# Updated Surgical Technique (Stereo-EEG) in Epilepsy Surgery

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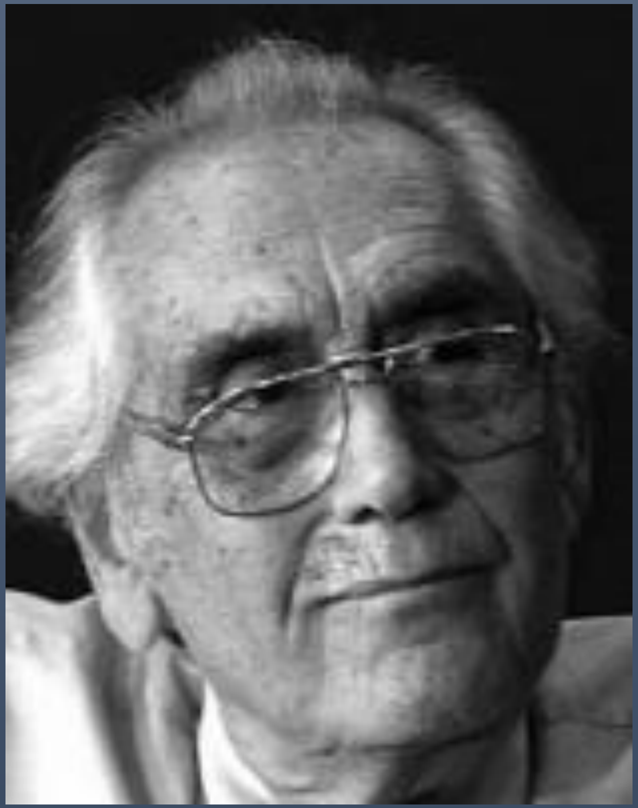
# Stereoelectroencephalography (SEEG)



- Jean Talairach & Jean Bancaud (1950s) at Hópital Saint Anne, Paris
- Recorded electrical activity by intracerebral electrodes, implanted stereotactically in predefined cortical and subcortical structures.

# Principle of SEEG methodology

"Anatomo-electro-clinical correlation"

- Hypothesis of preferential origin and spread of seizures (Ictal clinical picture, interictal, ictal scalp-EEG discharge)
- Spatiotemporal dynamic of seizure
- Presurgical and therapeutic surgical phases to be dissociated.
- Coordinate system based on AC-PC
- Individualized "Custom-tailored"

# Essential rules for electrodes implantation

- Demonstrated brain regions suspected to be involved in seizure onset and early propagation show the expected ictal pattern
- Possibility the propagation of an ictal discharge generated elsewhere
- Delineating the border of the ‘epileptogenic zone’ > minimum cortical resection
- Investigation of eloquent areas relatively to the hypothetical ‘epileptogenic zone’
- Relationships between and anatomical lesion and the ‘epileptogenic zone’

# SEEG

- Lesional zone
  - Abnormal slow-wave activity, alteration of background activity, electrical silence
- Epileptogenic zone
    - Ictal onset + early spread (primary organization of the epileptic seizures)
    - Fast synchronizing discharges that might involve a single region, or distinct but interconnected regions
    - Order and sequence of semiological elements must be view as a whole “Seizure pattern”
- Irritative zone (FCD, potential seizure onset zone)

# Indications

- Drug resistant focal epilepsy
- Non-invasive investigations fail to correctly localize the epileptogenic zone

# Specific criteria for SEEG

- Deep-seated or difficult-to-cover location of the epilptogenic zone (mesial structures of the temporal lobe, opercular areas, cingulate gyrus, interhemispheric regions, posterior orbitofrontal areas, insula, and depth of sulci)
- Failure of a previous subdural invasive study
- Extensive bihemispheric explorations
- Normal MRI

Gonzalez-Martinez J. Epilepsia 2013; 54:323-30.

# SEEG setup

- Epileptologist
- Epilepsy (+ stereotactic) neurosurgeon
- MRI (3T) + contrast
- Angio image (CTA, Angiogram)
- Stereotactic device (Frame-based, Frameless, Robot)
- Fluoroscopy

# SEEG instruments

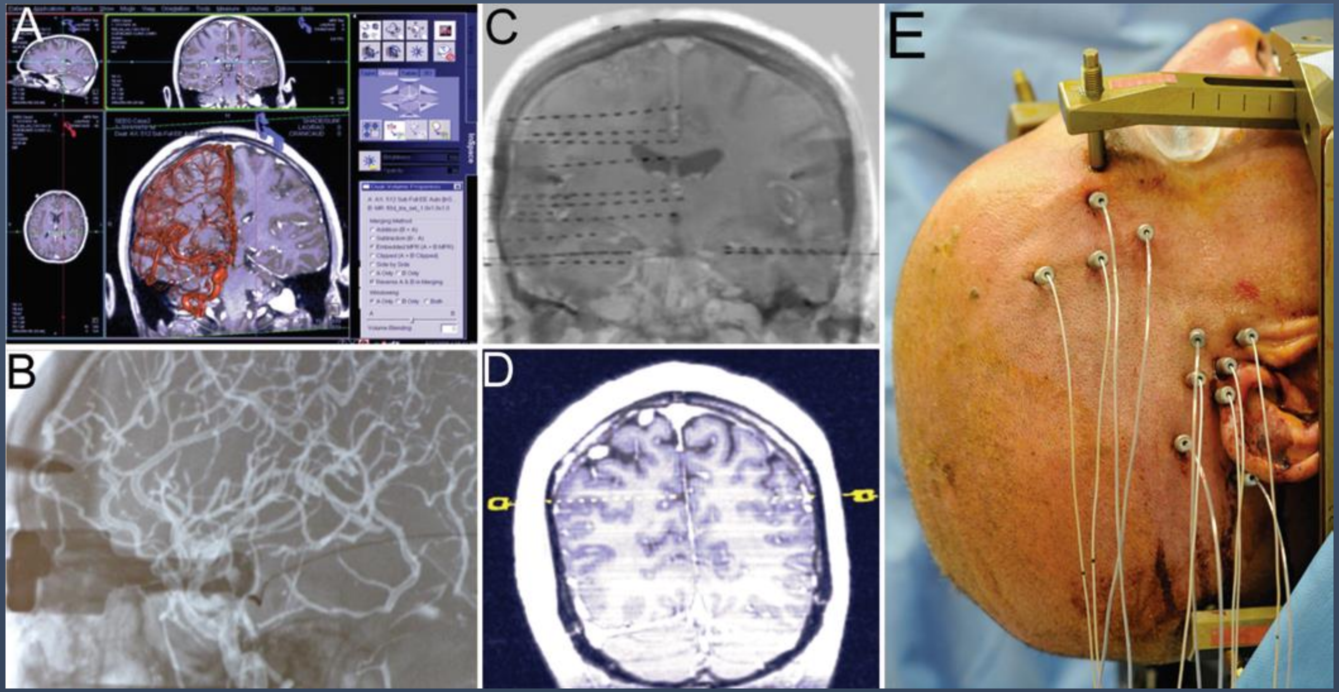
- Skin Probe
- Dura Probe
- Ruler
- Screw drivers
- (PMT, Adtech, DIXI)

# Talairach technique

- Multiphase, complex-time-consuming
- Stereotactic neuroradiology
  - Talairach stereotactic frame + Angiography studies+ 3D MR
- Placement of electrode placement [Orthogonal trajectories]
- Removal of electrodes

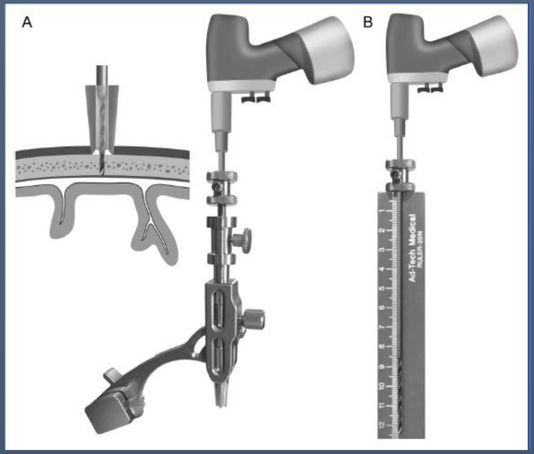
# Cleveland Clinic

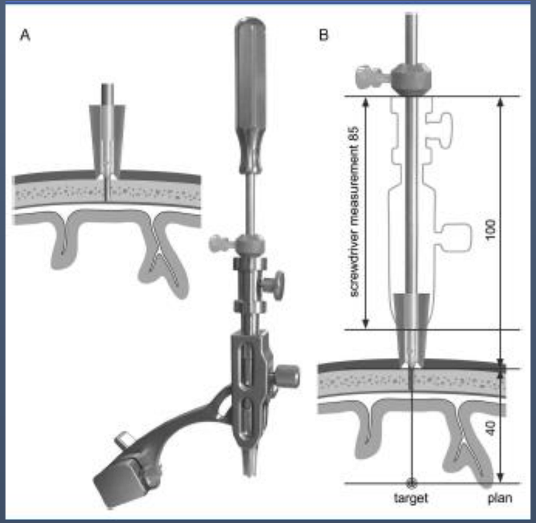
- Preop MRI
- Intraop Frame placement + Stereotactic DynaCT+ 3D digital subtraction angiopgraphy
- Ave planning time 33 mins, Implantation time 107 mins

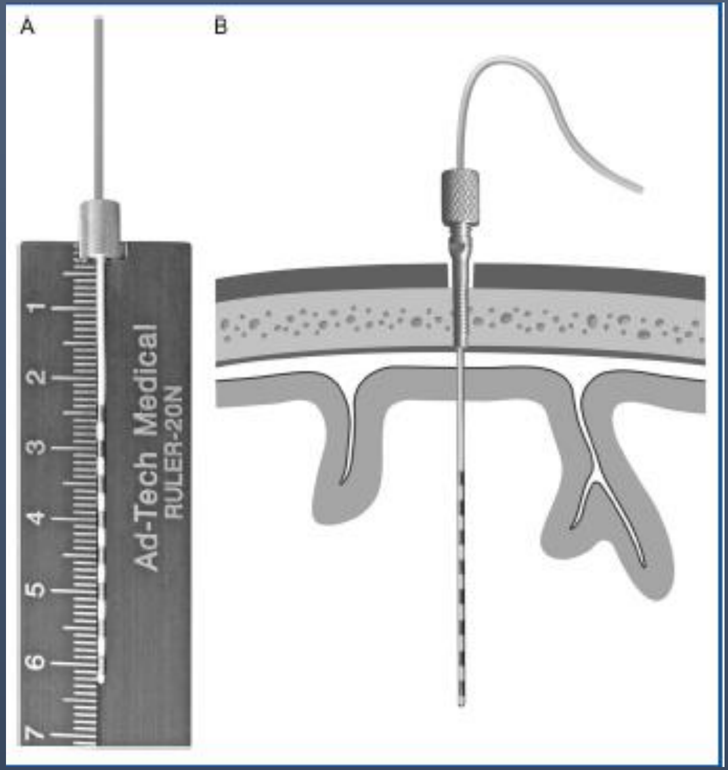



Gonzalez-Martinez, et al. J Neurosurg 2014; 120:639-644.

# Frameless stereotactic placement of depth electrodes



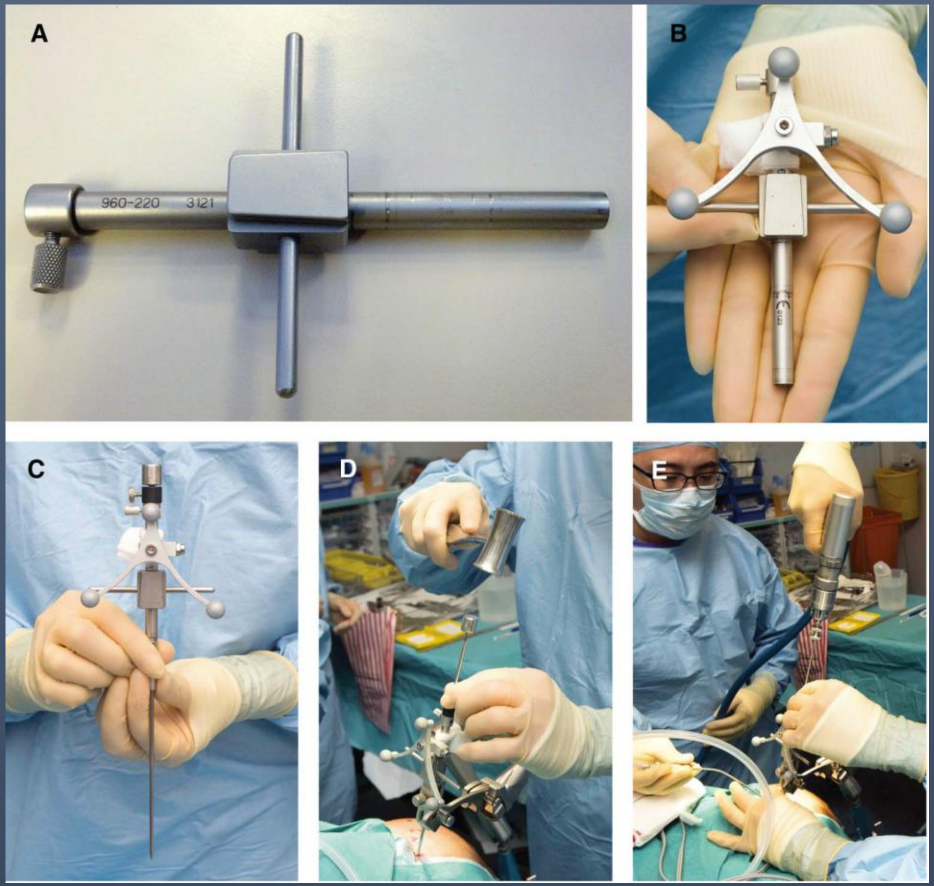




±SD from the intended target 3.0±1.9 mm

Dorfer C, et al. Operative Neurosurgery 2014; 10:582-591.

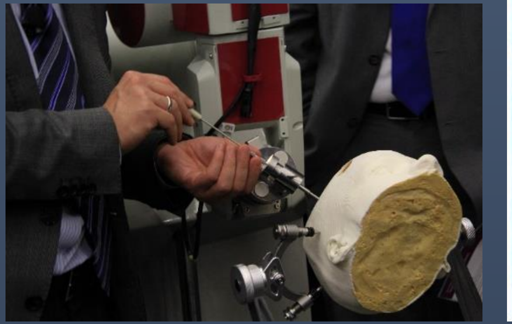
# Frameless stereoEEG in epilepsy surgery

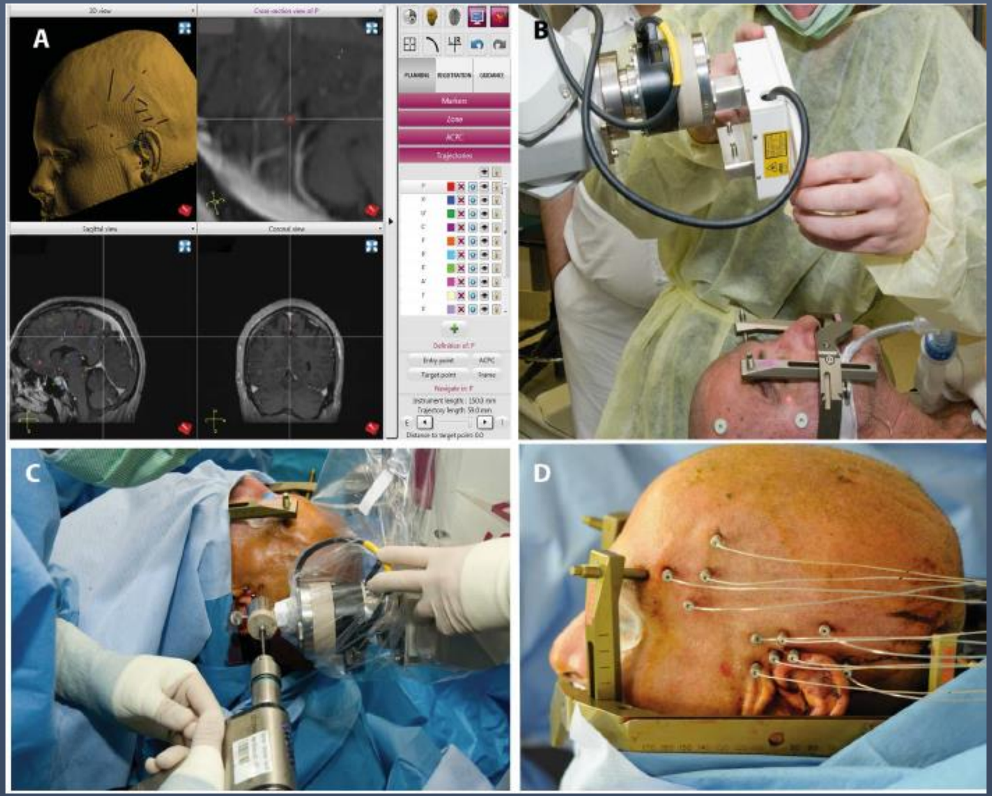



Mean error 3.6 mm

Nowell M, et al. Operative Neurosurgery 2014; 10:525-534

# Robot-assisted SEEG

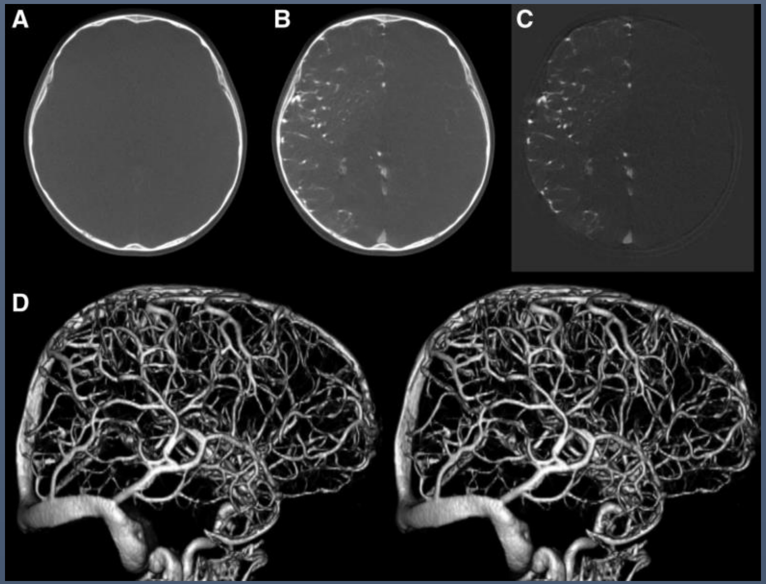





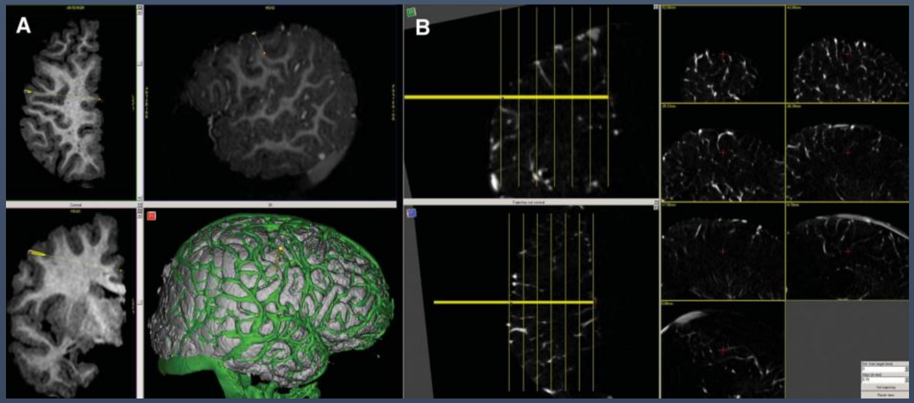

- ROSA
- Mean planning time 30 mins
- Mean operative time 130 mins
- Mean target error  1.7 mm
- Complication 4% (3 asymptomatic ICH )

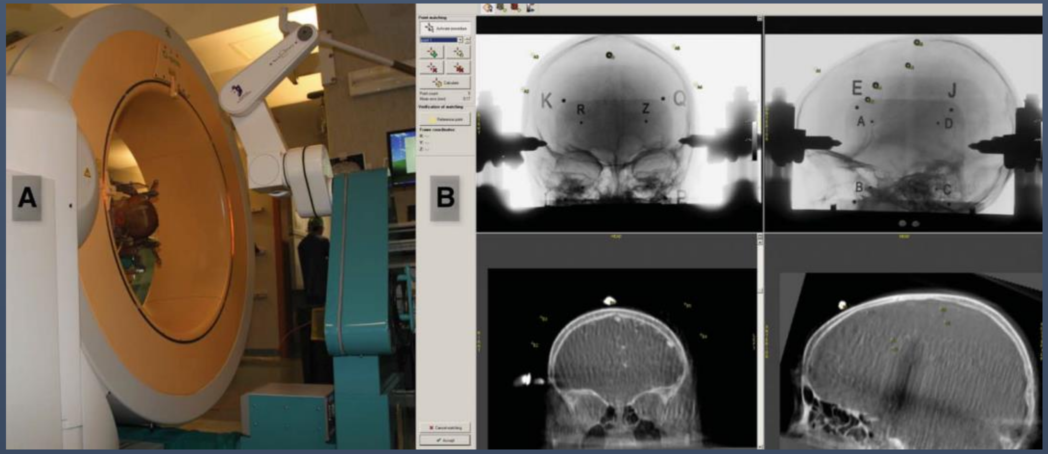
Gonzalez-Martinez J, et al. Neurosurgery 2016; 78:169-180.

# Milano, Italy




- Neuromate
- 3-D T1-weighted MRI, O-arm 1000 system for 3-D DSA
- GA duration 315 (traditional), 330 (new workflow)
- Target point error 2.69 mm (traditional) 1.77 mm (new workflow)
- Major complication 2.4%




Cardinale F, et al. Neurosurgery 2013; 72:353-366.

| | Frame-Based SEEG | Frameless SEEG | Robotic SEEG |
|---|---|---|---|
| **Need of Frame** | Yes | No | No |
| **Need of intraoperative imaging** | Yes | No | No |
| **Accuracy to target, mm** | <2 | >2 | <2 |
| **Stability of tool delivery** | Excellent | Reasonable | Excellent |
| **Suitability for high-risk trajectories** | Good | Poor | Good |
| **Uniformity of method** | Good | Poor | Good |
| **Software** | Varies among centers | Medtronic Stealth Station | ROSA, Neuromate |
| **Restrictions to surgical field** | Yes | No | No |
| **Flexibility to change plans intraoperatively** | Limited | Good | Good |
| **Ease of implementation with no specialist training** | Limited | Good | Good |

Nowell M, et al. Operative Neurosurgery 2014; 10:525-534.
Martinez J, et al. Neurosurgery 2016;76:169-180.

# Extent of resection

- Anatomo-electro-clinical correlation
- Up to the non-involved electrode
- Up to eloquent cortex
- Functional anatomy
- Surgeon judgement (risks & benefits)

# Complications (Meta-analysis)

- SEEG-Surgical complication 1.3%

| Complications | SEEG | SDE |
|---|---|---|
| Hemorrahage | 1.0% | 3.2-4% |
| Superficial infection | 1.4% | 3.0% |
| Meningitis | 0.6% | 7.1% |
| Permanent neurological deficits | 0.6% | 0.5% |
| Transient neurological deficits | 0.6% | 4.6% |

Mullin JP. , et al. Epilpesia 2016; 57(3):386-401.
Arya, et al. Epilepsia 2013; 54:828-839.
Tebo, et al. J Neurosurg 2014; 120:1415-1427.

# Thank you