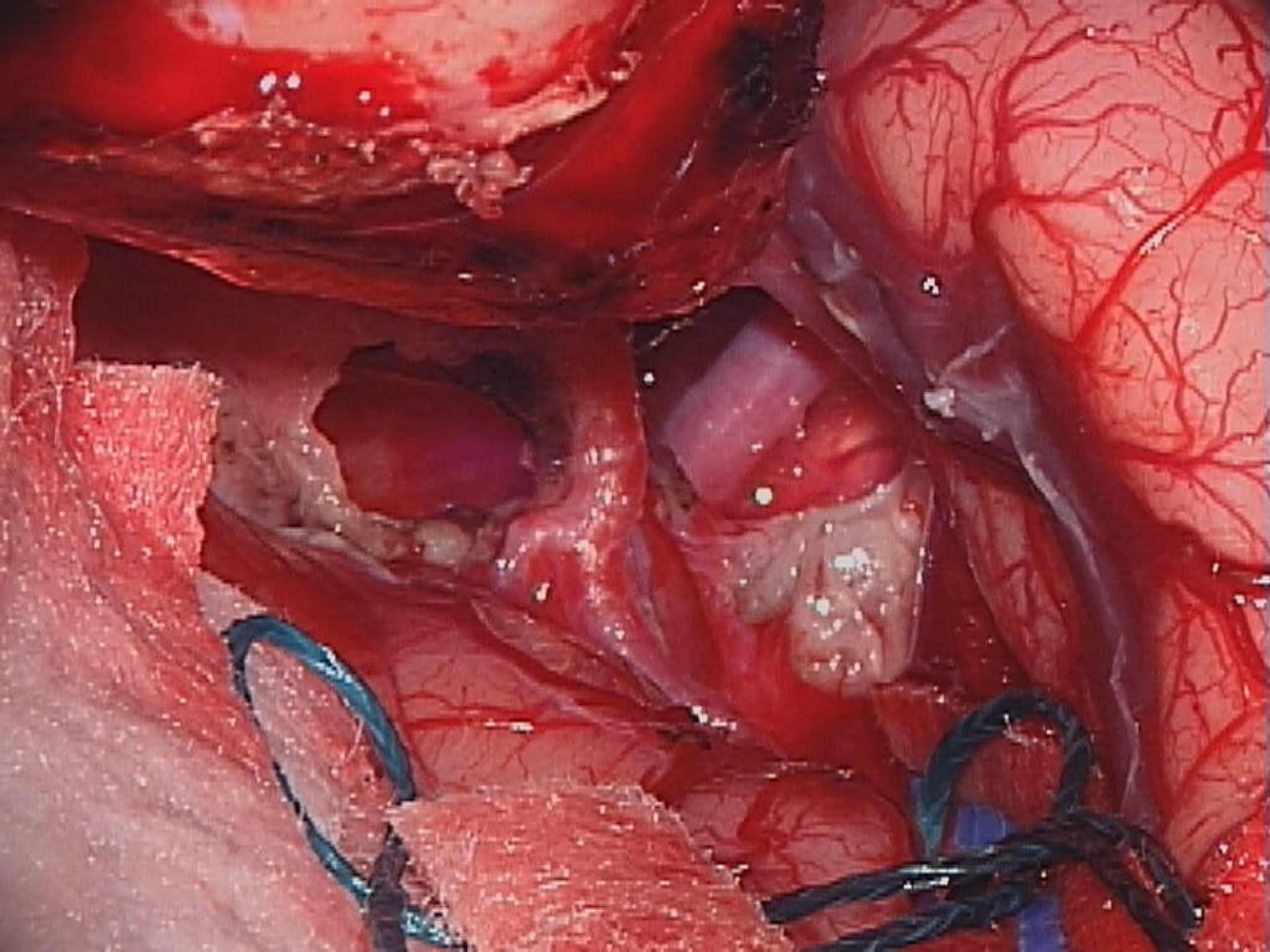

HERMES+

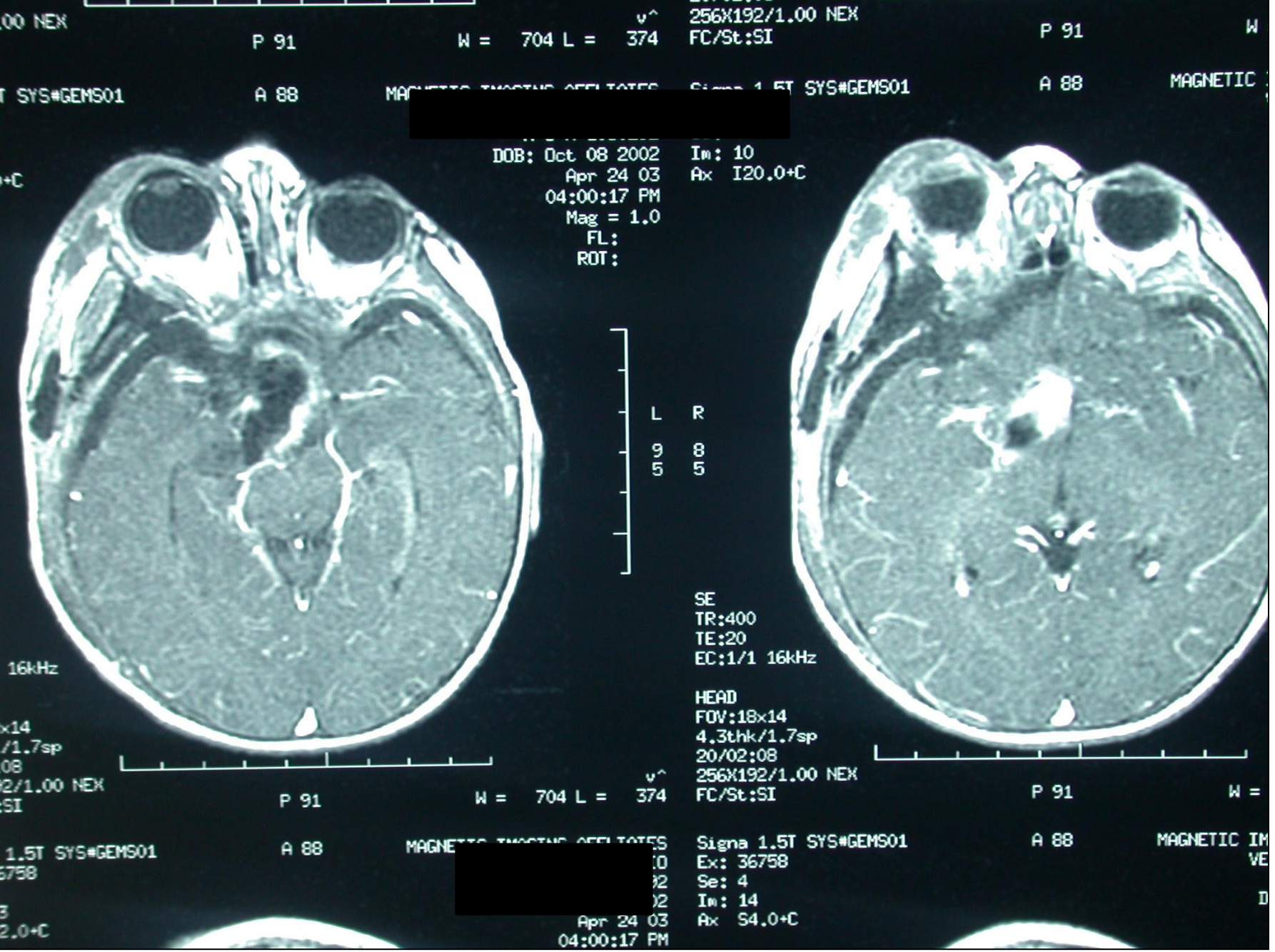





All gone

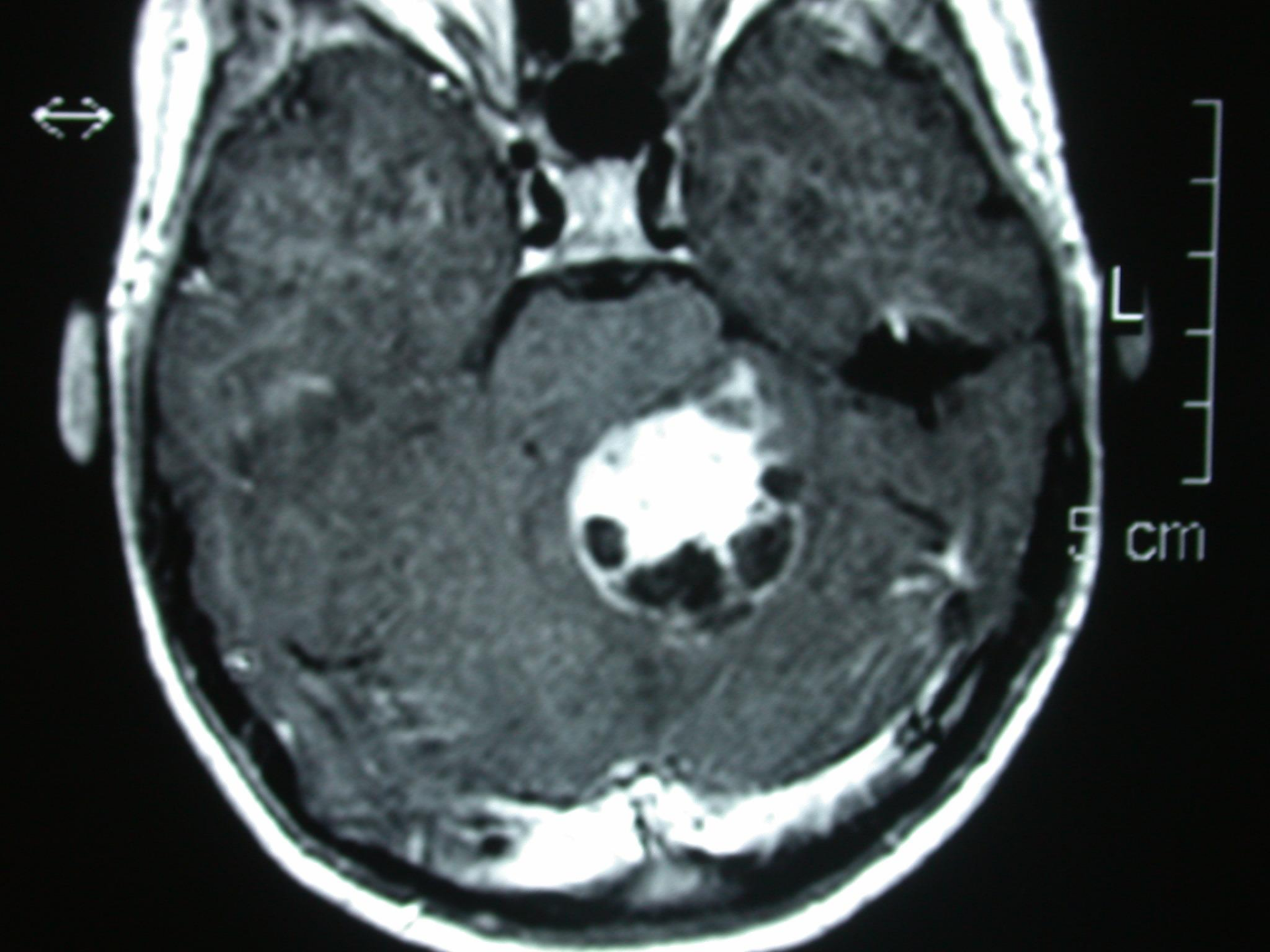

MAGNETIC IMAGING AFFLIATES
VERDUZCO, IGNACIO
M 6 M 1050292
DOB: Oct 08 2002
Apr 14 03
01:36:07 PM
Mag = 1.0
FL:
ROT:
Signa 1.5T SYS#GEMS01
Ex: 36526
Se: 5
Im: 8
Ax 16.8+C
A 71
P 109
W = 871 L = 448
FC/St:SI
R
L
SE
TR:400
TE:20
EC:1/1 16kHz
HEAD
FOV:18x14
4.0thk/2.0sp
20/03:57
256X192/2 NEX
Im: 12

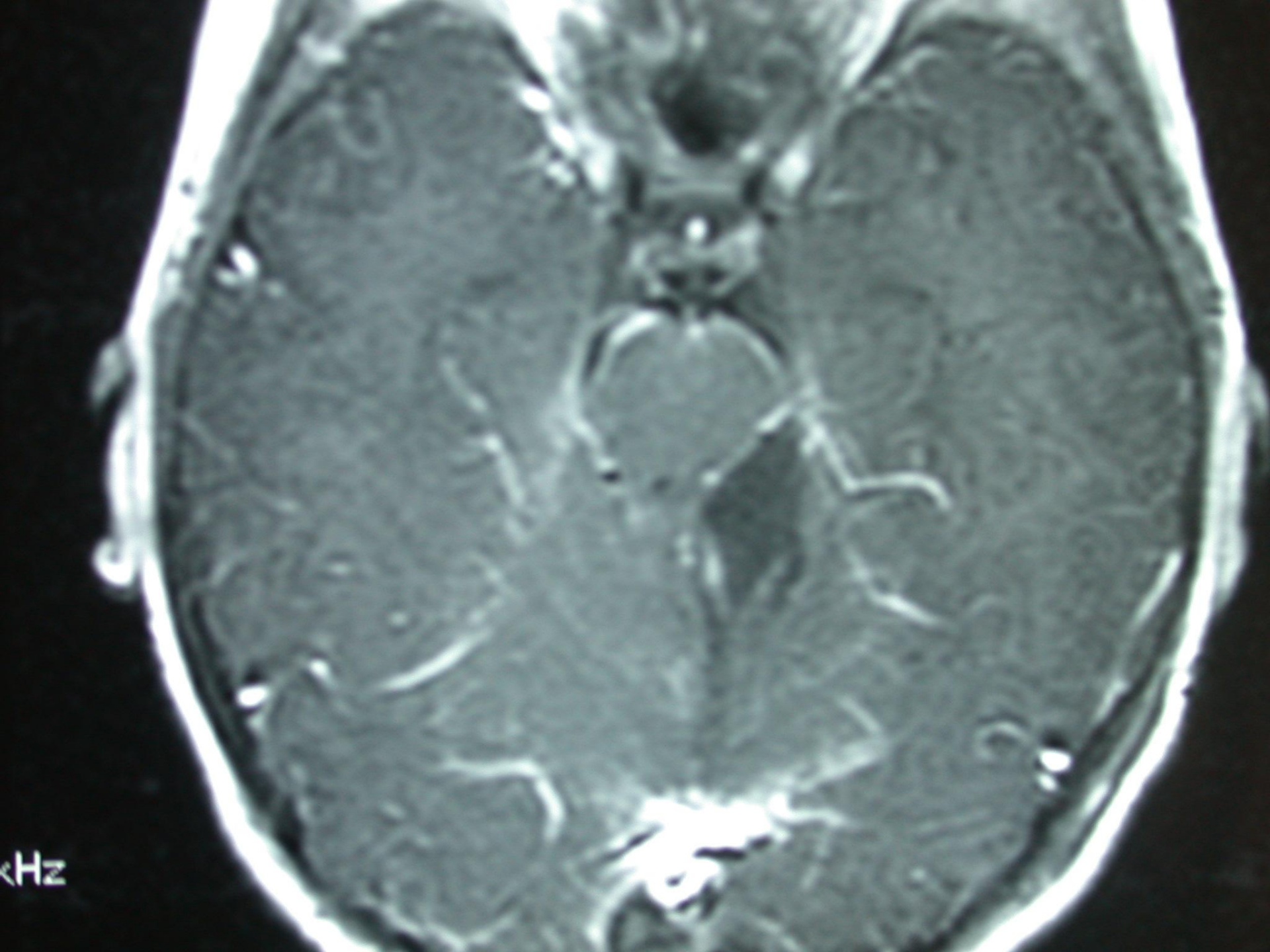


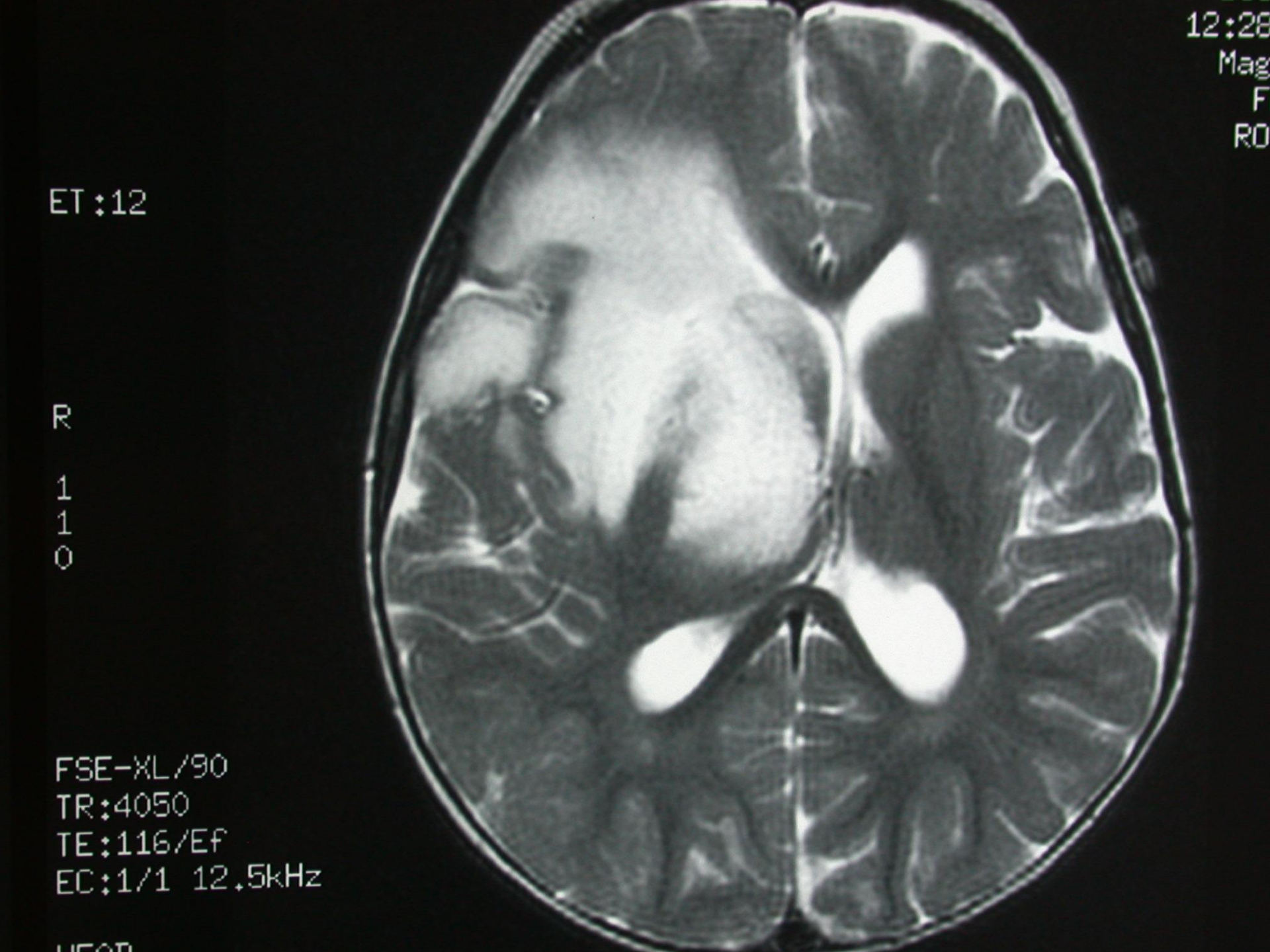


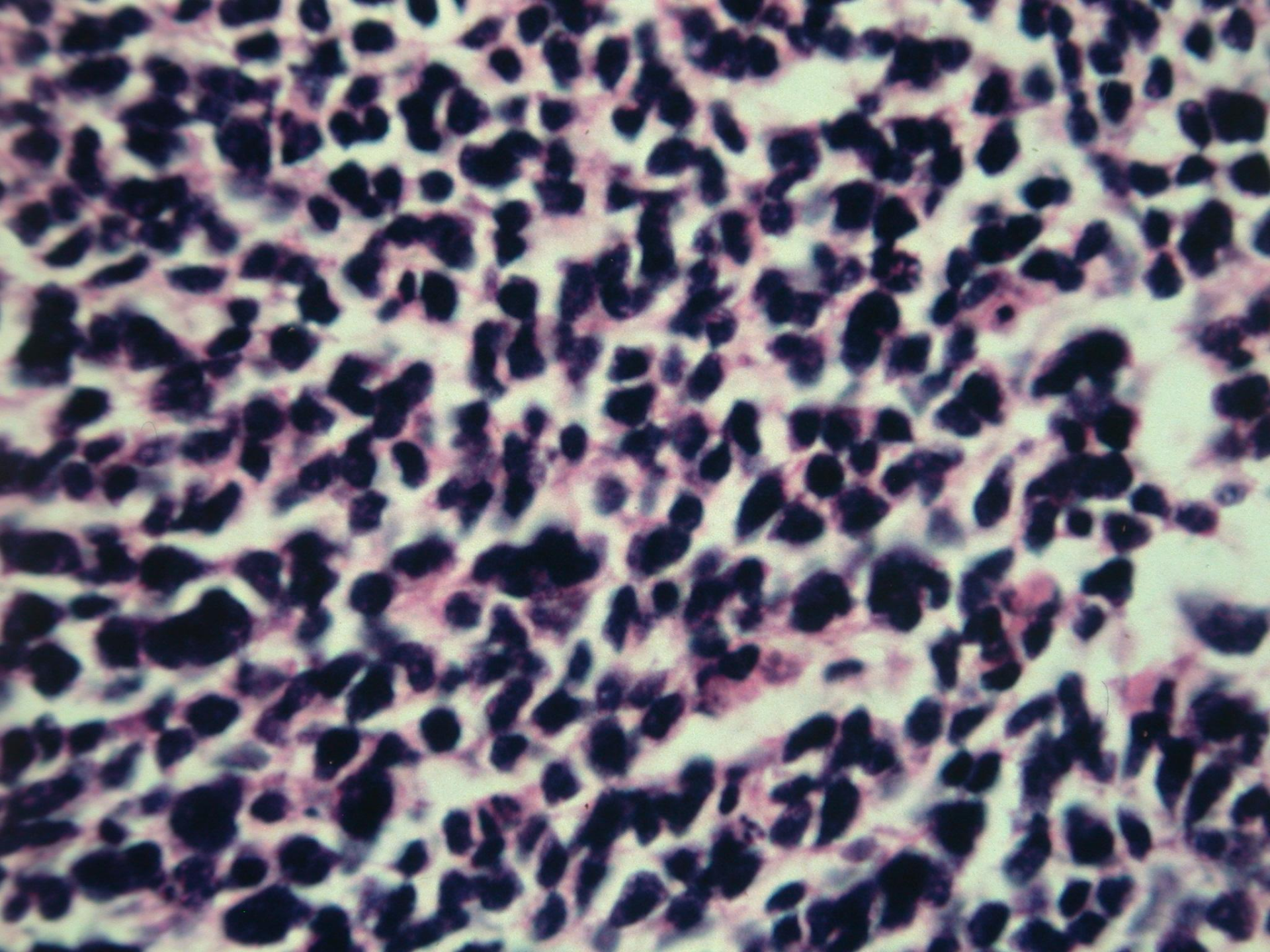


Not all gone, rest intertwined with optic nerve treated with chemo


L
5 cm


kHz


12:28
Mag
F
RO
ET:12
R
1
1
0
FSE-XL/90
TR:4050
TE:116/Ef
EC:1/1 12.5kHz



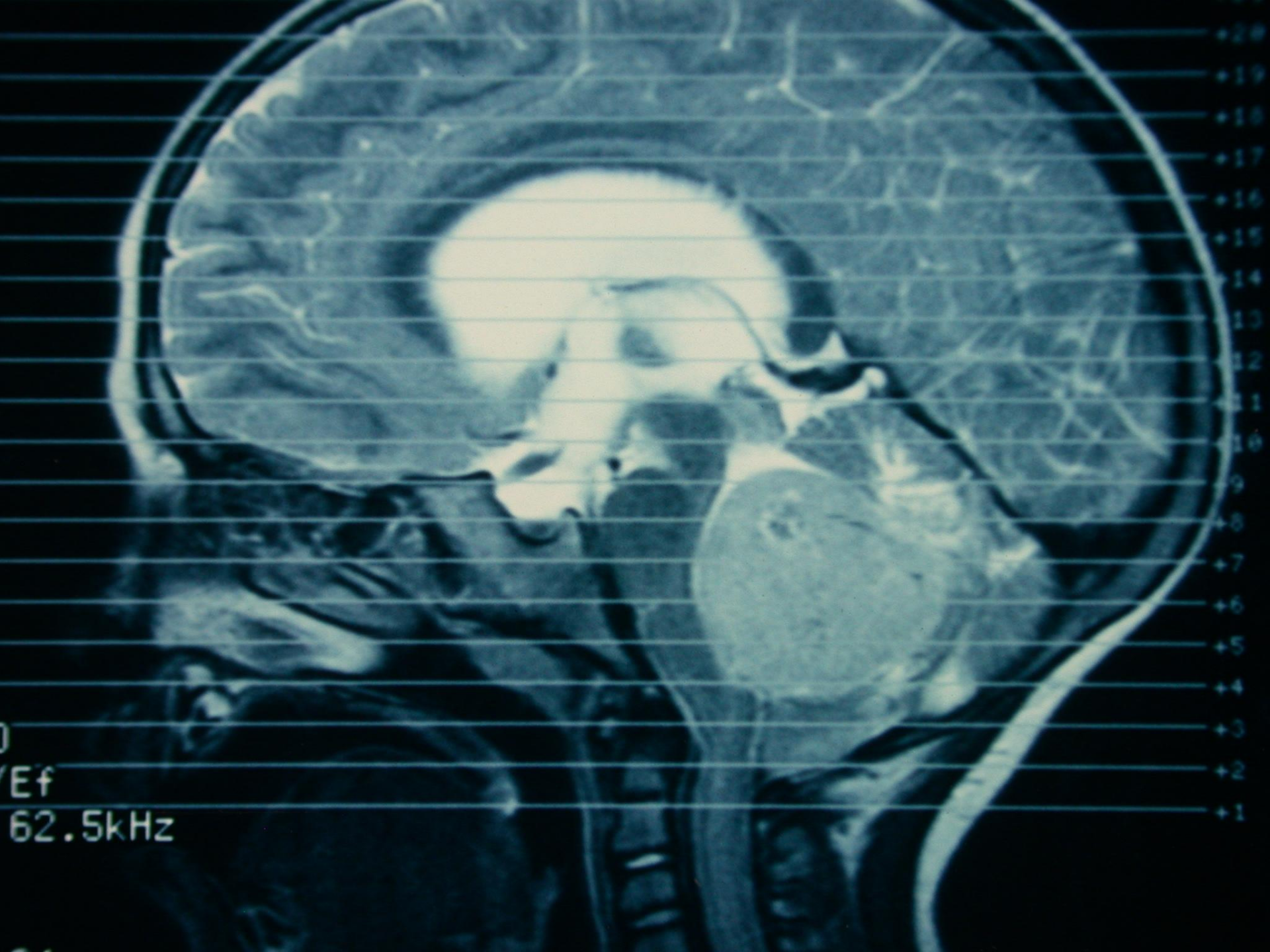
PNET (medulloblastoma)

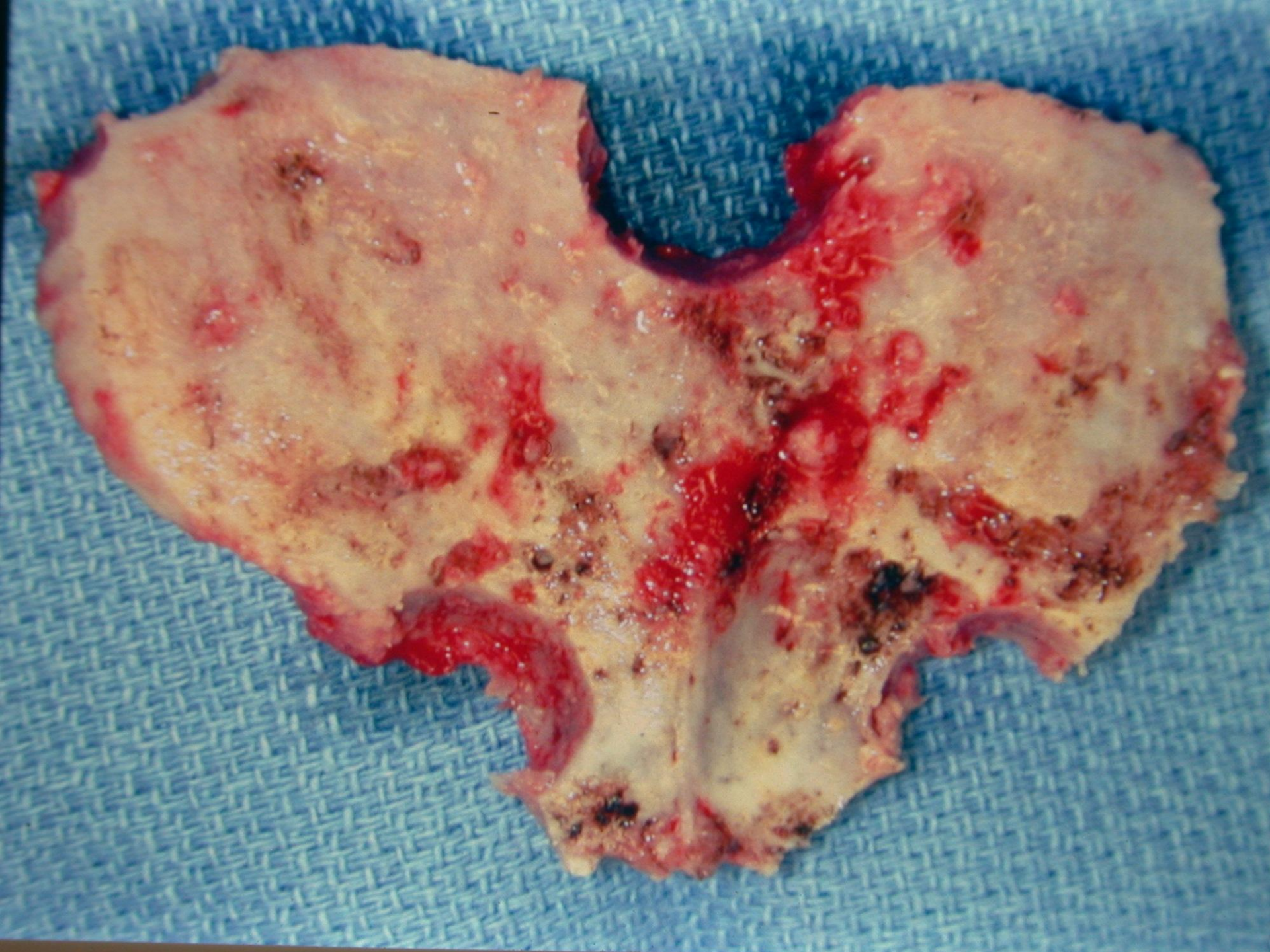
Treatment: Surgery (<1.5cm^2), chemotherapy, craniospinal XRt +local Xrt

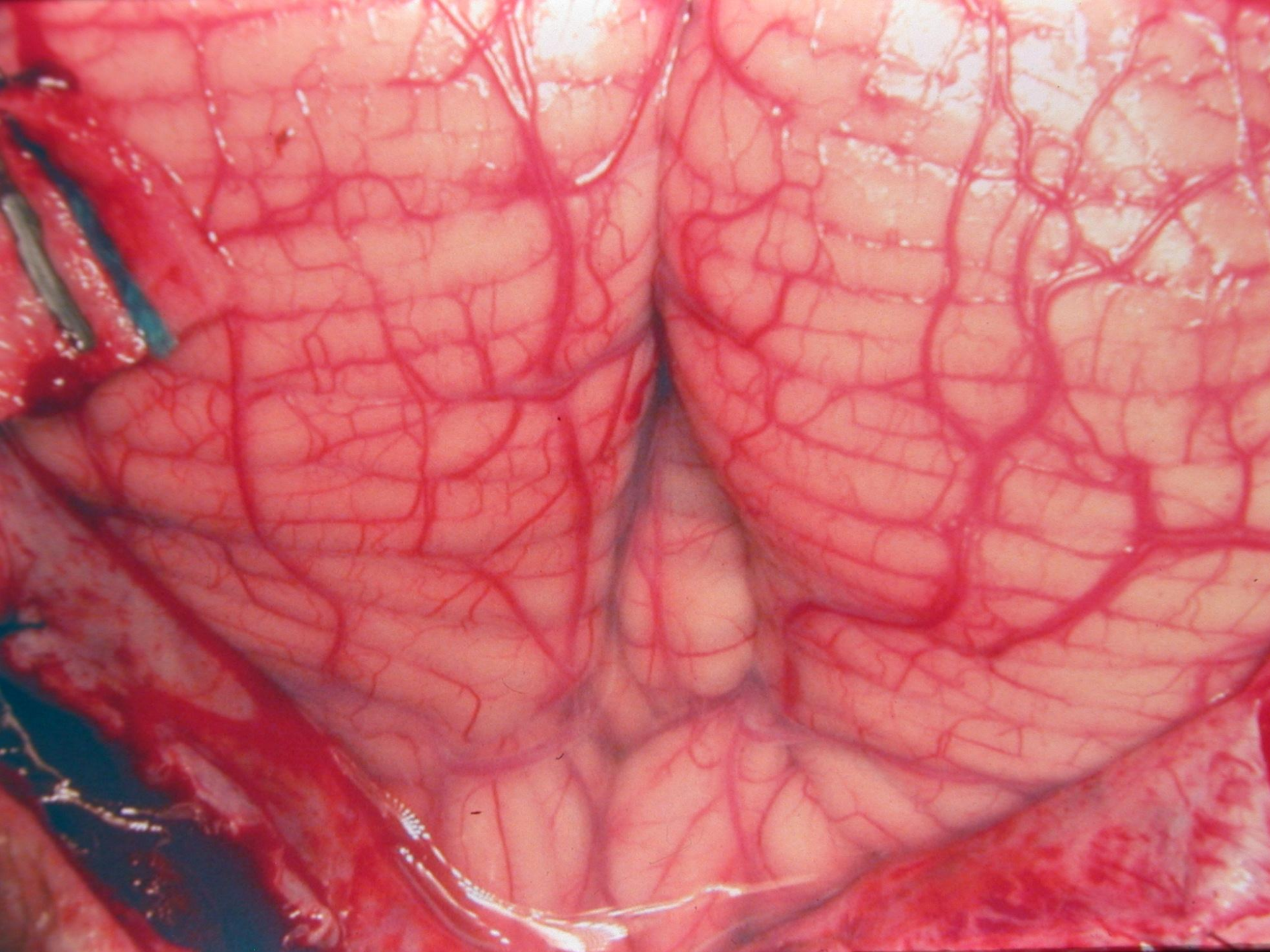
Prognosis

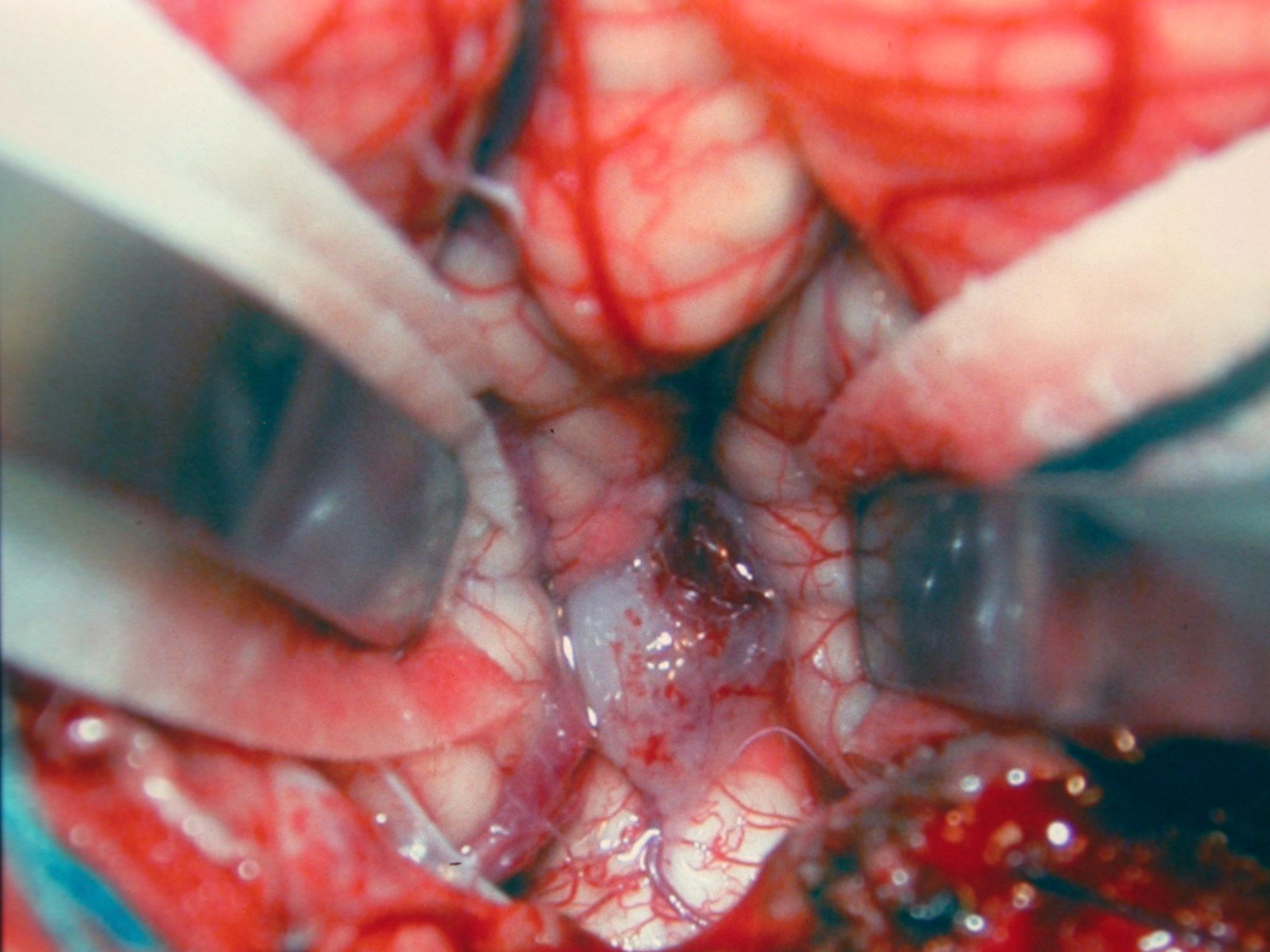
1. Staging, amount of post operative residual tumor
2. Age < 3yo

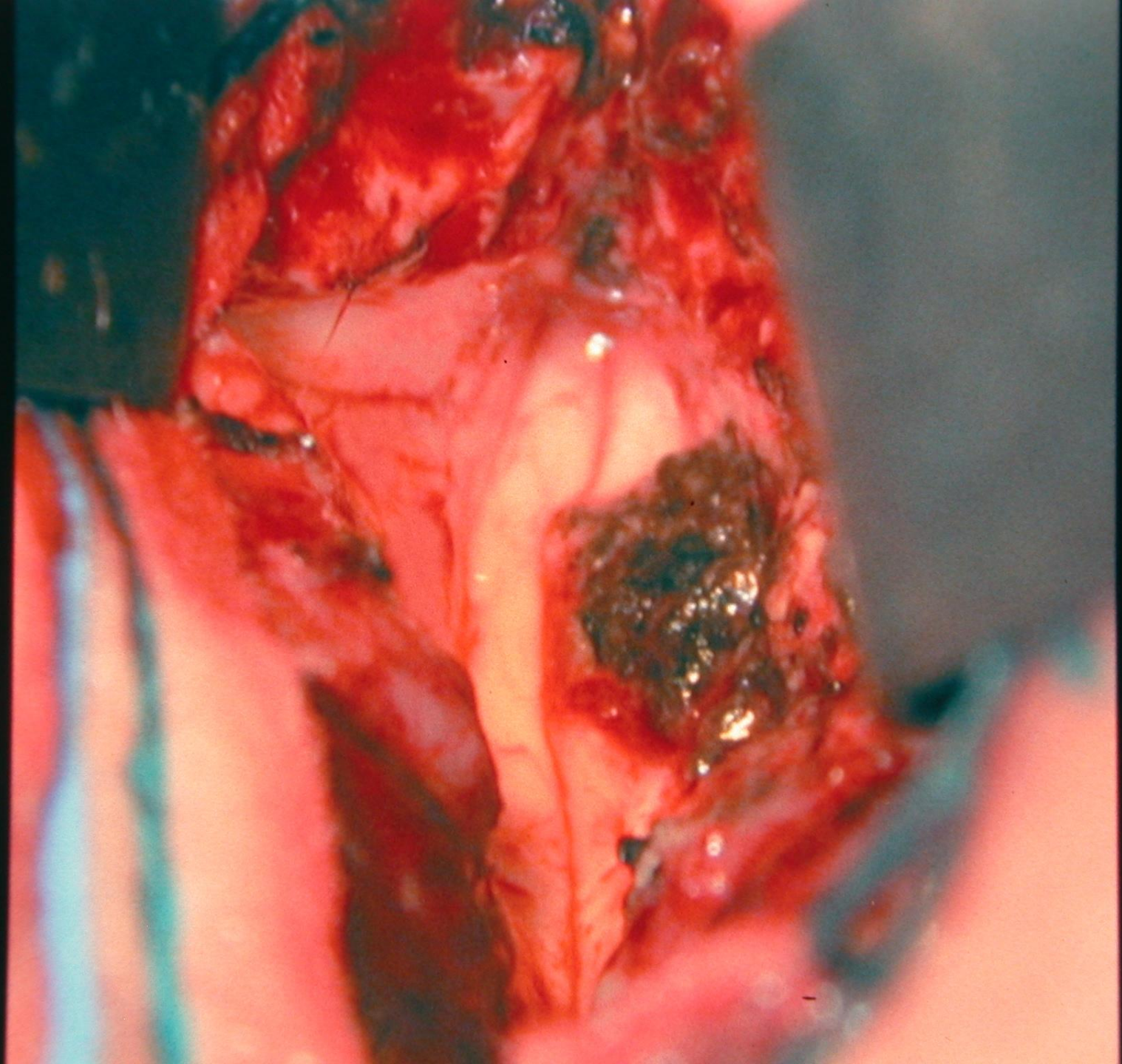
3. Emerging evidence for histology, molecular markers


Ef
62.5kHz

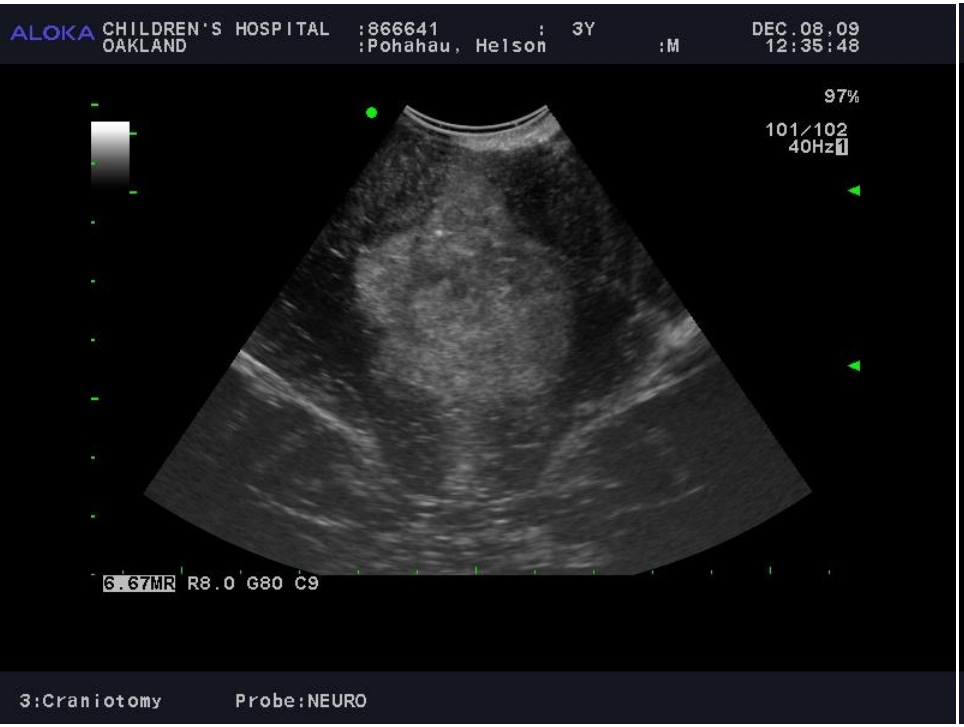


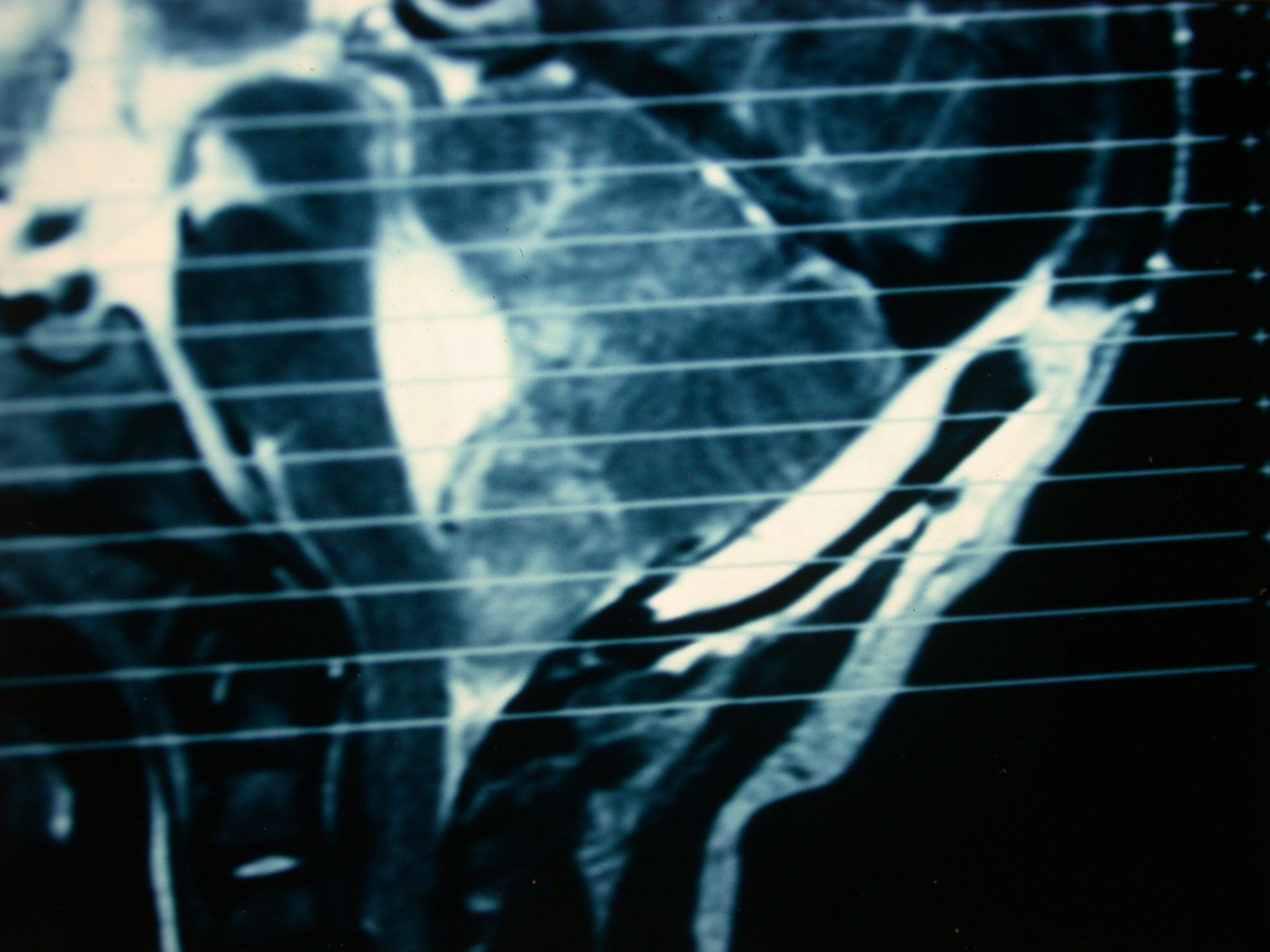






Intraoperative ultrasound:





PNET (medulloblastoma)

Survival: 65-85 % standard risk

40-50% high risk

Relapses (2-4 yrs, locally and CSF pathways) are very difficult to cure

Current directions:

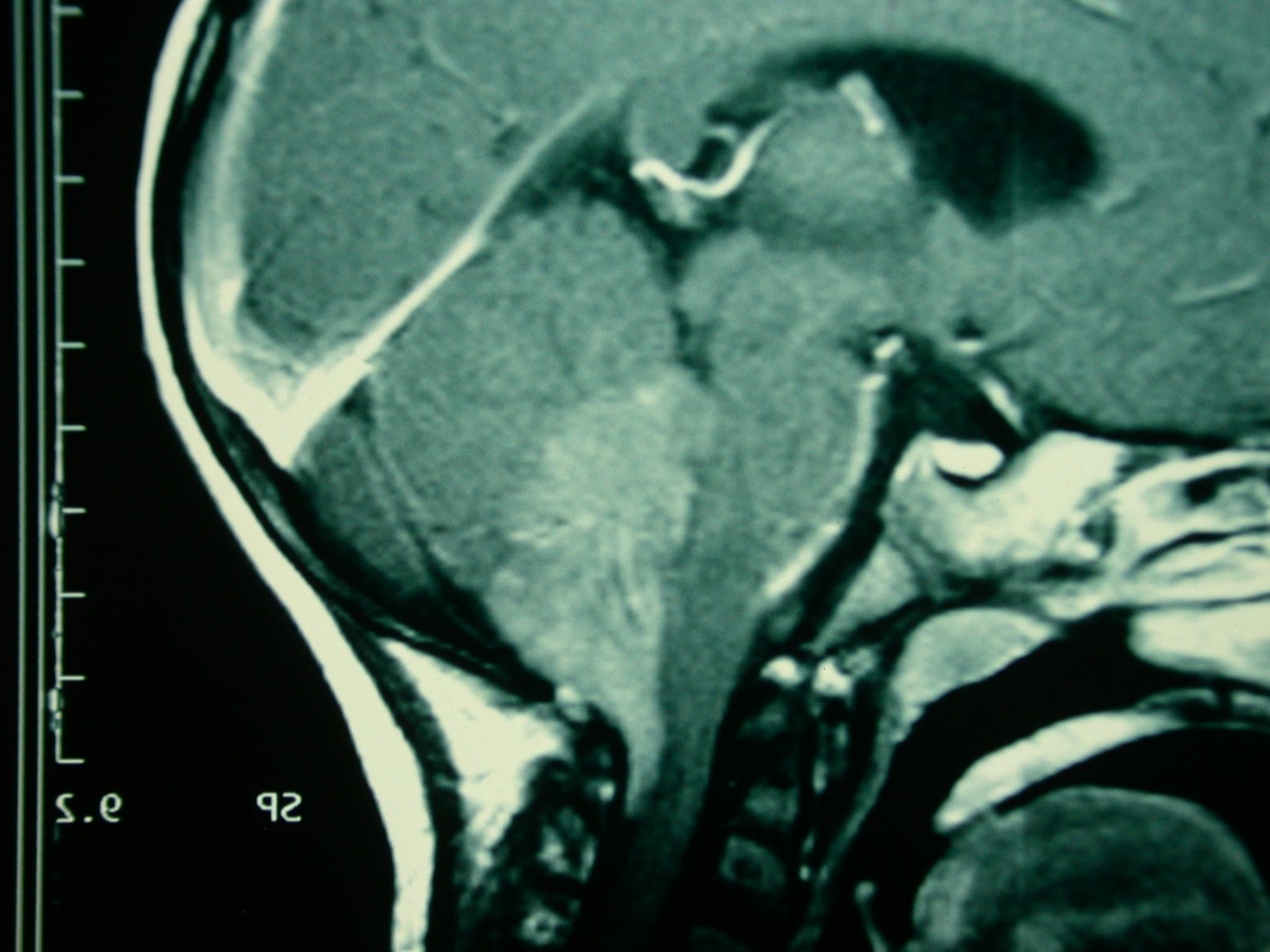
HEAD START 3 and 4- chemo for high risk pts, less Xrt (1800cGy) for standard risk pts to reduce neurocognitive sequelae, high dose chemo and bone marrow transplant with no Xrt for young children CHO is the only Head Start institution in Northern California

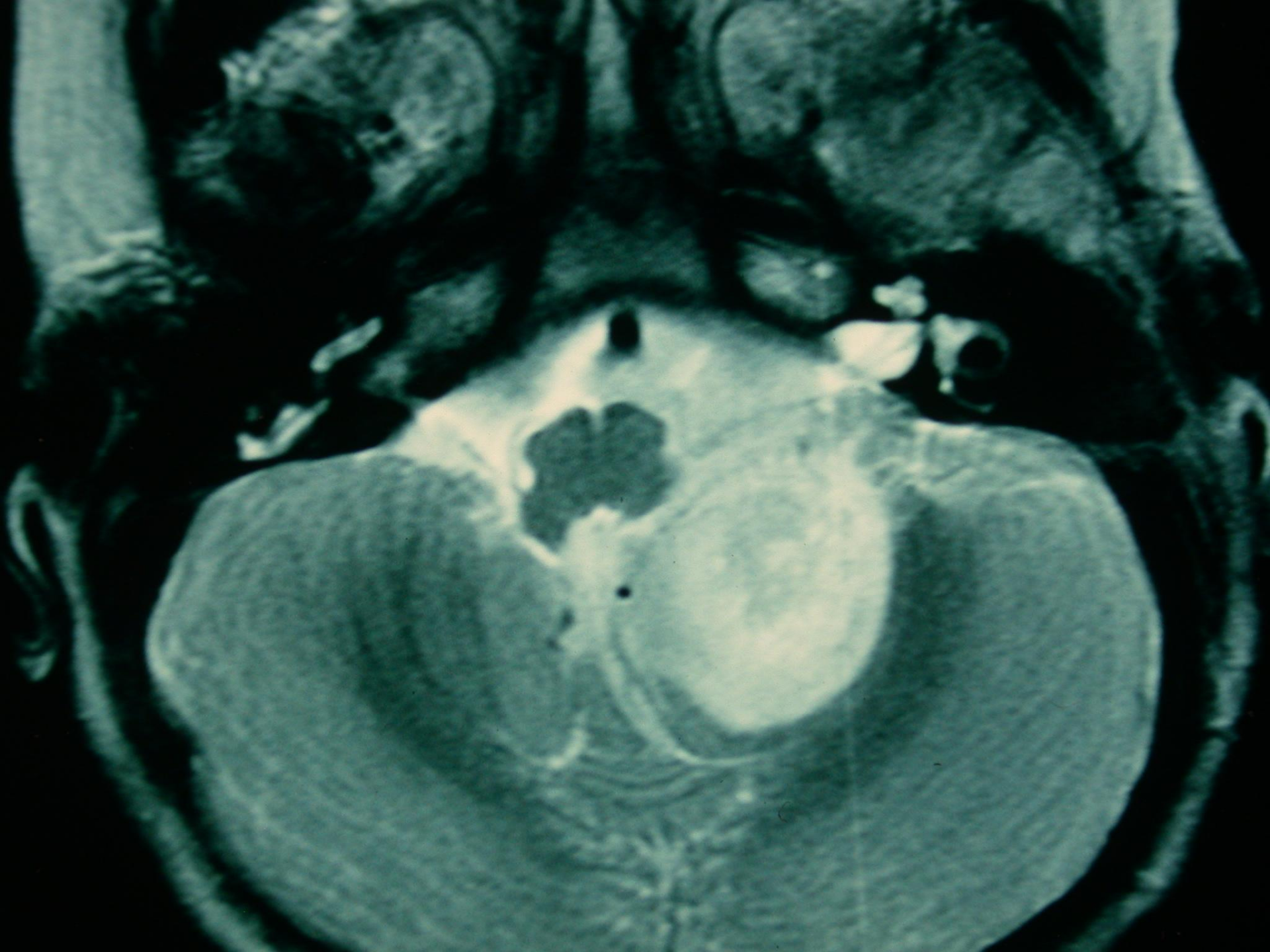
Ependymoma

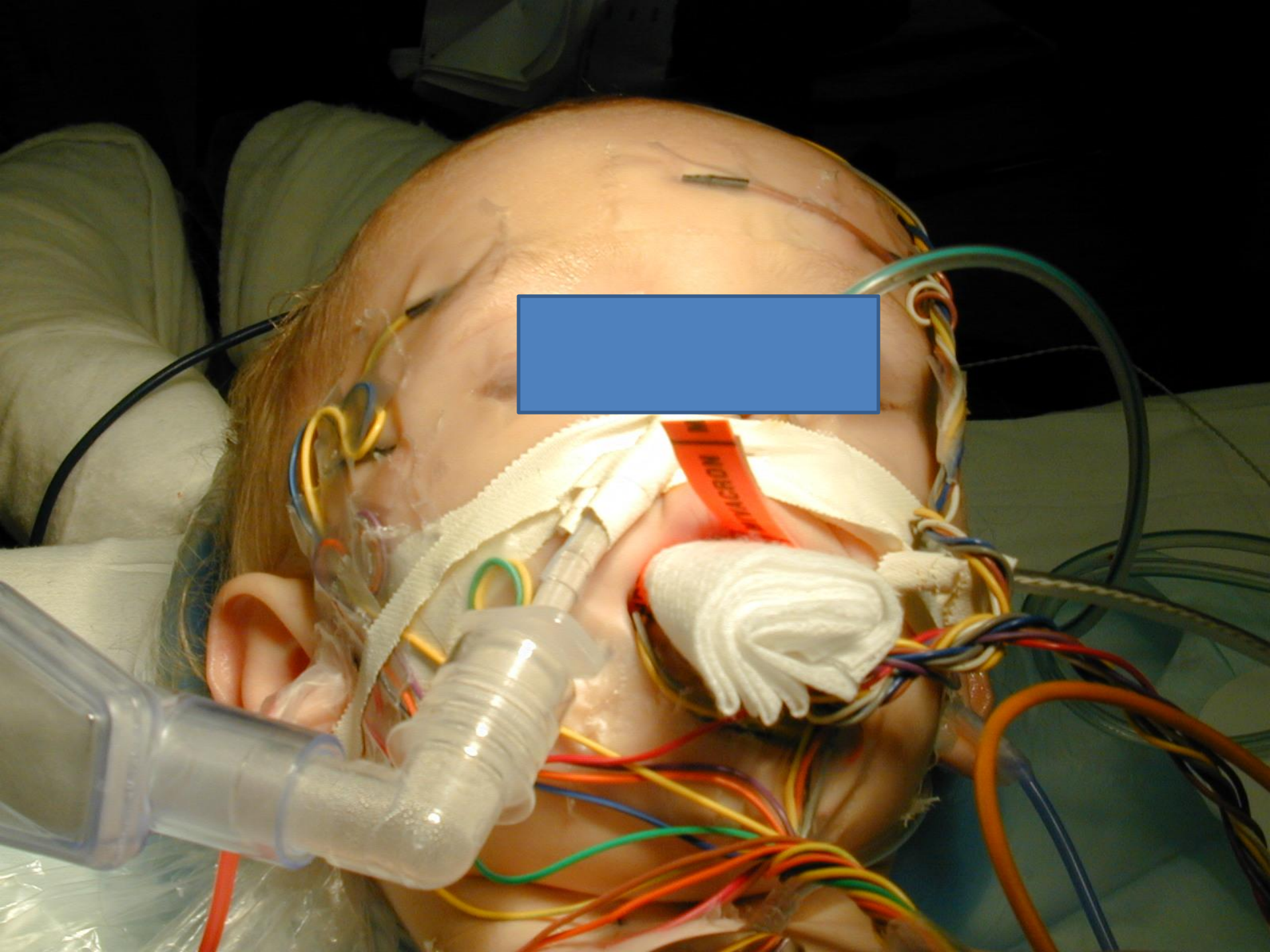
4th ventricle, fingers projecting out of foramens

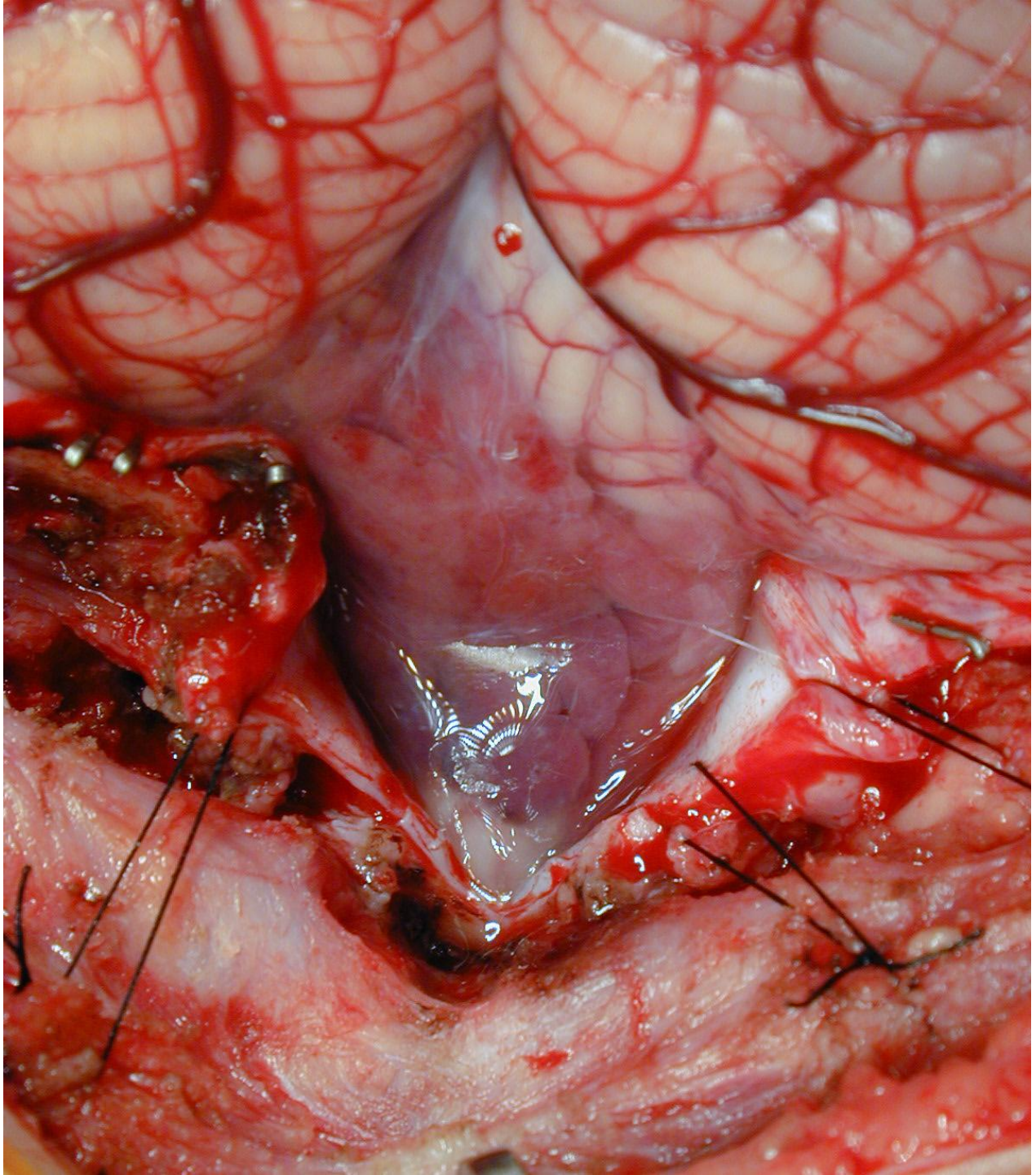
Treatment:
Surgical resection major determinant of outcome
Complete Resection + Xrt: 60-70% 5 yr EFS

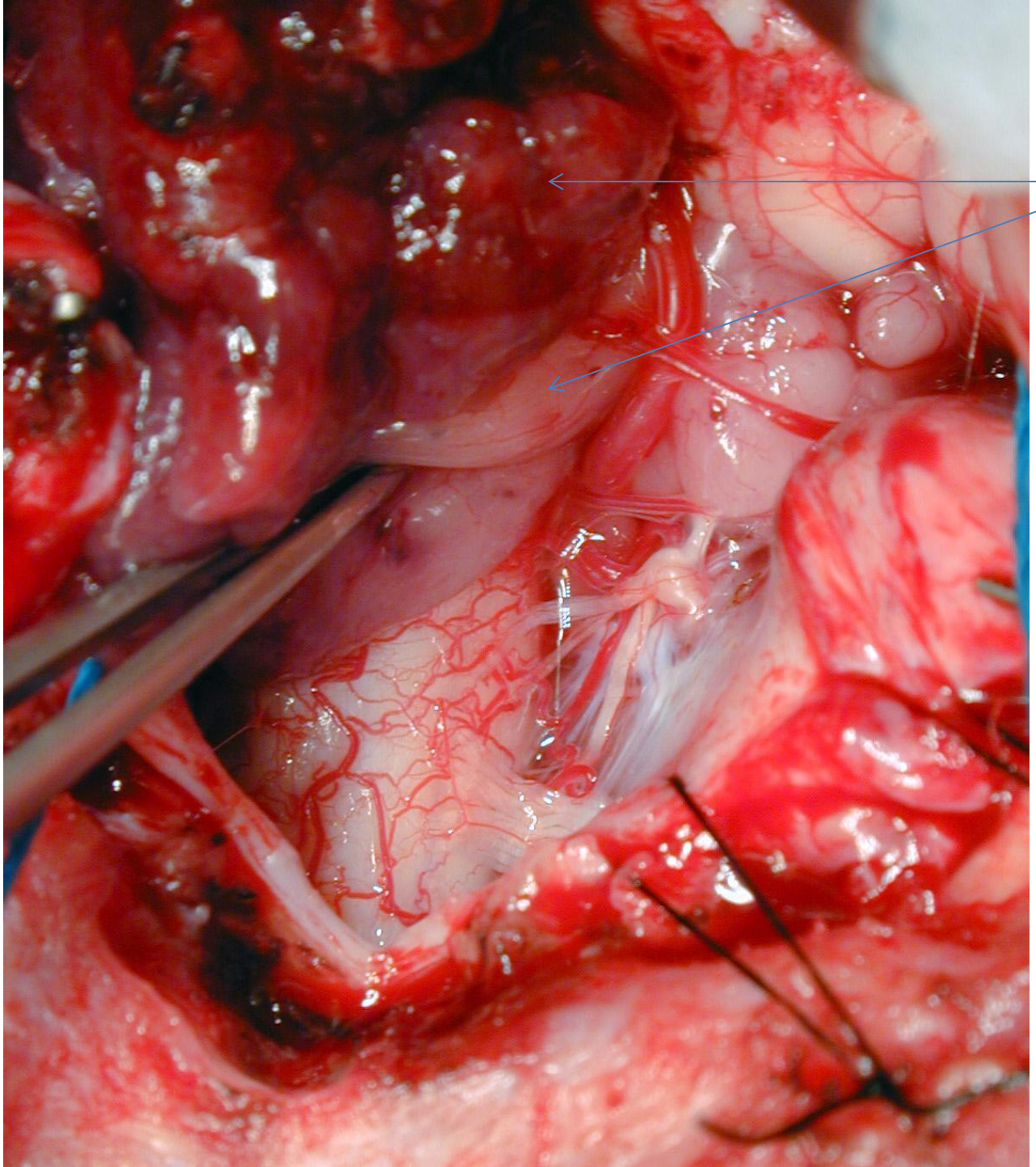
Disseminated Disease (11%), subtotal resection: 20-30%

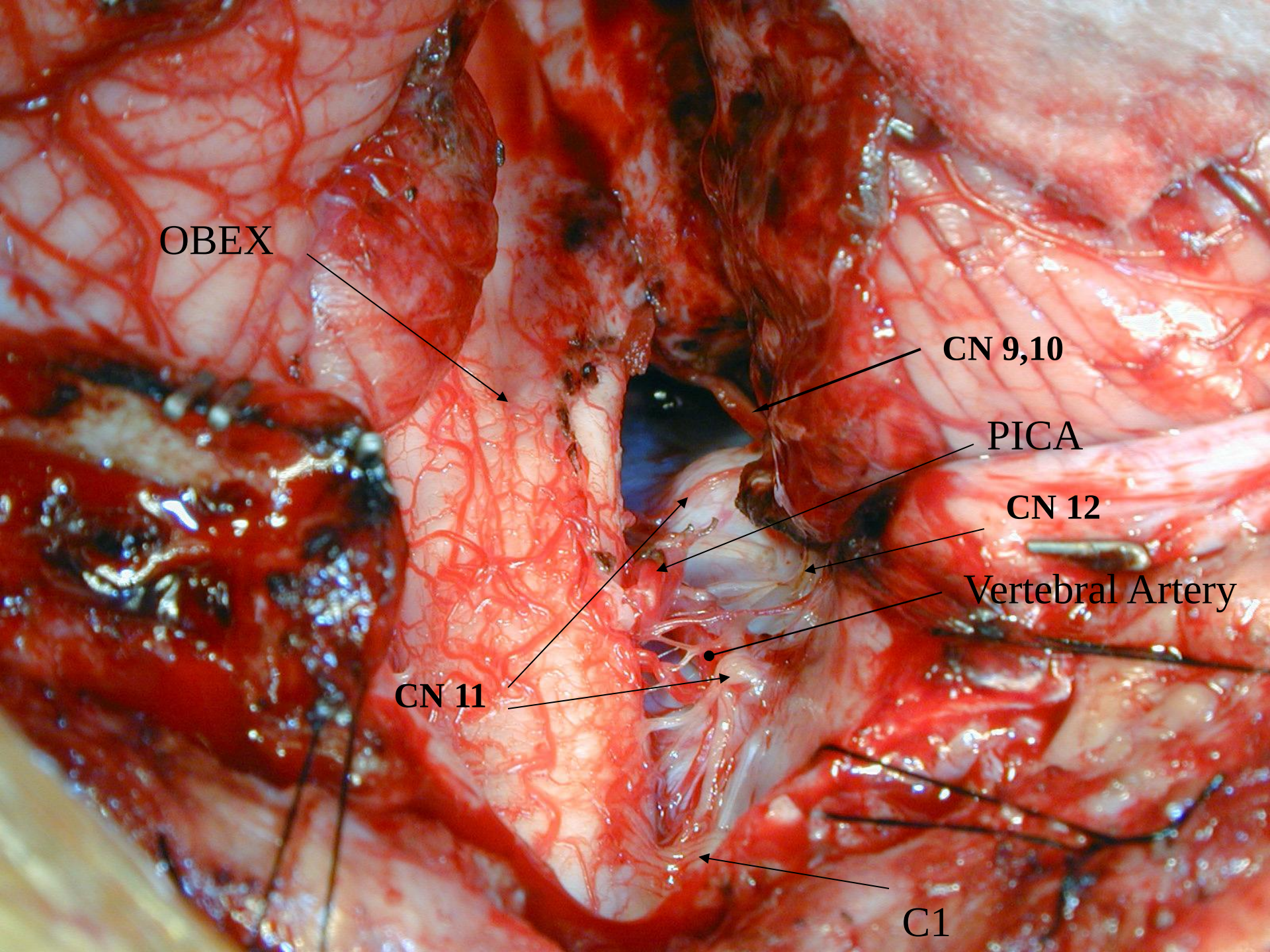


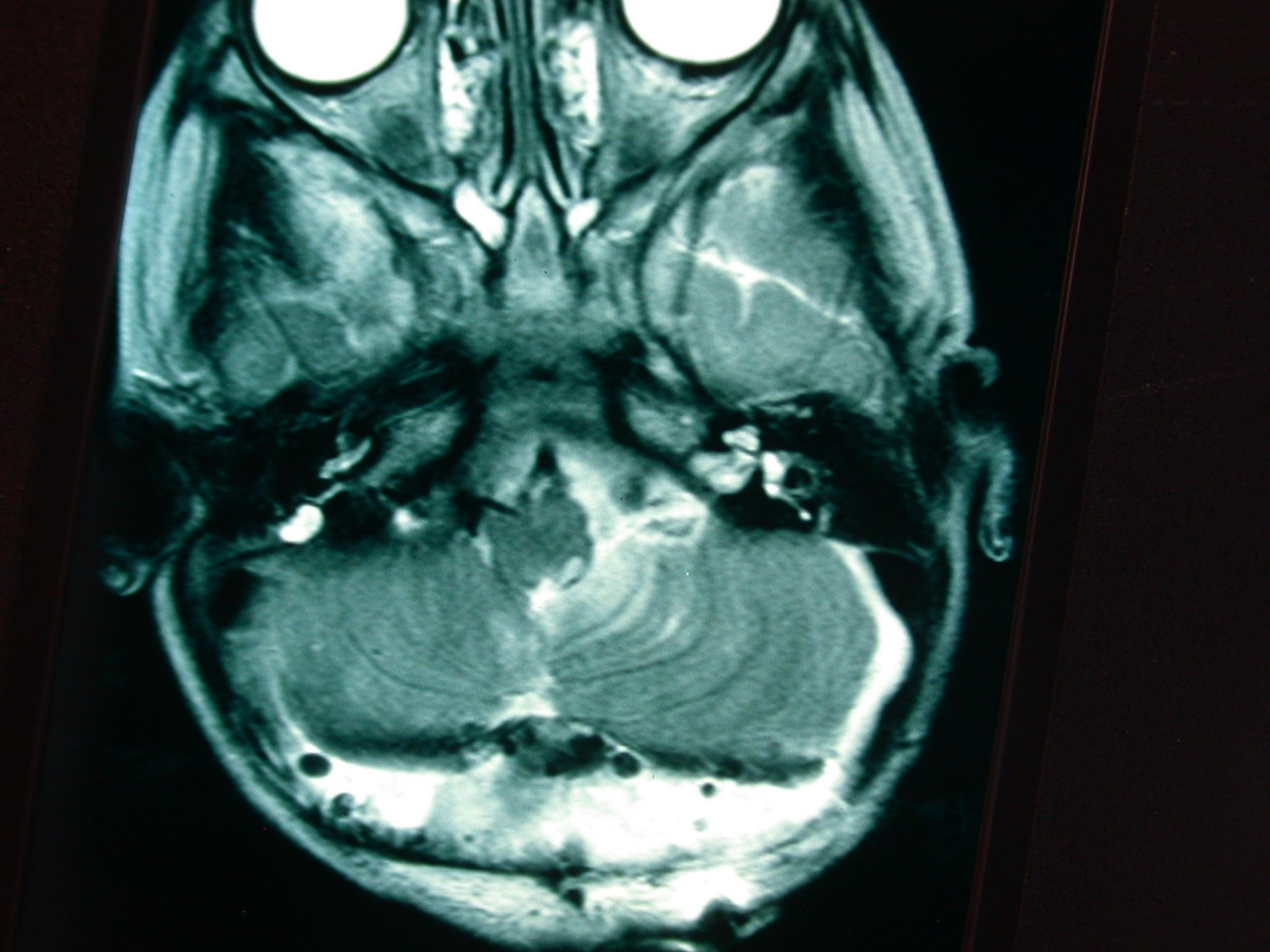







tumor

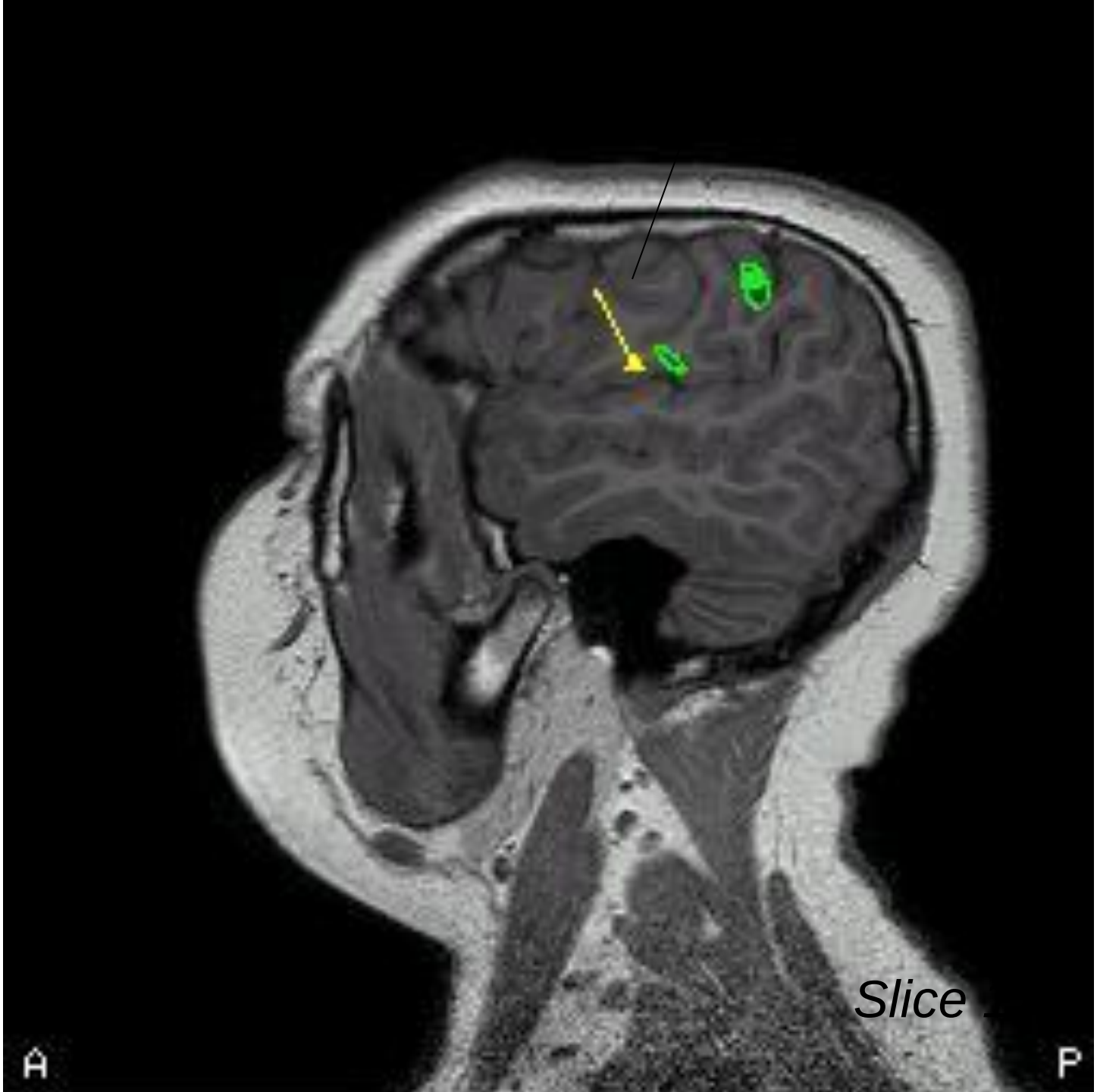

OBEX
CN 9,10
PICA
CN 12
Vertebral Artery
CN 11
C1

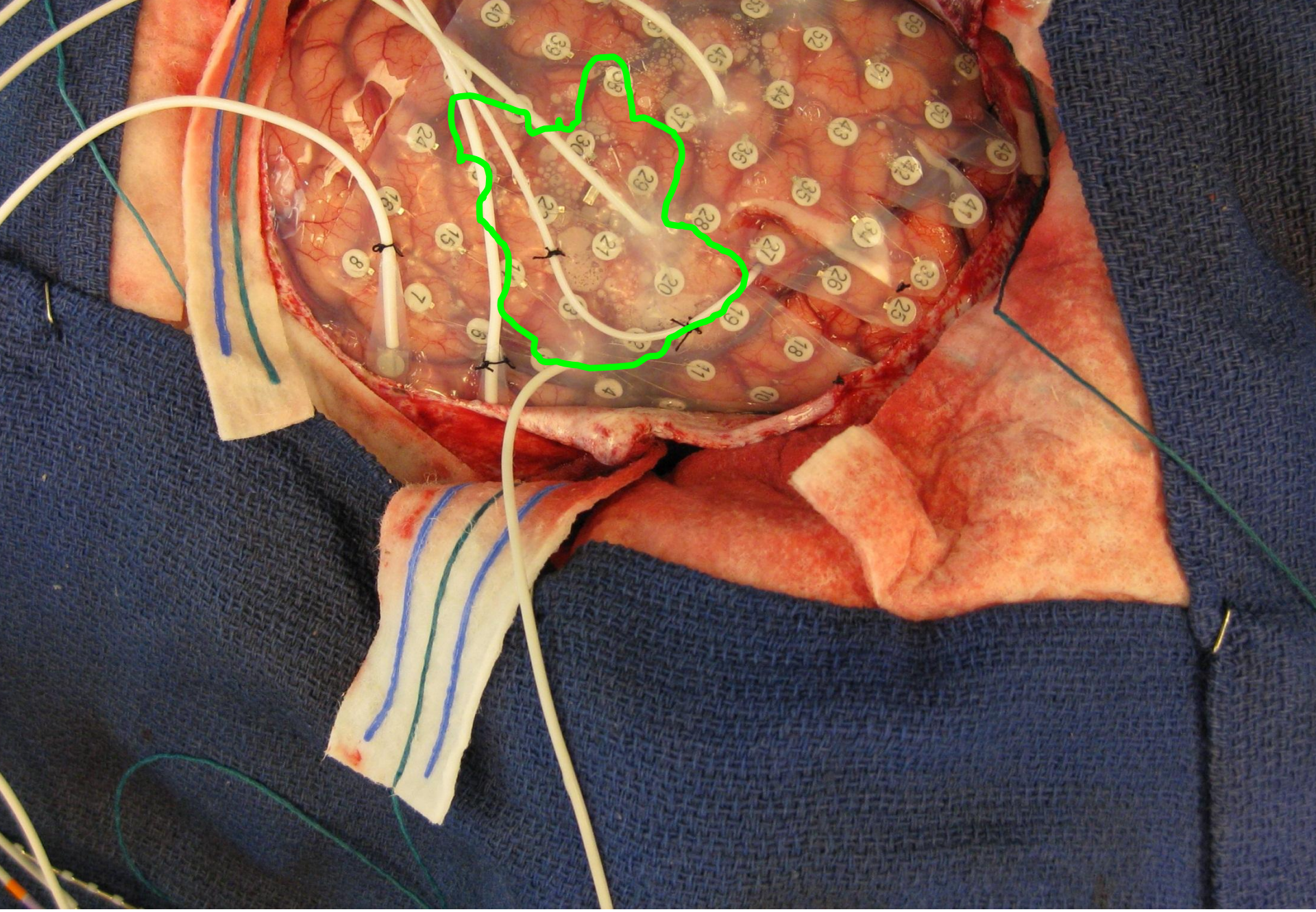


K. A.

MEG 5/4/07

MRI 11/28/05





Surgical removal of seizure focus

CHILDREN'S HOSPITAL

& RESEARCH CENTER AT OAKLAND