Focal lesion ablation

Less invasive, more effective?
new treatment options in epilepsy surgery

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On behalf of the epilepsy surgery working group (AWEC)
Maastricht / Kempenhaeghe

Focal lesion ablation in epilepsy

NO DISCLOSURES

Focal lesion ablation in epilepsy

I A

SEEG-guided RF-thermocoagulation of epileptogenic foci (2004 France/2016 NL)

IB

First results: our patient cohort with periventricular heterotopias

II

MR-guided stereotactic laser ablation of epileptogenic foci

SEEG-guided RF-thermocoagulation of epileptogenic foci

SEEG-technique

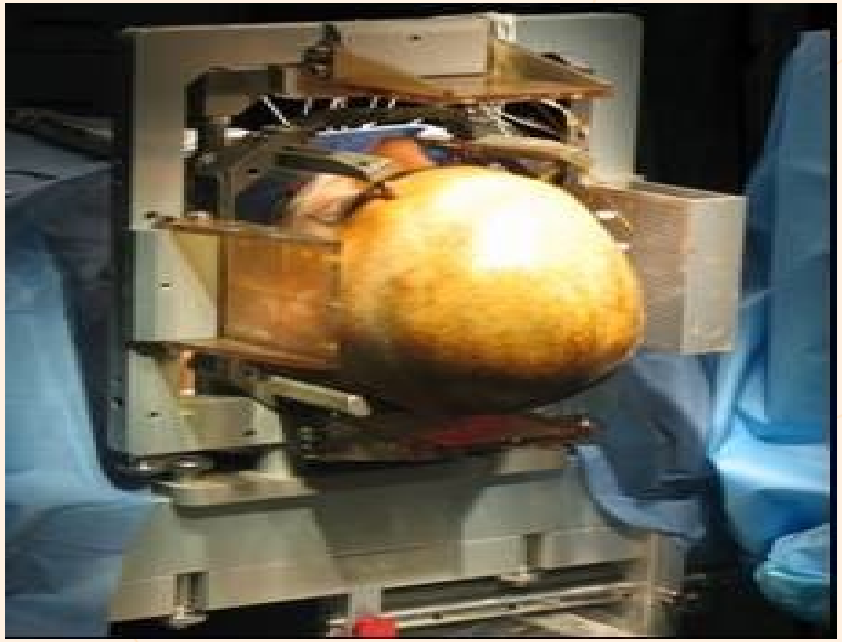
-stereotactic implantation of depth electrodes

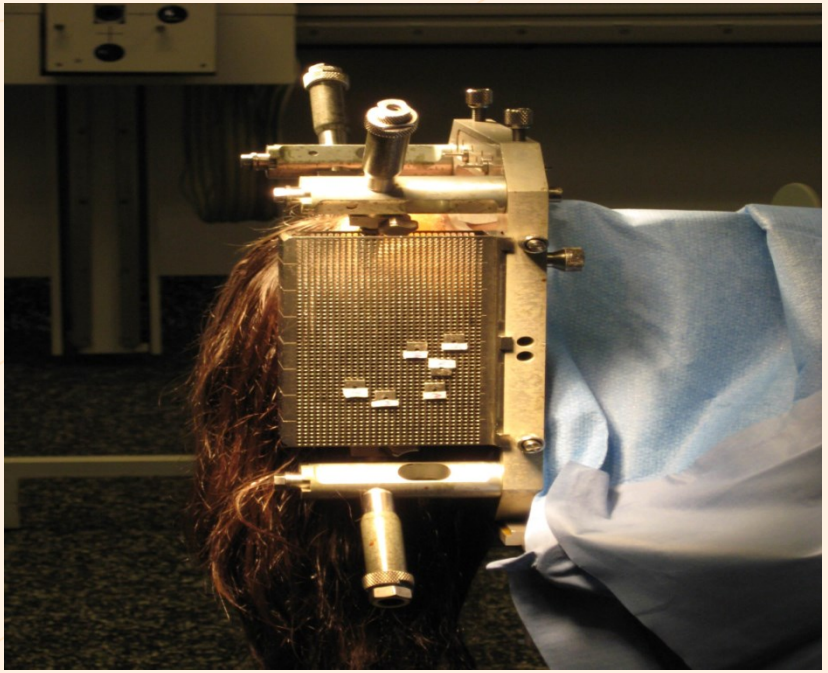
-pioneers: J.Talairach & J.Bancaud, Hopital St.Anne, Paris, 1962
(Bancaud et al;Electroencephalogr Clin Neurophysiol 1962;14:788)

-detailed detection of the spatiotemporal electrical distribution & correlation to semiology

SEEG-guided RF-thermocoagulation of epileptogenic foci

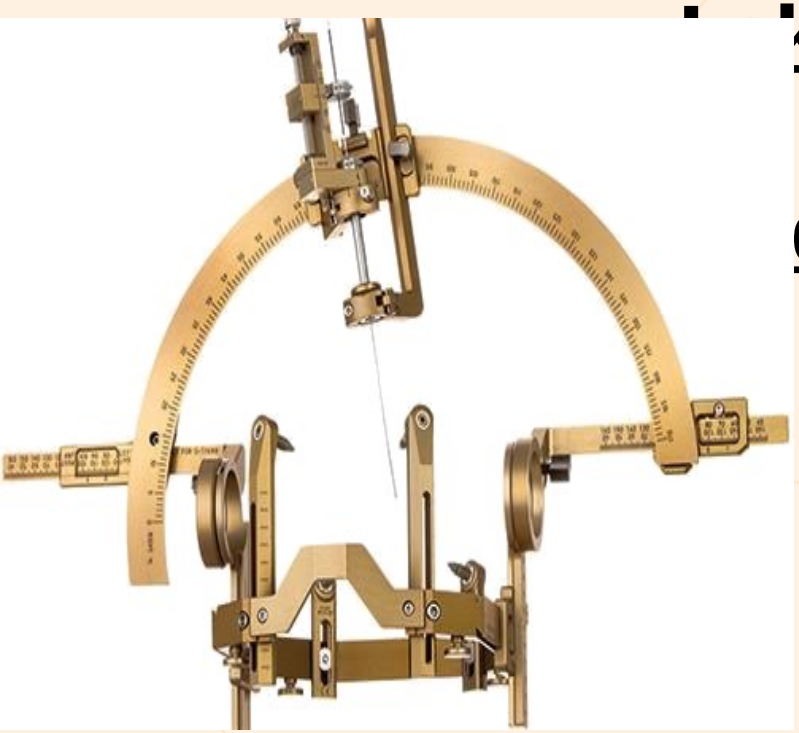
SEEG-technique: Talairach frame





SEEG-technique MUMC

3T double GD-MRI fusion with CT & ksell frame



008-2013: Stealth, Medtronic

2014-2018: Iplan, Brainlab

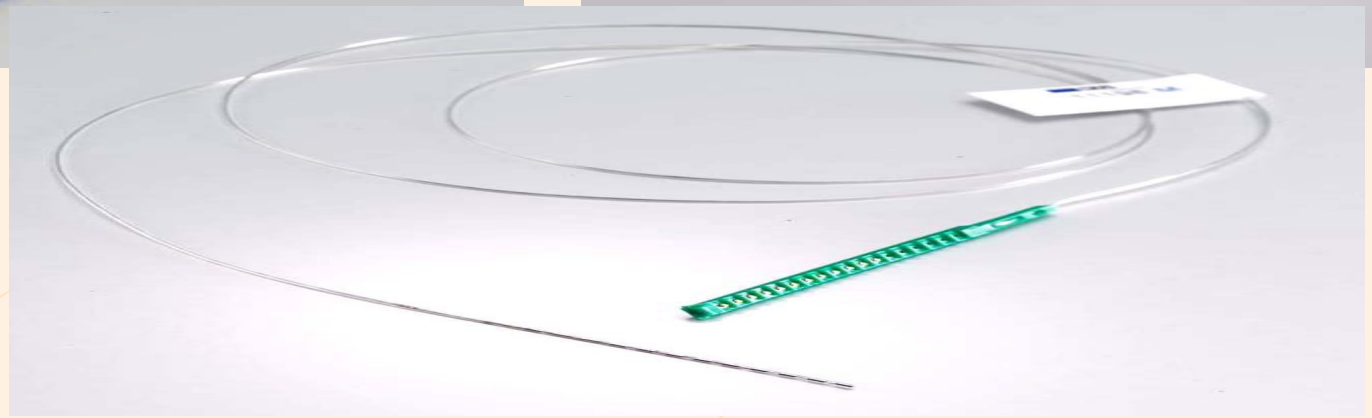
SEEG-technique: The MUMC version

-orthogonal and OBLIQUE trajectories

-postop CT+MRI / fusion with preop MRI

SEEG-technique MUMC: Dixi depth electrodes

SEEG-technique MUMC: Dixi depth electrodes

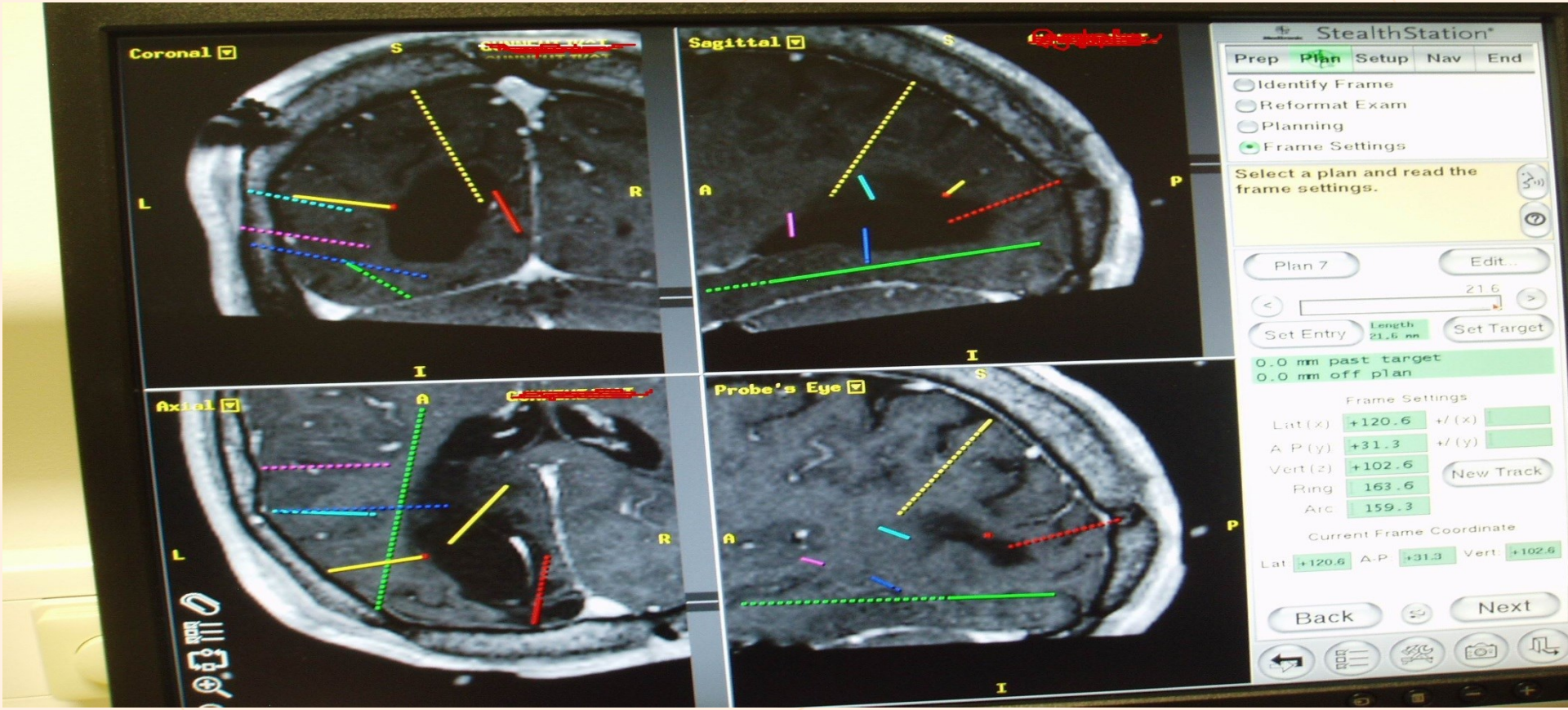


SEEG-technique MUMC: Dixi depth electrodes

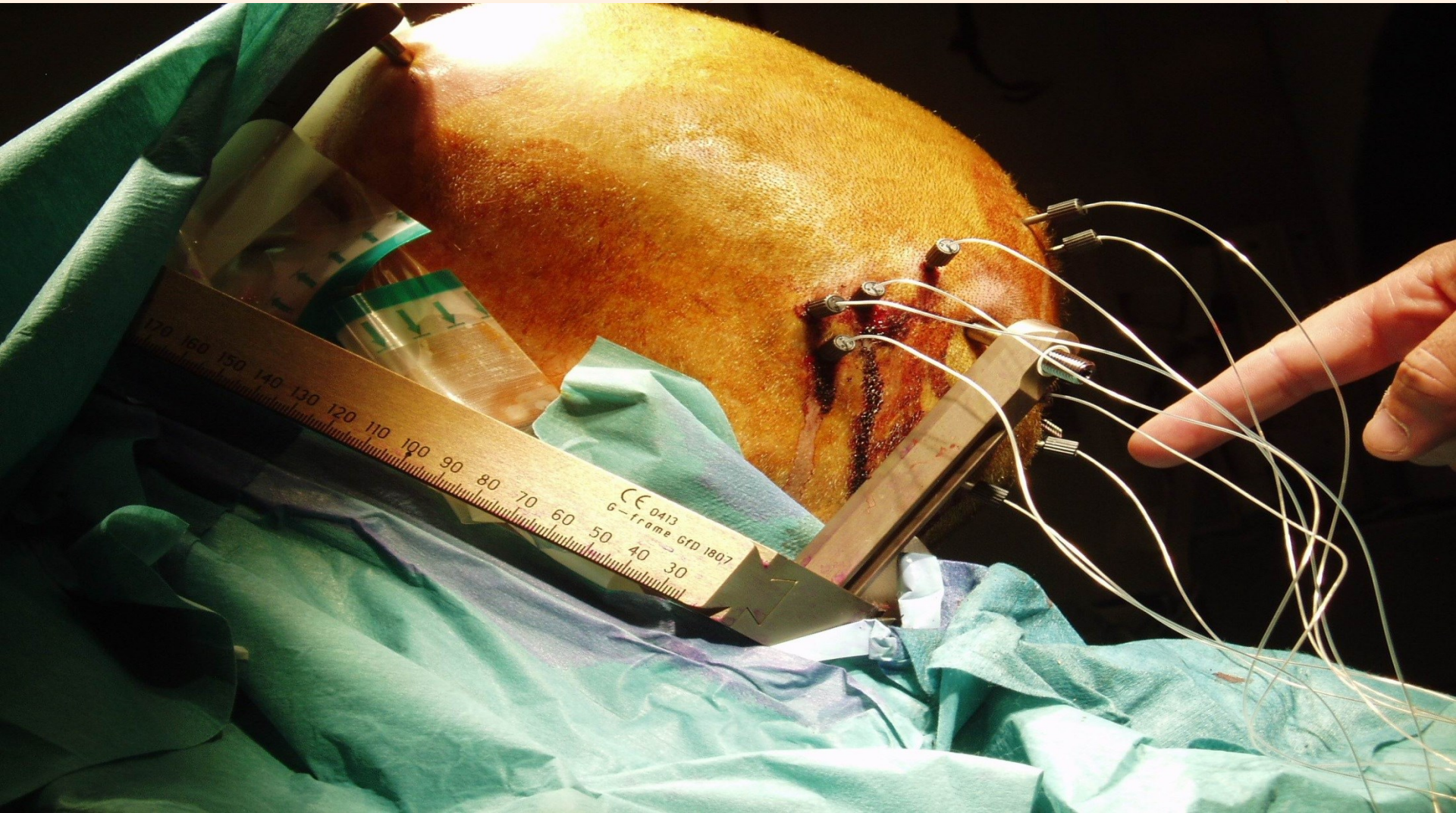
Diameter 0.8 mm
Contact length 2mm

☐ Implantation procedure and
accessories validated for over 30 years (more than 20 000 implanted electrodes)
☐ Platinum/iridium
☐ Adapted to the treatment of epilepsy thanks to thermocoagulation by radio frequency at the end of a SEEG for a diagnosis and therapeutic use
☐ MR Conditional

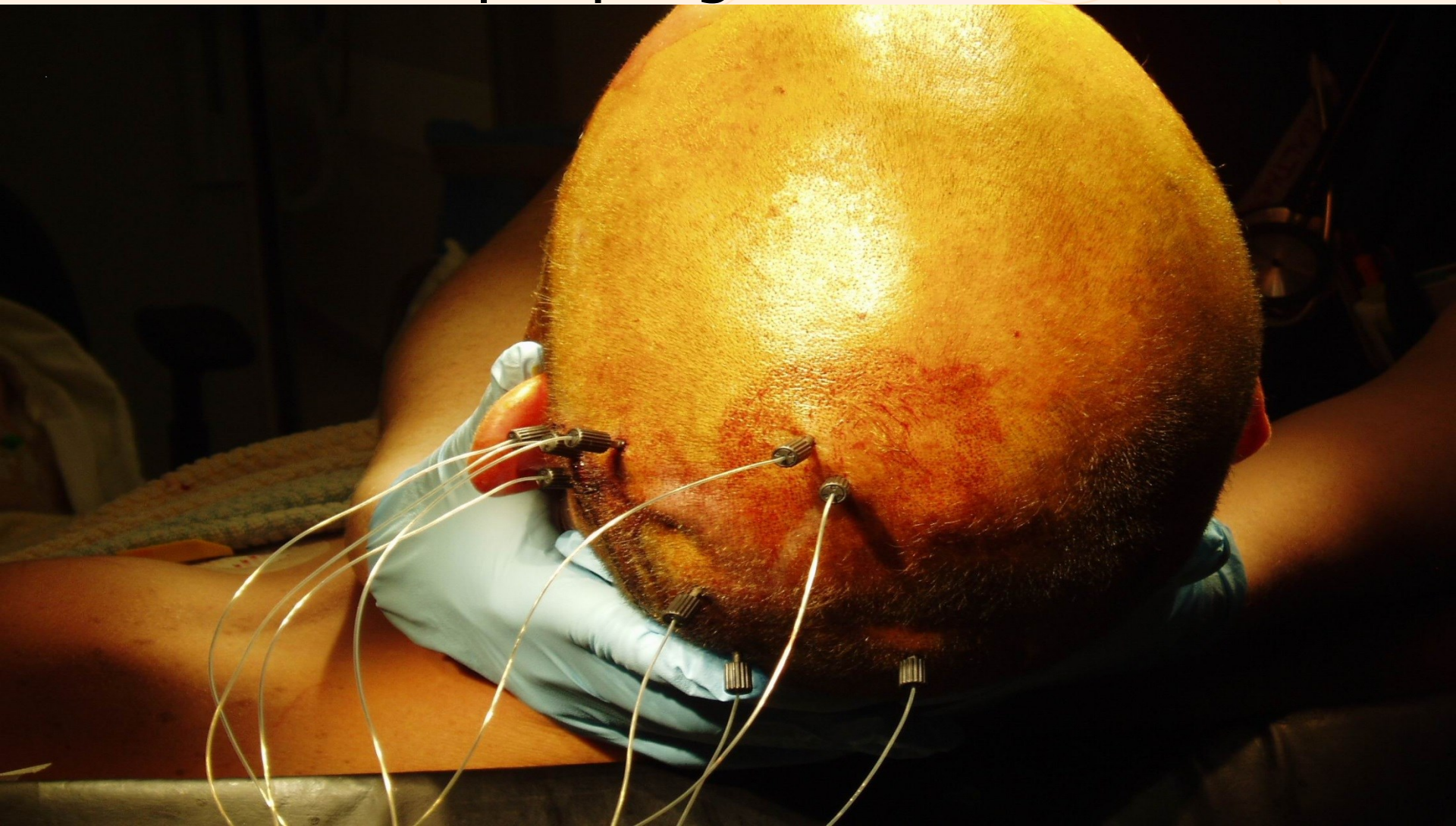
SEEG-technique Maastricht
Planning trajectories

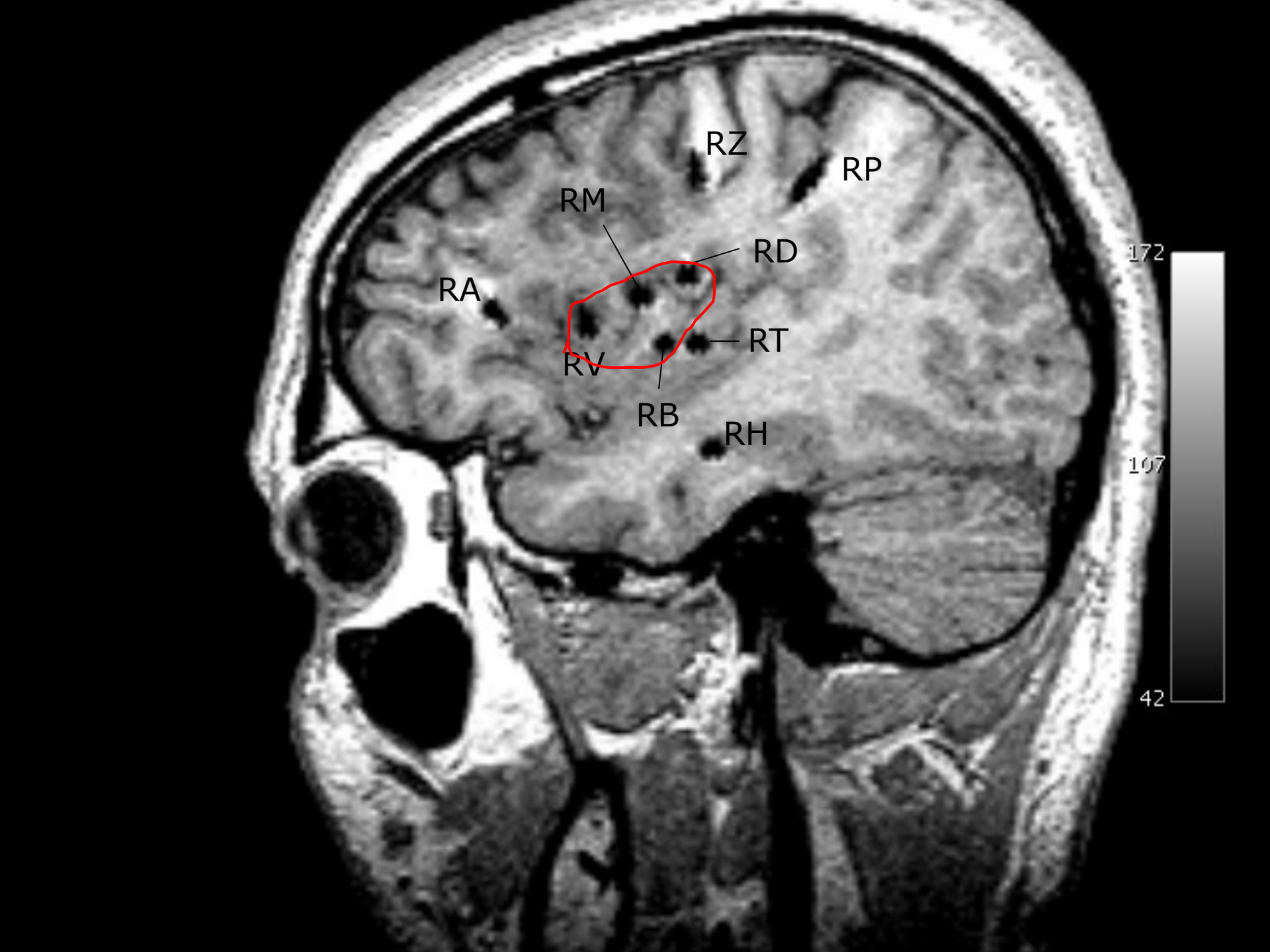


SEEG-guided RF-thermocoagulation of epileptogenic foci



SEEG-guided RF-thermocoagulation of epileptogenic foci

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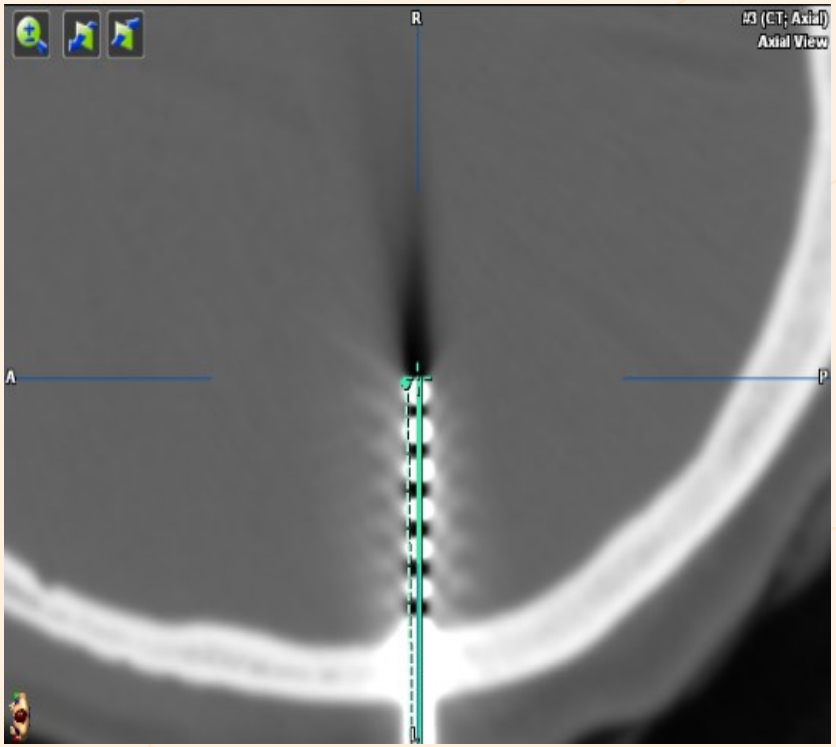
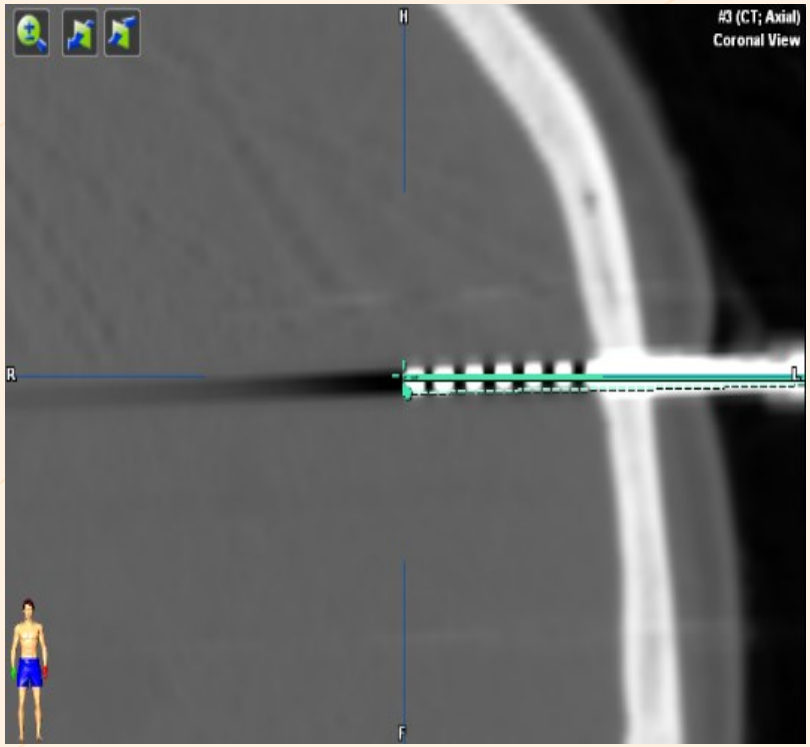
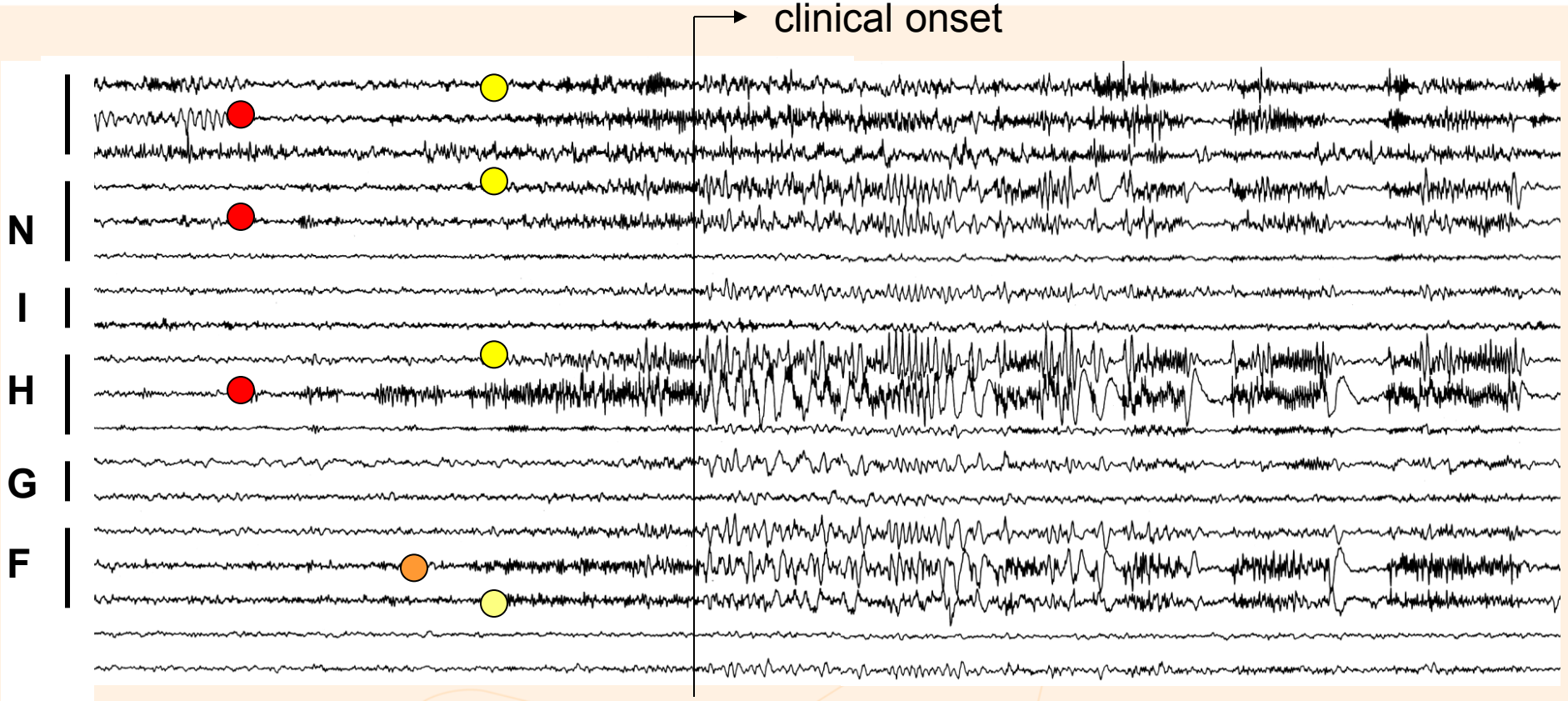
Postoperative CT



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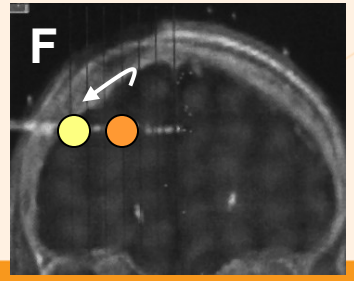
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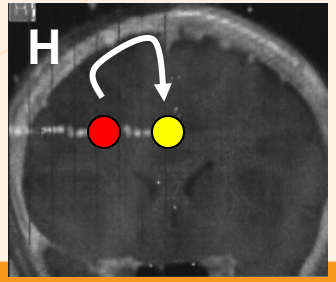
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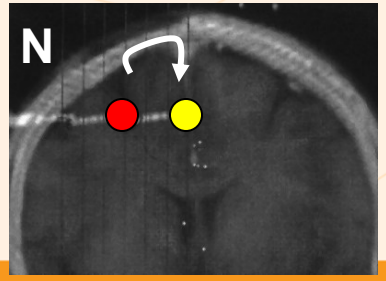
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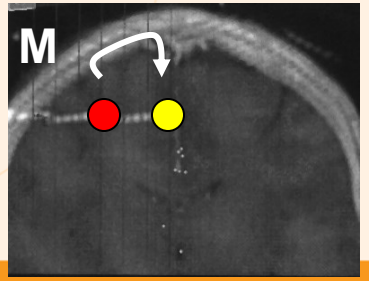
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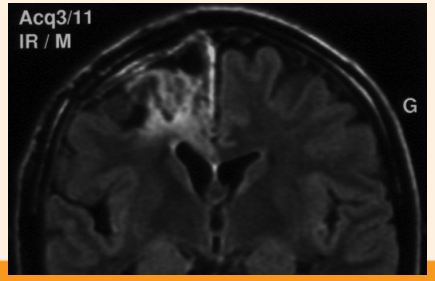
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Publication

Acta Neurochir
DOI 10.1007/s00701-017-3242-9

ORIGINAL ARTICLE - FUNCTIONAL

Methodology, outcome, safety and in vivo accuracy in traditional frame-based stereoelectroencephalography

Lars E. van der Loo[1] & Olaf E. M. G. Schijns[1,2,3] & Govert Hoogland[1,2,3] & Albert J. Colon[3] & G. Louis Wagner[3] & Jim T. A. Dings[1,3] & Pieter L. Kubben[1,3]

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Stereotactic (monopolar)RF thermocoagulation

History

-Use of stereotactic surgery for RF waves: first report by Spiegel et al., Science **1947**

-First paper (amygdalotomy for behavioral problems) with positive effect in epilepsy (Schwab et al.,**1965**)

Stereotactic (monopolar)RF-thermocoagulation
History

-Lesioning specific brain structures with

*oil wax injection (Narabayashi,1963)
*isotope implants (Talairach, 1965)
*cooling (Heimburger, 1966)

Stereotactic (monopolar)RF-thermocoagulation
History

-proposal to treat drug-resistant TLE by (monopolar TC) lesioning amygdalo-hippocampal foci (Flanigin, Acta NCH, 1976)

-Sz outcome proved to be less favorable than resective surgery (Parrent,Can J Neurol Sci,2000 & Patil, Stereot Funct Neurosurg, 1995)

SEEG-guided RF-thermocoagulation of epileptogenic foci

-**diagnostic** method (SEEG) turned into **therapeutic** method due to application of RF-thermal energy = new approach

(Guenot, 2004;Catenoix, 2008; Guenot,2011;Cossu, 2014; Catenoix, 2015; Cossu, 2015; Bourdillon,2016;Bourdillon,2017)

-therapeutic alternative for drug-resistant non-resective partial epilepsies

SEEG-guided RF-thermocoagulation of epileptogenic foci

Lesions

Periventricular Nodular Heterotopia (PNH)

Mild Malformations of Cortical Development (mMCD)

Hypothalamic Hamartoma (HH)

Focal Cortical Dysplasia (FCD)

Hippocampal sclerosis (HS)

SEEG-guided RF-thermocoagulation of epileptogenic foci

*Excellent indication:

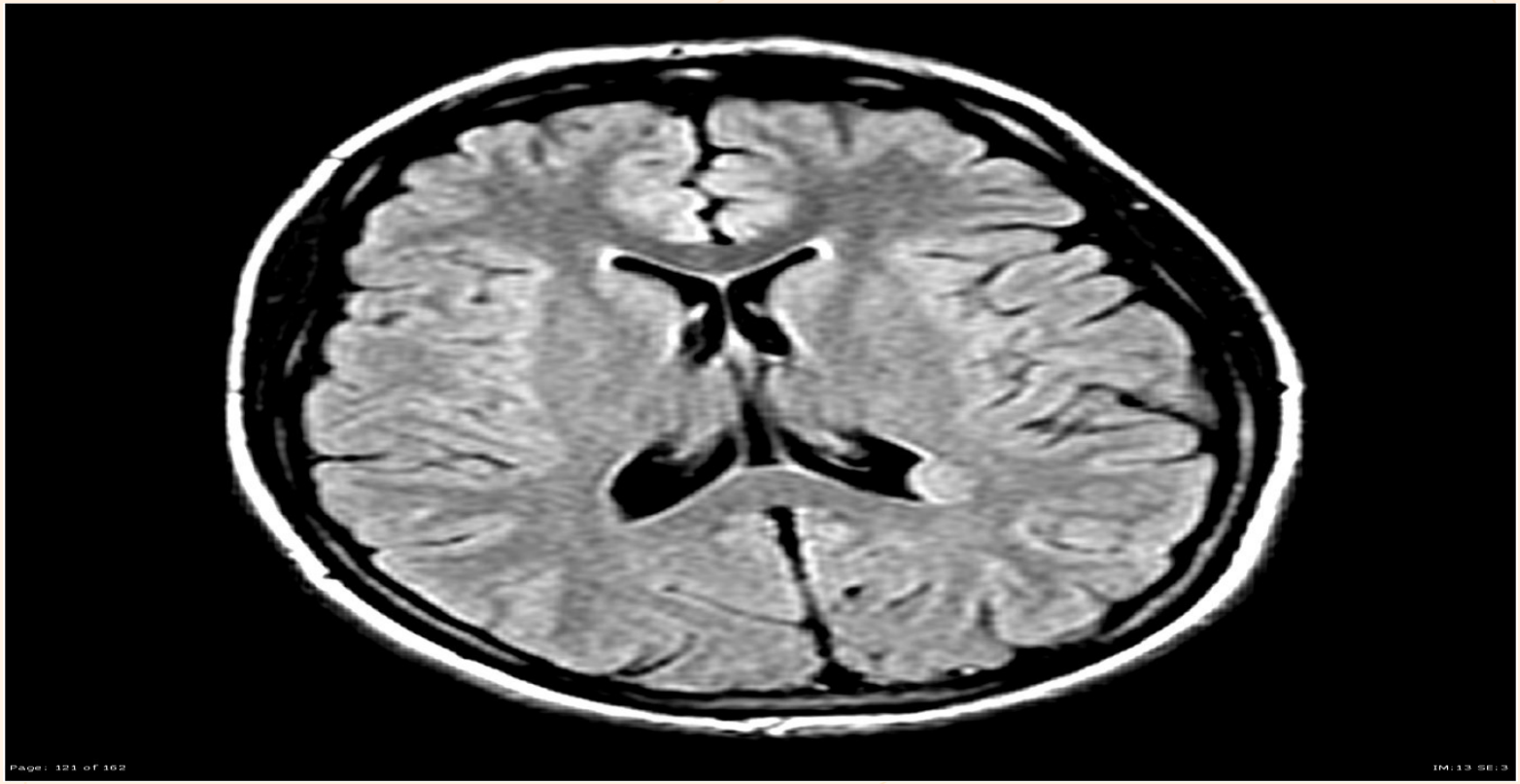
- (deep seated) Heterotopia.

*Potential good indication: HH, MCD and HS

*Discussion: other lesions (incl FCD), MRI-negative.

Indication for good Sz-outcome: LAFA and Sz-reproduction

SEEG-guided RF-thermocoagulation of epileptogenic foci



SEEG-guided RF-thermocoagulation of epileptogenic foci

pulsed RadioFrequency-technique for tissue ablation:

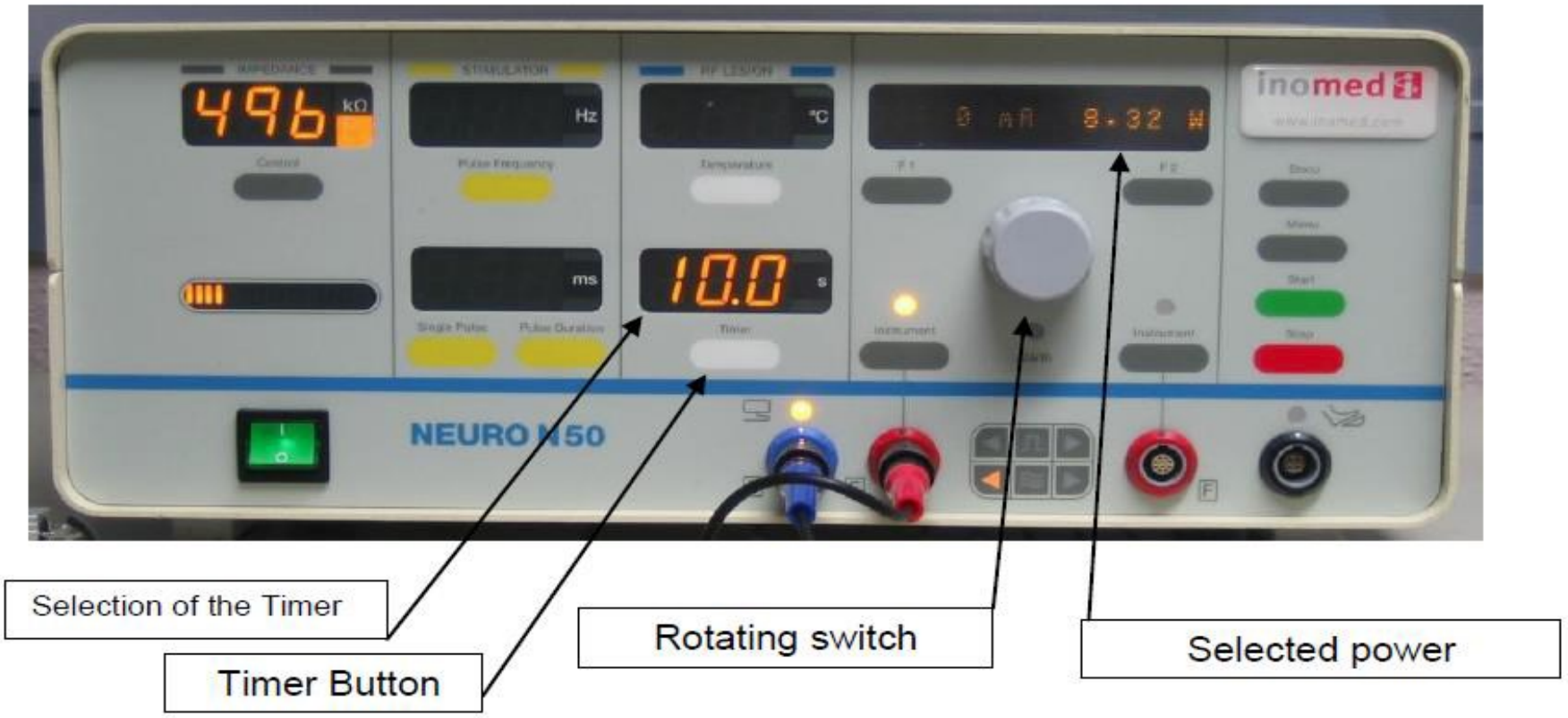
-RF power generator => RF energy. Frequency range 400-500 kHz, 50V, 120mA, 30 sec.

=>abrupt current decrease, indicates tissue coagulation

⇒ temperature raise between 78-82° C; lesion <10-30 seconds

-RF is pulsed to prevent coagulum formation on electrode(tip)

SEEG-guided RF-thermocoagulation of epileptogenic foci



SEEG-guided RF-thermocoagulation of epileptogenic foci

-lesions in areas showing low-amplitude fast pattern or spike-wave discharges at seizure-onset

-targets first functionally tested using electrical stimulation (50Hz/0.5ms pulseduration/1-3mA/3s)

-only targets without clinical response are selected for thermolesion; no RF-TC < 2mm from vessels

SEEG-guided RF-thermocoagulation of epileptogenic foci

-bipolar lesions (between 2 contiguous contacts) placed without anaesthesia (for clinical monitoring of the patient)

-thermocoagulation parameters: 50Hz / 50V / 30 seconds

-each thermocoagulation produces a 5-7mm diameter (sub)cortical lesion (100 mm^3)

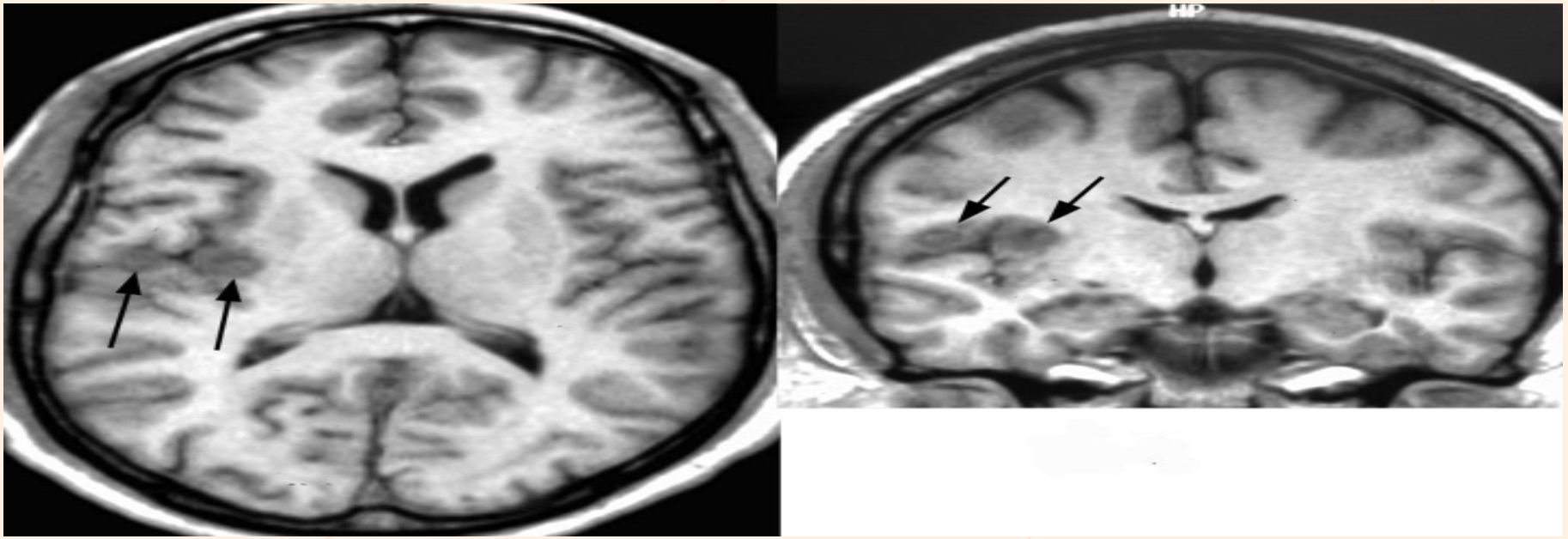
-inability to measure temperature in situ and to monitor ablation in real-time
(in contrast to laser therapy)

SEEG-guided RF-thermocoagulation of epileptogenic foci

-after each coagulation=>depth electrode recording=>absence of focal epileptiform activity

-removal of electrodes same day after coagulation and discharge 24-48h later

SEEG-guided RF-thermocoagulation of epileptogenic foci



Post RF thermolesion MRI with lesions in right insula and frontal operculum(1-2M post RF)

SEEG-cohort Maastricht

Period 2008 – 2018

SEEG – **diagnostic** cohort

N = 116 patients (N= 90 adults / N= 26 children)

Period 2016 – 2018

SEEG – **diagnostic & therapeutic** cohort

N = 12 patients (only adults)

SEEG-guided RF-thermocoagulation of epileptogenic foci

The ACE-MUMC experience

Pilot-study (March 2016 - today)

-12 patients, all with Periventricular Nodular Heterotopia (PVNH), 16 RFTC's

-all focal lesions, 9 uni- and 3 bilateral

SEEG-guided RF-thermocoagulation of epileptogenic foci

The ACE-MUMC experience

-oligo lesion: N = 5

-multiple PVNH's: N = 7 (uni-& bilateral)

-PVNH in Seizure-Onset Zone (SOZ): N = 12

-in most Sz: SOZ visible in PVNH

SEEG-guided RF-thermocoagulation of epileptogenic foci

The ACE-MUMC experience

Follow-up: average 15 M (3-33 M) (N=12)

Mean: 7 depth electrodes (1-22)

Mean: 16 RFTC points (1-34)

SEEG-guided RF-thermocoagulation of epileptogenic foci

The ACE-MUMC experience

-complete lesioning of PVNH: N = 3

-complete lesioning:
N = 1 => Sz free patient
N = 1 => PNEA patient
N = 1 => >80% Sz reduction patient
➔ Incomplete lesioning in 5/6 Sz free patients!

SEEG-guided RF-thermocoagulation of epileptogenic foci

The ACE-MUMC experience

Seizure outcome

-Sz free: N=6 (50%)

->80% Sz reduction: N=2 (17%)

- >50% Sz reduction: N=1 (8%) *
- <50% Sz reduction: N=3 (25%)
- * developed psychogenic Sz's (PNEA)

SEEG-guided RF-thermocoagulation of epileptogenic foci:

The ACE experience

Complications:
Permanent: N=0
Transient, minor: N=2

N=2: fever and headache 1 week after RFTC
Analysis: no etiological explanation
Spontaneous recovery after 3 days

SEEG-guided RF-thermocoagulation of epileptogenic foci:

The ACE experience

Discussion:

-several reports:

1. Overlying cortex “more important” than PVNH
2. Incomplete lesioning not “fruitful”

➔our experience: destruction “critical hub” in PVNH as part of epileptogenic network => can be sufficient

Bourdillon et al, Epilepsia 2017

- 162 patients, “mixed bag” (44 FCD, 5 heterotopia), no correlation outcome-pathology. Lesions/patiënt? 24 re-procedures
- 2 months: 25% sz-free, after 1 year 7%
- 2 months: 67% responders (>50% Sz-reduction), after 1 year 48%
- 58% of responders maintained their status during 5 yrs F/U

Bourdilon et al, Epilepsia 2017

- PPV of being responder<2months after RFTC and an Engel I/II after surgery = 93%

- =>being a responder appears to be a reliable indicator for predicting Sz outcome

Bourdilon et al, Epilepsia 2017

- 1.1% permanent complications
- 2.4% transient complications

Catenoix, Neurosurgery, 2015

- 14 patients with MCD. Avg 25,8 lesions. 9 (64%) responders (>50% Sz-reduction), 6 Sz-free.
- Sz-begin with LAFA: 87% responder
- Sz reproduction after stimulation: all responders.

SEEG-guided RF-thermocoagulation of epileptogenic foci

- **Summary of advantages:**

1. Target choice based on SEEG data
2. Diagnostic electrodes=therapeutic ones
3. Multiple electrodes means multiple possible lesion sites

SEEG-guided RF-thermocoagulation of epileptogenic foci

- **Summary of advantages:**

4.real-time monitoring clinical&neurophysiological status of the patient

5.No anesthesia

6.Resective surgery after RFTC=possible

7.Electrode explantation=possible without additional bleeding risk

SEEG-guided RF-thermocoagulation of epileptogenic foci:

Future perspective

Robot-assisted implantations

II
MR-guided stereotactic laser ablation of epileptogenic foci

Indications

Hypothalamic hamartoma:

Congenital, non-neoplastic,heterotopia variant, gelastic epilepsy, pubertas precox, behavioral problems, prevalence 1:1.000.000

MR-guided stereotactic laser ablation of epileptogenic foci

=

MR-guided Laser Interstitial Thermal Therapy

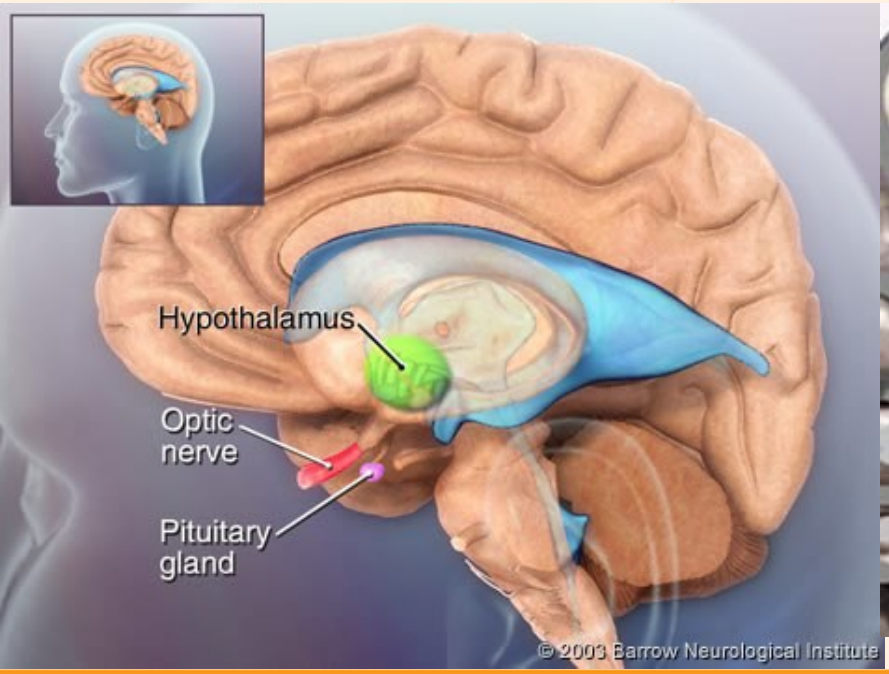
=

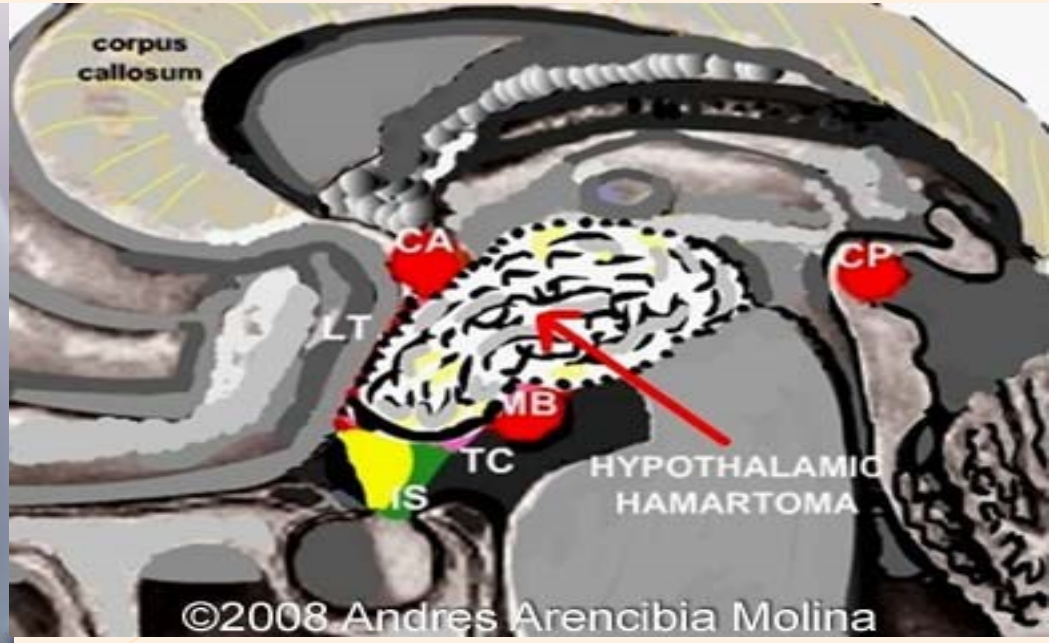
MRgLITT

MR-guided stereotactic laser ablation of epileptogenic foci

Indications

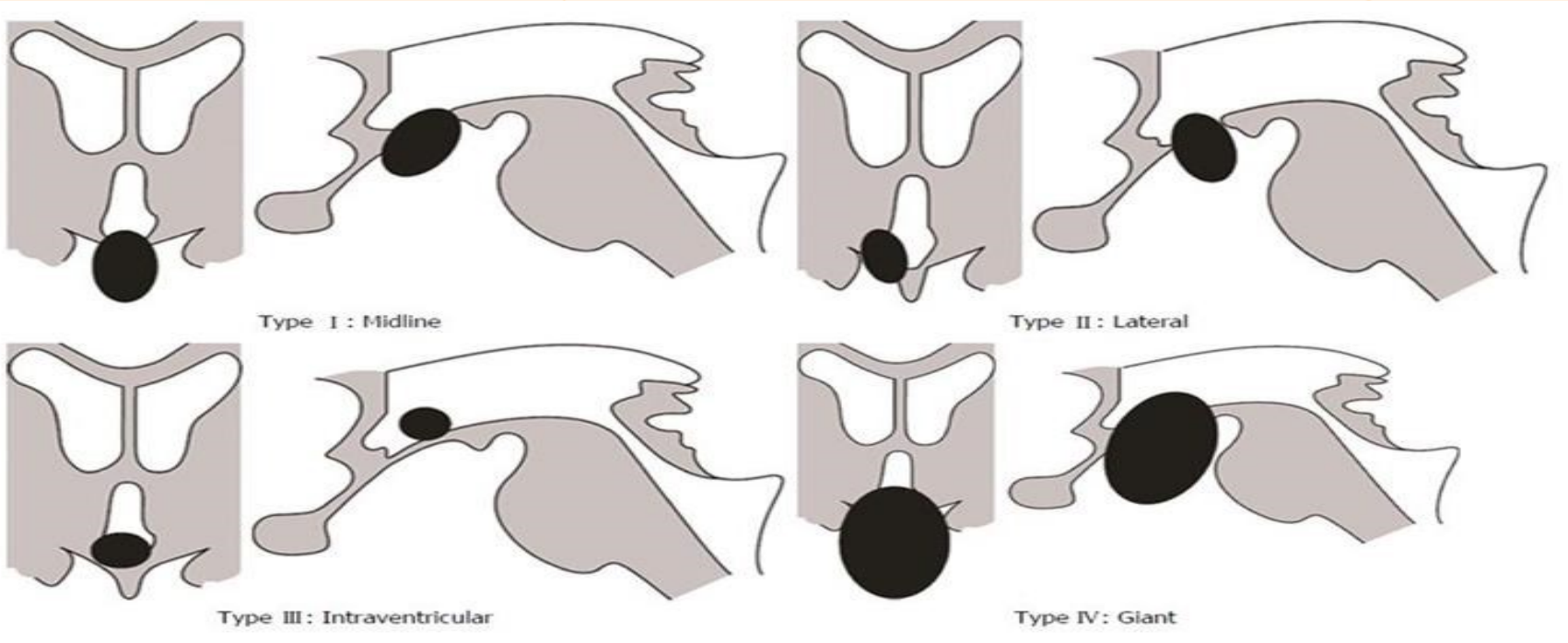
Hypothalamic hamartoma





MR-guided stereotactic laser ablation of epileptogenic foci

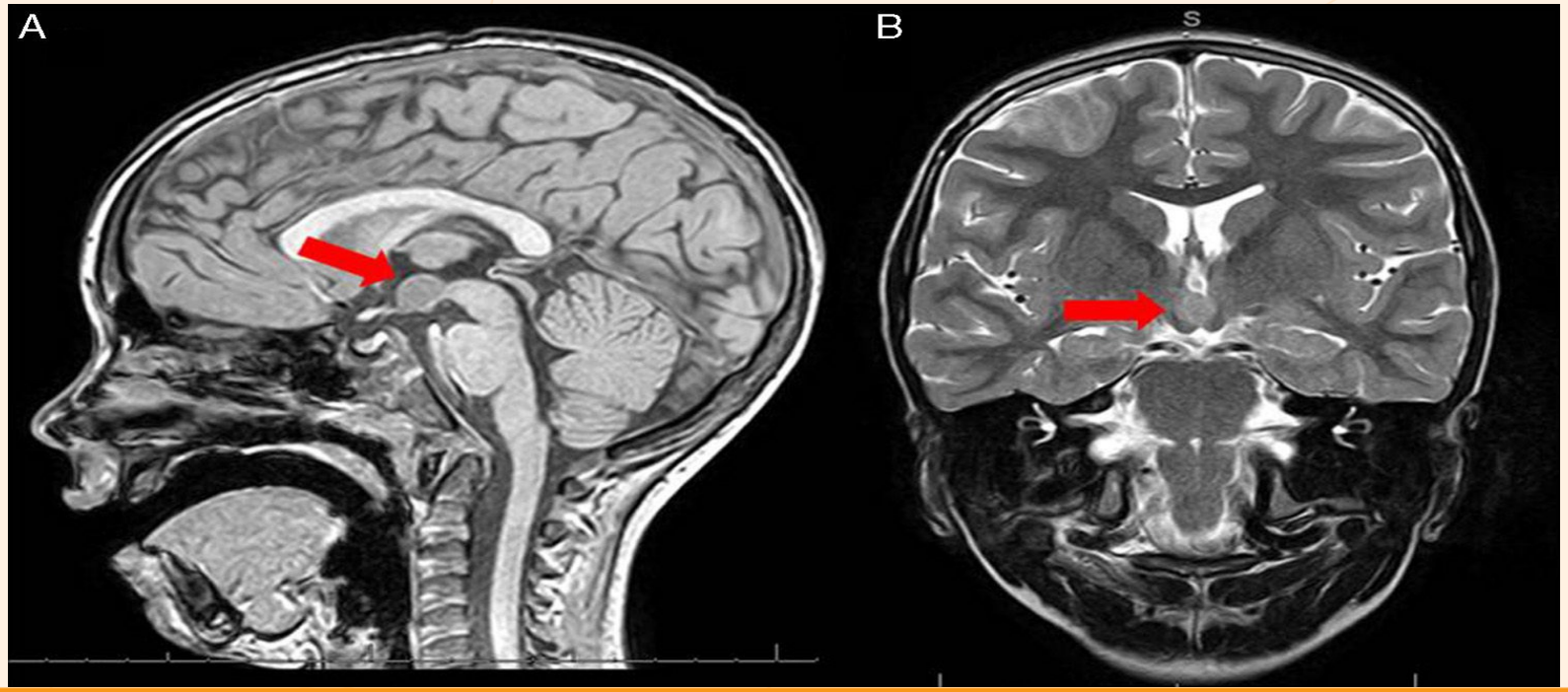
Hypothalamic hamartoma classification



MR-guided stereotactic laser ablation of epileptogenic foci

Indications

Hypothalamic hamartoma



MR-guided stereotactic laser ablation of epileptogenic foci

Indications

Periventricular nodular heterotopia

Congenital,6th-24th week,neuronal migration disturbance, 5 PNH groups dependent on location

MR-guided stereotactic laser ablation of epileptogenic foci

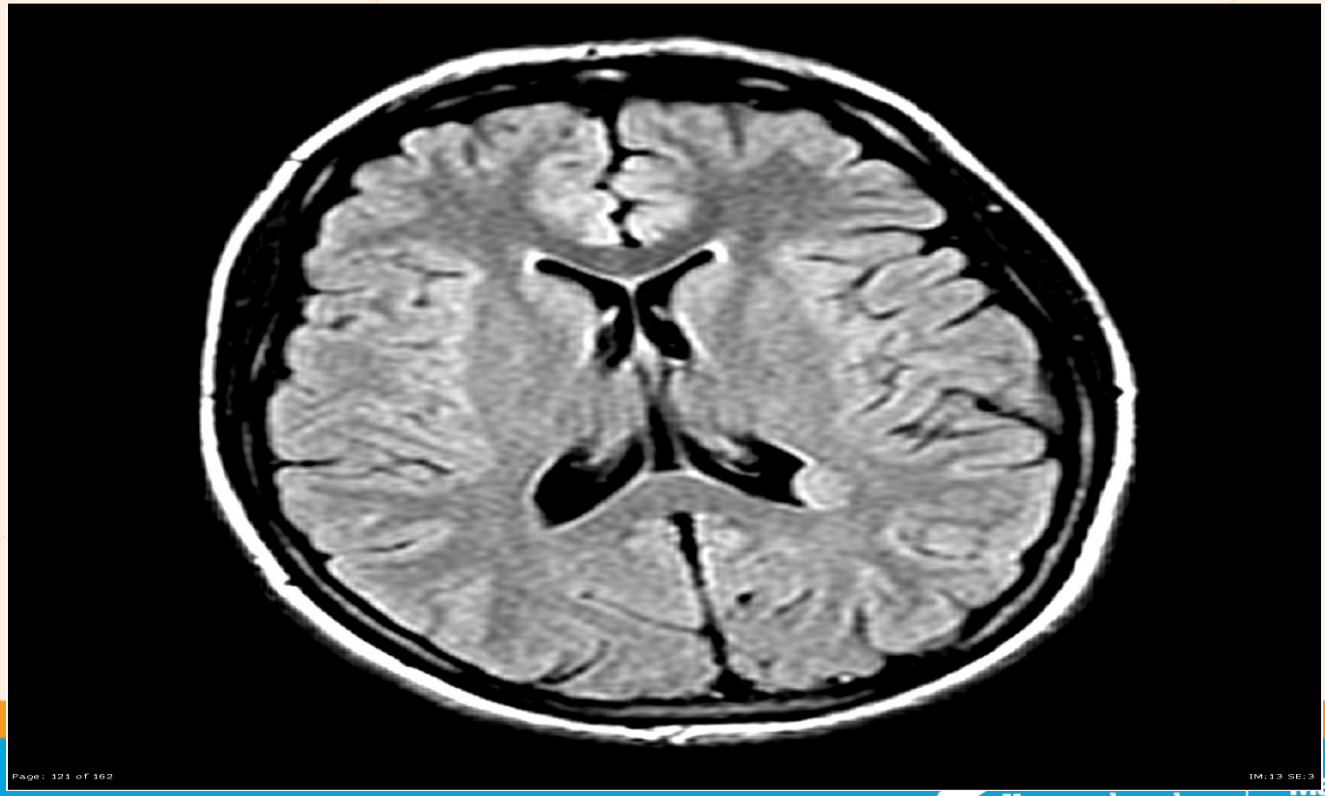
Indications

Periventricular nodular heterotopia

MR-guided stereotactic laser ablation of epileptogenic foci

Indications

Periventricular nodular heterotopia



MR-guided stereotactic laser ablation of epileptogenic foci

Other Indications in literatue

Focal cortical dysplasias

Tubers (TS)

MTS

LEAT

MR-guided stereotactic laser ablation of epileptogenic foci

percutaneous MRI-guided laser interstitial thermal therapy (MRgLITT)

Two major LITT platforms:

1. Visualase®, Medtronic

FDA approved 2007; mid 2017 expected CE approval

2. NeuroBlate®, Monteris Medical, Minnesota

FDA approved 2009

MR-guided stereotactic laser ablation of epileptogenic foci

Major components of the laser system:

1.15W, 980nm diode laser

2.disposable saline-cooled laser applicator probe with cooling catheter (diameter 1.65cm)

3.computer workstation communicating with MRI

MR-guided stereotactic laser ablation of epileptogenic foci

Visualase

Computer-workstation

MR-guided stereotactic laser ablation of epileptogenic foci

procedure under general anesthesia

stereotactically guided twist drill burr-hole

bone anchor placed in skull

cooling catheter & laser probe is stereotactically inserted to the intended target area & locked

MR-guided stereotactic laser ablation of epileptogenic foci

patient transport to the MRI

T2-imaging & probe tip placement confirmation

fast-spoiled gradient MRI images at temperature as baseline

circulation cooling system+test pulse: 3-4 W for 30-60 sec: exact location distal probe

MR-guided stereotactic laser ablation of epileptogenic foci

Ablation treatment doses:
10-15W for 30-60 sec until "damage zone" covers target

After completion:removal of catheter and anchor and stitching the small skin puncture site

MR-guided stereotactic laser ablation of epileptogenic foci

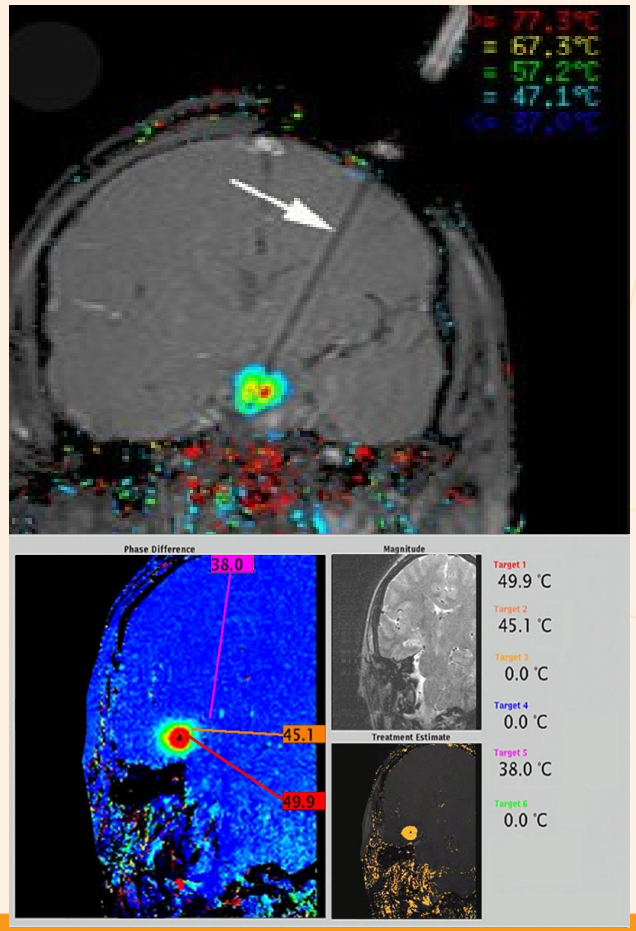
Physics: emitted photons =>absorbed by pathogenic tissue>healthy tissue => tissue heating

Irreversible cell damage => 46-60 Celsius

Instantaneous coagulation necrosis => >60 Celsius

Sharp temp.fall off at border of the coagulation zone =>sharp margin between viable/nonviable tissue

MR-guided stereotactic laser ablation of epileptogenic foci



Laser light heats and destroys target area. Temperature maps show the physician the extent of the tissue being destroyed, minimizing risk of potential damage to surrounding healthy tissue.

MR-guided stereotactic laser ablation of epileptogenic foci

Review by LaRiviere et al.
Frontiers in Surgery;2016;3:64

1963:first described by Narabayashi, Tokyo

1995:first CT-guided stereot.RF amyg.hippocampotomy:highly variable results regarding Sz outcome in follwing series (2-75% Engel I)

1997:first MR-guided RF ablation of amyg/hippoc.

MR-guided stereotactic laser ablation of epileptogenic foci

Review by LaRiviere et al.
Frontiers in Surgery;2016;3:64

1990:first report on LITT = Laser Interstitial Thermo Therapy in tumors

1991:first report on MRI thermometry in tumors

MR-guided stereotactic laser ablation of epileptogenic foci

Review by LaRiviere et al.
Frontiers in Surgery;2016;3:64

1996:first report on “water proton resonance frequency shift MRTI” = technique for modern laser ablation systems

➔Start MRIguidedLITT = MRgLITT

MR-guided stereotactic laser ablation of epileptogenic foci

Review by LaRiviere et al.
Frontiers in Surgery;2016;3:64

2007: first commercially available MRgLITT system ➔Visualase, Medtronic

2008:first human application in patient with metastases

MR-guided stereotactic laser ablation of epileptogenic foci

Review by LaRiviere et al.
Frontiers in Surgery;2016;3:64

2012:first Visualase report in epilepsy:5 pediatric patients by Dr Curry, Houston

2xHypothalamic hamartoma/1xFCD/1xtub.sclerosis/1x MTS

MR-guided stereotactic laser ablation of epileptogenic foci

Review by LaRiviere et al.
Frontiers in Surgery;2016;3:64

Indications: hypothalamic hamartoma/ mTLE (HS) / FCD / PNH / LEAT / Tub.sclerosis

Only small case series with short follow up (<24 months)

MR-guided stereotactic laser ablation of epileptogenic foci

Review by LaRiviere et al.
Frontiers in Surgery;2016;3:64

-Curry 2013;14 HH's:86%EngelI;mean 9 months follow up

1 transient complication (memory!!)

-Willie 2014;13 SLAH: 54%EngelI,

F/U 5-26months;potentially improving neuropsychological outcome

MR-guided stereotactic laser ablation of epileptogenic foci

Review by LaRiviere et al.
Frontiers in Surgery;2016;3:64

2014:reports on MRgLITT in PNH's:2 patients;both Sz free; 1 after AED adjustment + 1 after ATL

2015:report on MRgLITT in 9 FCD's:outcome substantially worse compared to open resection

MR-guided stereotactic laser ablation of epileptogenic foci

Complications:

13% of all => transient neurologic def.

(paresis/hemianopia/dysphagia

3% permanent neurolog.complications

2.5% intracerebral hemorrage

2.5% infections

MR-guided stereotactic laser ablation of epileptogenic foci

Review by LaRiviere et al.
Frontiers in Surgery;2016;3:64

Conclusion:MRIgLITT is in its infancy in epilepsy & evidence is limited

Only small series - variable inclusion criteria - mixed pathology - short F/U - no prospective trials yet => predisposing to selection bias

SEEG-RFTC or MRgLITT in HH?

Perhaps:

World Neurosurg. 2018 Jun;114:e1073-e1078. doi: 10.1016/j.wneu.2018.03.148. Epub 2018 Mar 30.

Stereoelectroencephalography-Guided Radiofrequency Thermocoagulation for Hypothalamic Hamartomas: Preliminary Evidence.

Wei PH[1], An Y[1], Fan XT[1], Wang YH[1], Yang YF[1], Ren LK[2], Shan YZ[3], Zhao GG[4].

China


QUESTIONS
ANSWERS