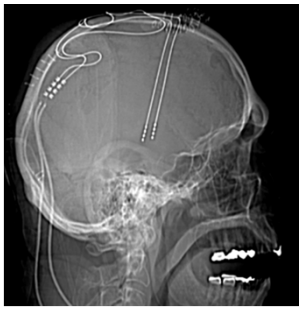
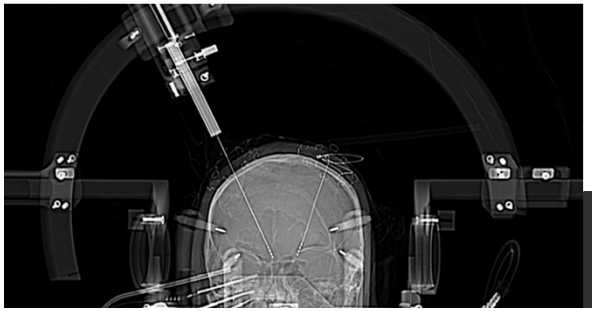


Restoring Function with Deep Brain Stimulation

Kyle Swanson, MD

AdvocateAuroraHealth®



October 9, 2020

Financial Disclosures

None

Introduction

- Neurosurgeon - Aurora St. Luke's Hospital in Milwaukee
- Focus on Functional Neurosurgery
  - Deep brain stimulation for movement disorders
  - Epilepsy surgery
  - Procedures for pain – spinal cord stimulation, trigeminal neuralgia
- Also treat: intracranial hemorrhage and tumors, degenerative spine disease, spine trauma, spine tumors, hydrocephalus, peripheral nerve disease

Deep Brain Stimulation

- Placement of electrodes in the brain to alter the firing of neurophysiological circuits

Can't we just use medications??

- **Medications are first line therapy**
  - Parkinsons disease – Levodopa/Carbidopa and levodopa equivalents
- Many patients are inadequately treated with medications or develop significant side effects to the medications

Deep Brain Stimulation

- Effect is usually reversible if you turn the stimulation off
- Used as second line if medications fail or side effects of medications become severe
  - Eg: On-Off phenomena or hyperkinetic dyskinesias related to levodopa use for Parkinsons' disease

DBS for Parkinson's Disease

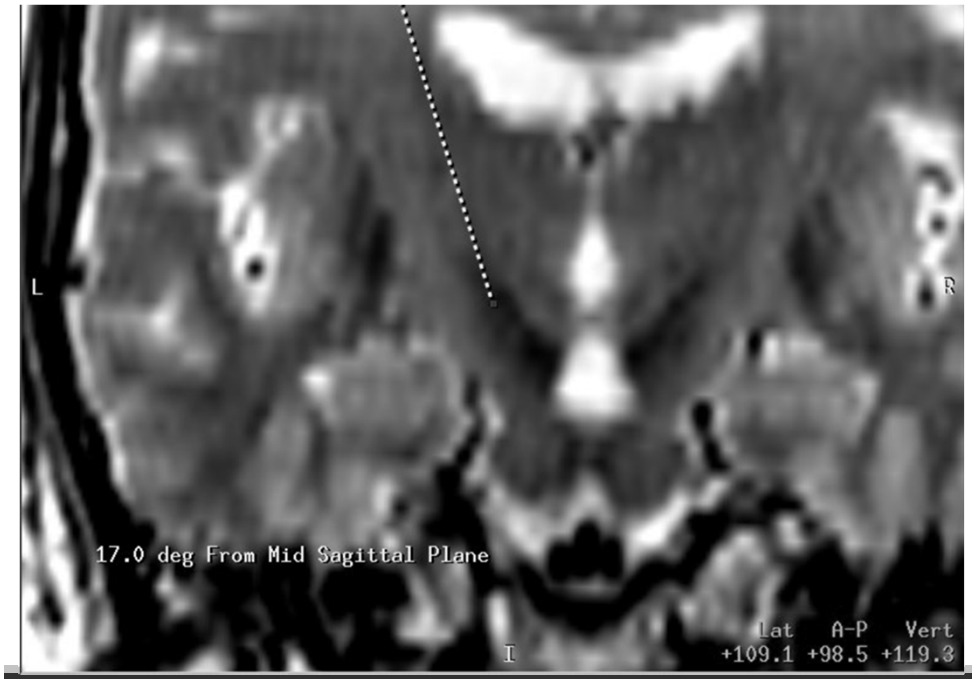
- Confidence in diagnosis (DAT scan can be useful)
- Disease responsive to L-Dopa
- No evidence of dementia or significant psychiatric comorbidities (neuropsych testing preop)

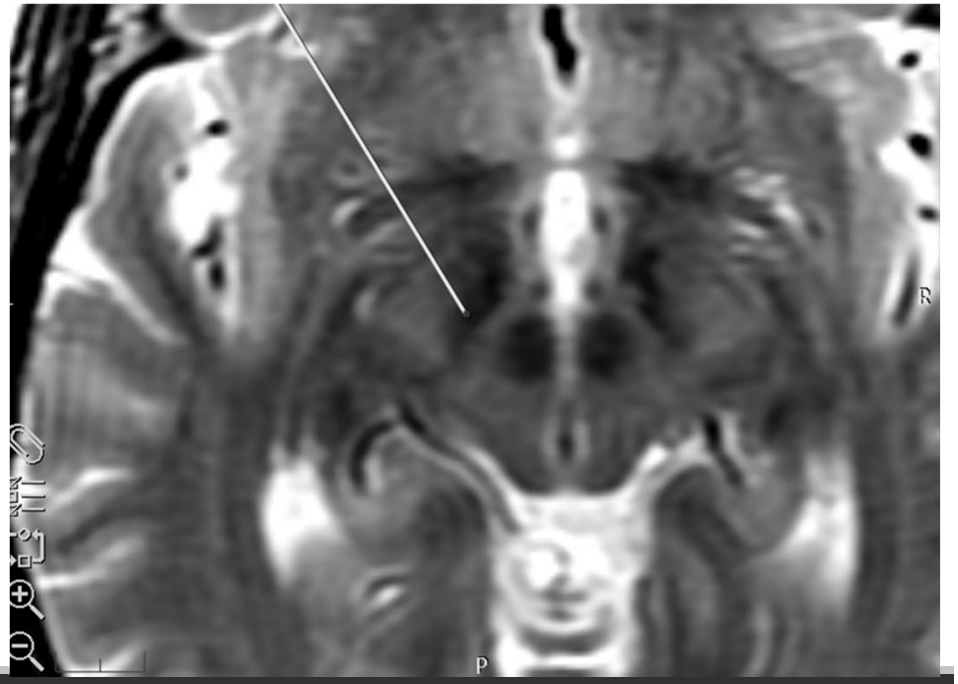
DBS for Parkinson's Disease

- Disease duration of 4 years with at least 4 months:
  - Significant On/Off motor fluctuations
  - Uncontrollable side effects of medication, such as dyskinesias
  - Drug resistant tremor

DBS Targets for PD

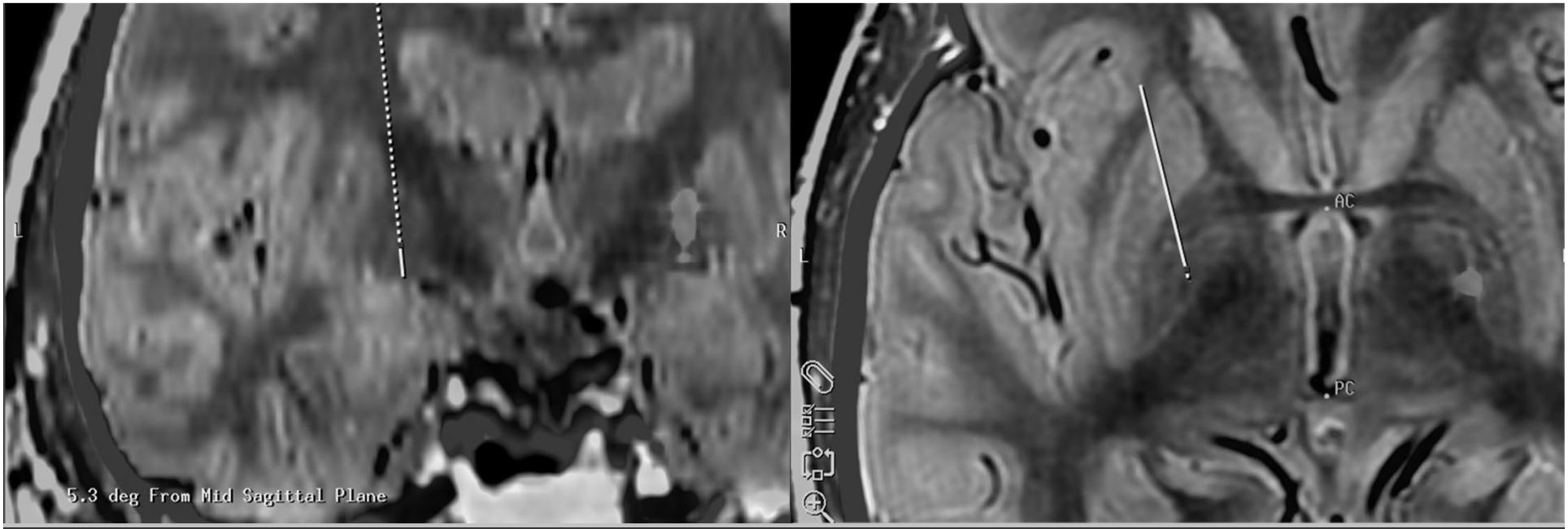
- Subthalamic Nucleus (STN)





DBS Targets for PD

- Globus Pallidus Internus (GPi)



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What does DBS help

- Increase “on” time
- Reduces medication dose
- Improves rigidity and bradykinesia
- Tremor
- Improves medication induced dyskinesias

- Variable: Gait (effect of L-dopa helps predict effect w/ DBS)

What is DBS less likely to help or could worsen

- Balance
- Cognitive Deficits
- Depression/Mood problems

Not experimental!

FDA approved 2002

Not a treatment of last resort

Level 1 randomized controlled trial evidence to support use in appropriately selected patients

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Bilateral Deep Brain Stimulation vs Best Medical Therapy for Patients With Advanced Parkinson Disease

A Randomized Controlled Trial

JAMA, January 7, 2009—Vol 301, No. 1

- Deep brain stimulation superior to best medical management for motor symptoms
- With DBS an average gain in 4.6 hours/day of ON time versus 0 hr/day for patient continued on medication alone
- Quality of life improved significantly in DBS group versus best medical management

Weaver FM, Follett K, Stern M, et al. Bilateral deep brain stimulation vs best medical therapy for patients with advanced Parkinson disease: a randomized controlled trial. *JAMA*. 2009;301(1):63-73.

DBS is for management of symptoms and is not a cure

DBS does not halt or change progression of underlying disease

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JNS

CLINICAL ARTICLE

Complication rates, lengths of stay, and readmission rates in "awake" and "asleep" deep brain simulation

Tsinsue Chen, MD, Zaman Mirzadeh, MD, PhD, Kristina Chapple, PhD, Margaret Lambert, BSN, RN, and Francisco A. Ponce, MD

- 490 electrodes in 284 patients – no deaths
- Transient postoperative mental status change (4.6%)
- Hemorrhage (1.4%)
- Seizure (1.4%)
- Hardware- related infection (1.1%)
- Mean LOS 1.19 ± 1.29 days
- 30-day readmission rate was 1.4%
- No sig. difference in complications btwn asleep & awake

Proceedings of the Meeting of the American Society
for Stereotactic and Functional Neurosurgery, Montreal 1987
Appl. Neurophysiol. *50:* 344–346 (1987)

Combined (Thalamotomy and Stimulation) Stereotactic Surgery of the VIM Thalamic Nucleus for Bilateral Parkinson Disease

A.L. Benabid[a], *P. Pollak*[b], *A. Louveau*[a], *S. Henry*[a], *J. de Rougemont*[b]

Departments of [a] Neurosurgery and [b] Neurology, Grenoble University, La Tronche, France

DBS surgery

- Initial report 1987

- Uses microelectrode recording and test stimulation to verify location
- Requires patient to be **awake**

Awake DBS Surgery

- Patient must be off Parkinson's medications for surgery
- Placed in stereotactic headframe which has 4 pins that attach to skull
- Frame is attached to bed – patient in same position for hours
- Requires multiple additional microelectrodes to be passed through the brain
- Test stimulation requires patient cooperation

Asleep DBS Surgery

- Patient under general anesthesia the entire time – eliminates patient discomfort
- Takes advantage of ability to obtain intraoperative MRI or CT
- Verify placement with radiographic location of the lead relative to preop target as opposed to physiologic testing

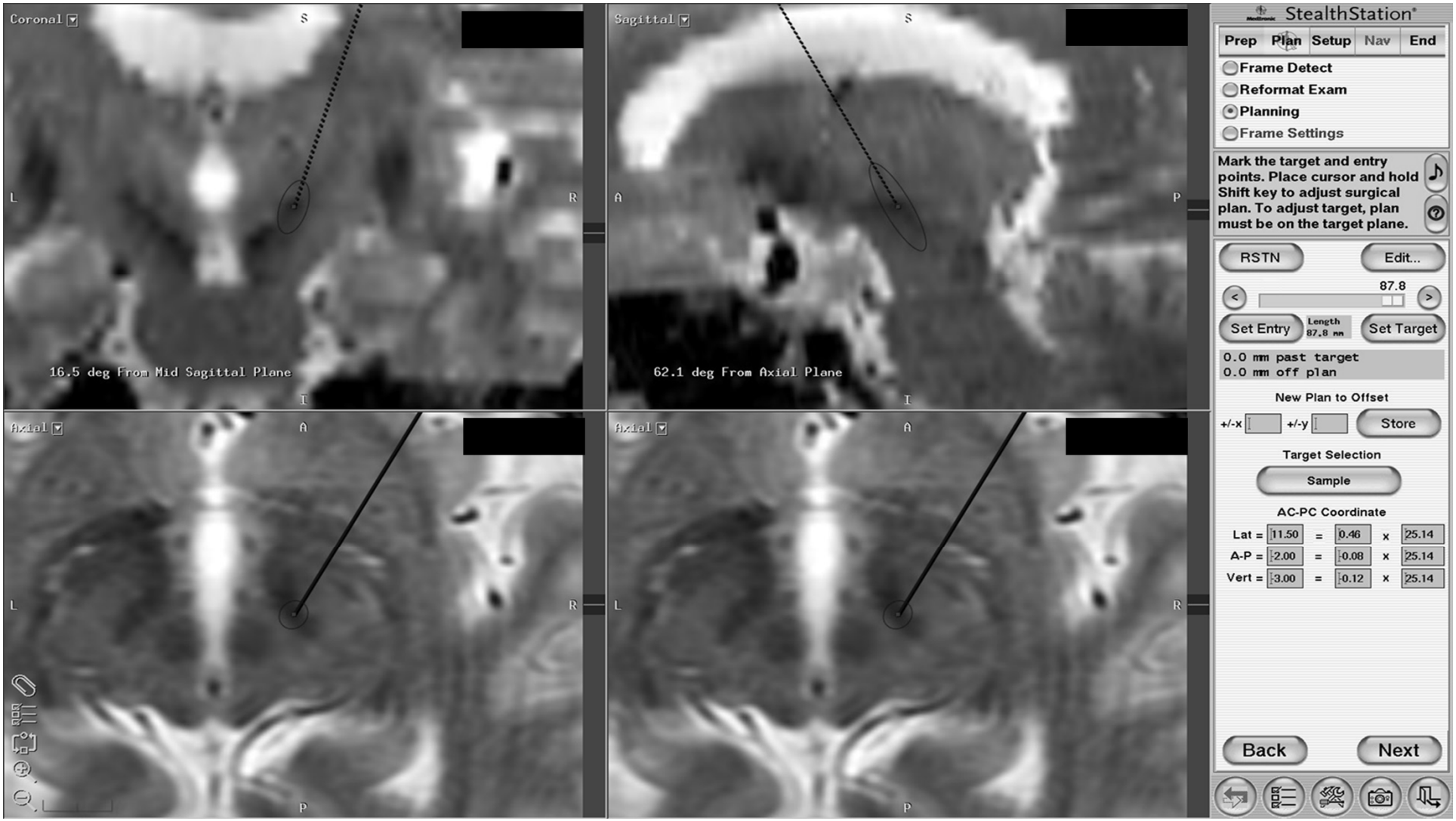
DBS at Aurora

- Vast majority of cases will be done asleep using intraoperative CT to verify lead location
- All necessary equipment for awake DBS is available (including microelectrode recording equipment and well trained anesthesia), but will only be used on unique cases

Preop Workup

After workup and selection of candidates by neurology

- Presentation at Movement disorder multidisciplinary conference
- Neurosurgery clinic visit
  - Discussion of surgery, risks, benefits, alternatives
- Preoperative clearance by PCP for medical clearance
- Preop MRI and CT to make surgical plan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Sample
AC-PC Coordinate
Lat = 11.50 = 0.46 x 25.14
A-P = 2.00 = 0.08 x 25.14
Vert = 3.00 = 0.12 x 25.14
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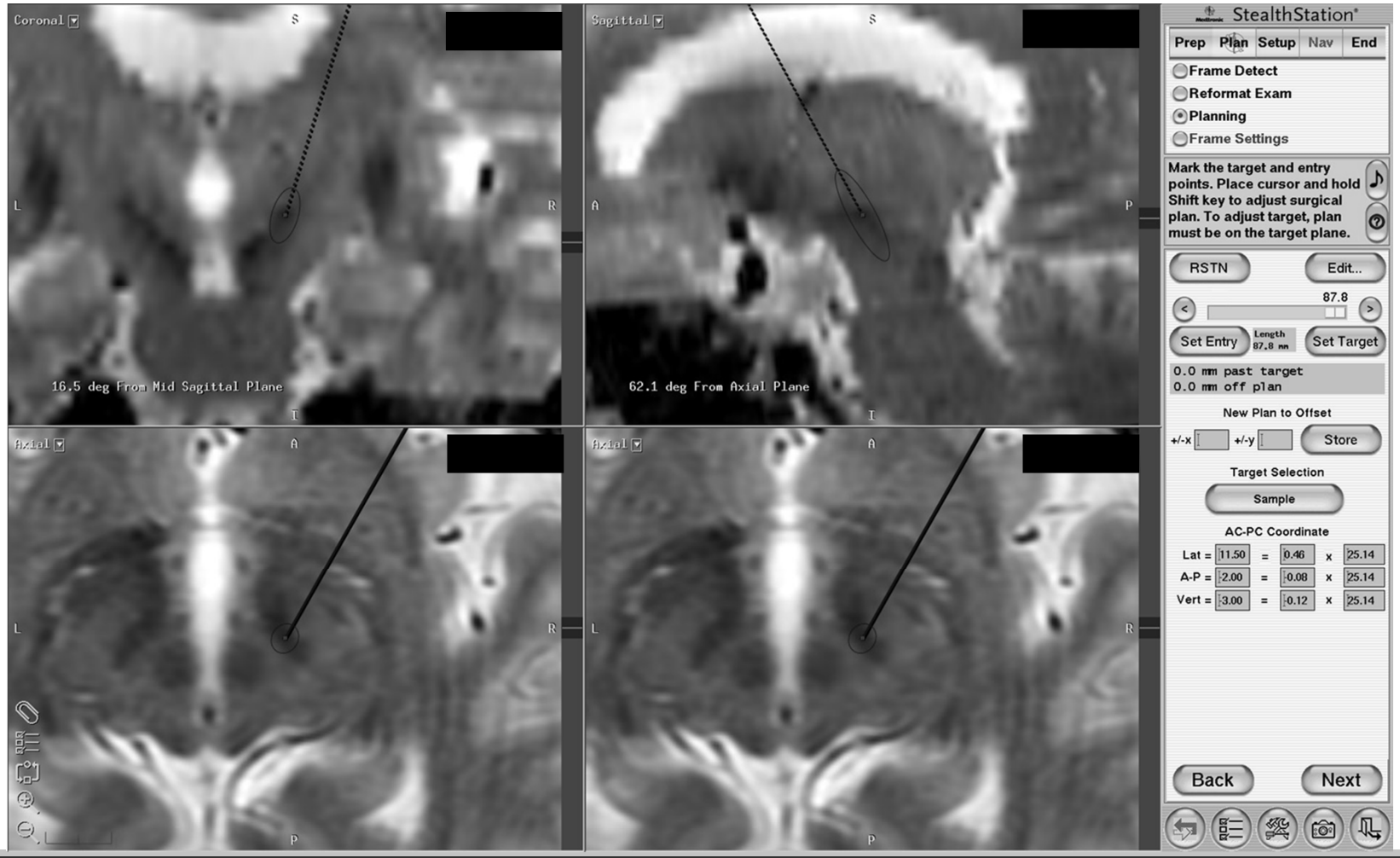
Day of Surgery

- For asleep patients – no need to hold Parkinson's medications prior to surgery
- Patient brought to OR and put under general anesthesia
- Leksell stereotactic frame placed (4 screws attach to the skull)

Surgery

- Pre-implant O-arm CT used to register patient's head to the frame
- Intraop CT imaging fused with preop plan to obtain "GPS" coordinates for targeting the DBS electrodes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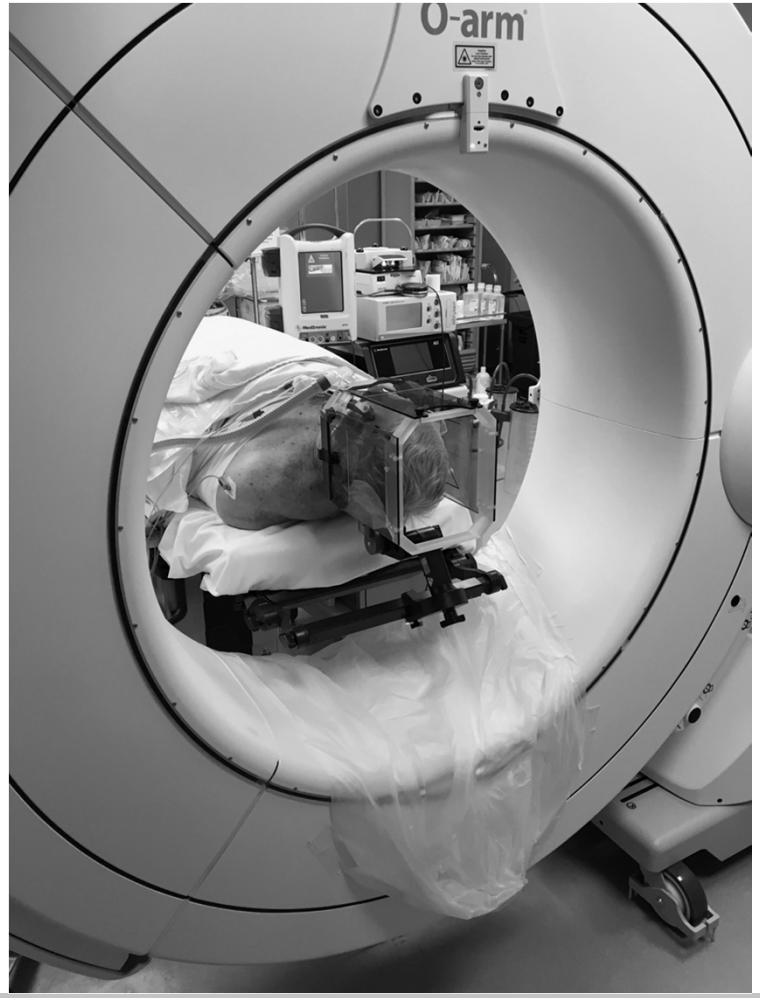
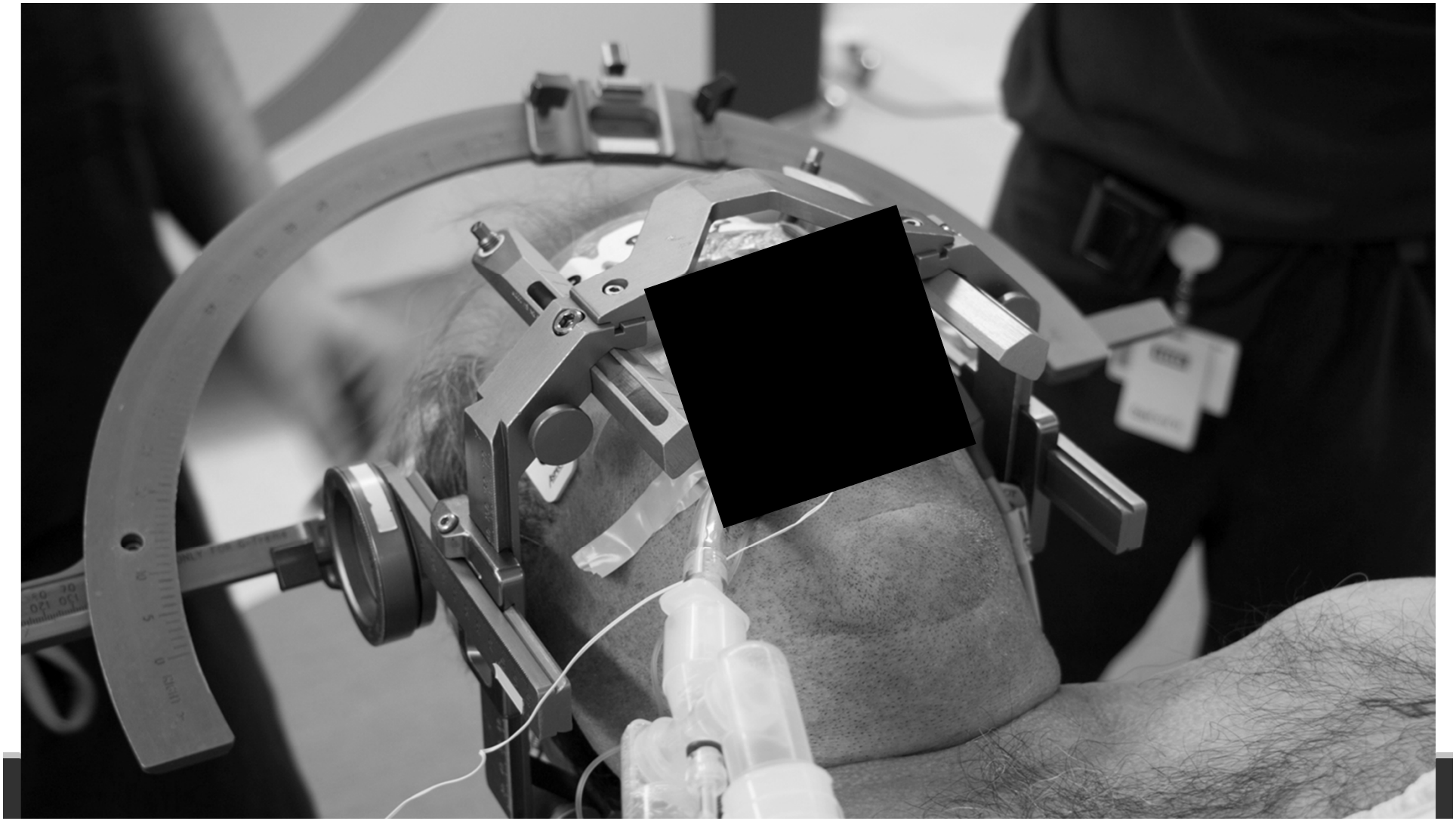
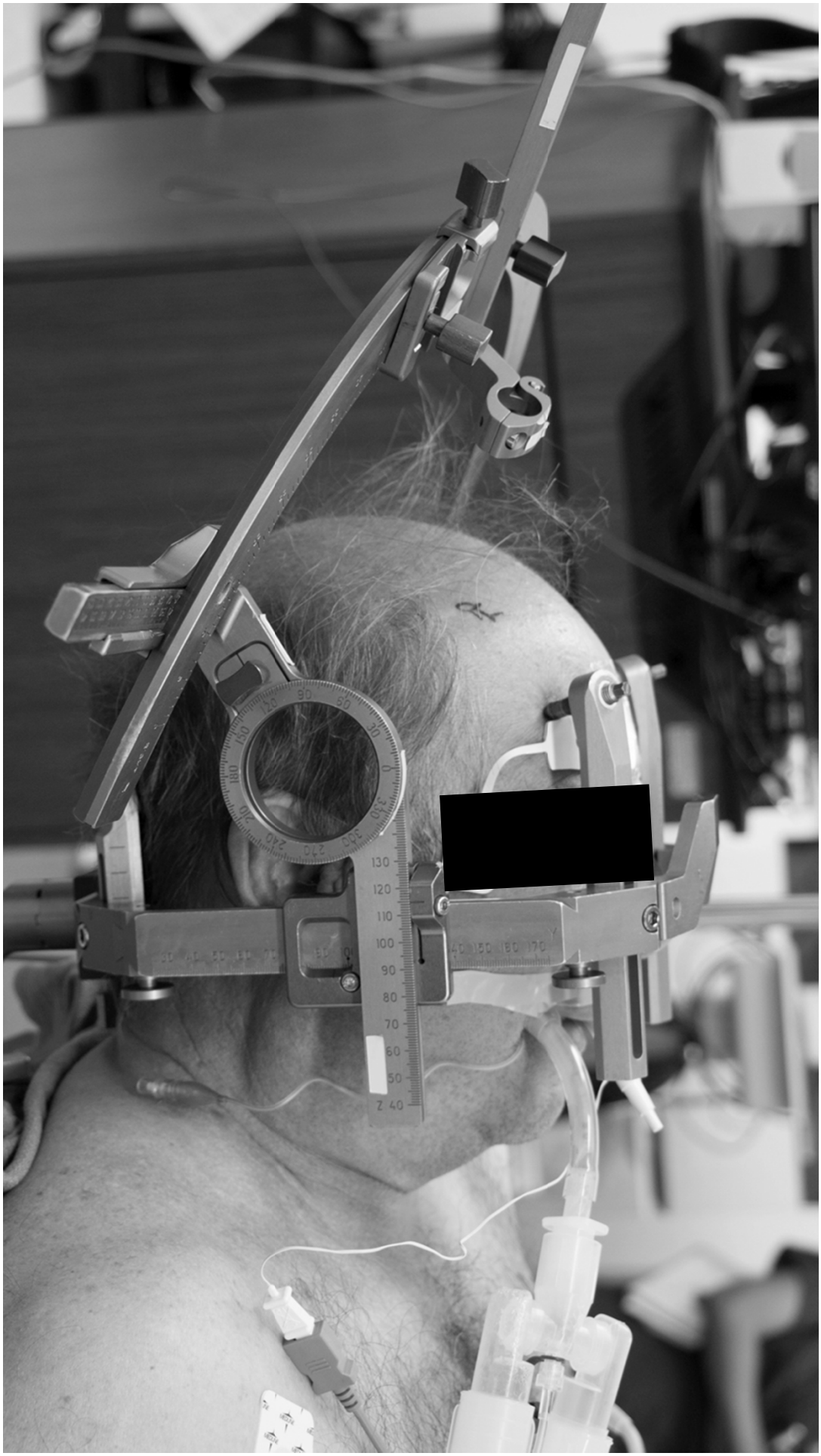

O-arm

Surgery

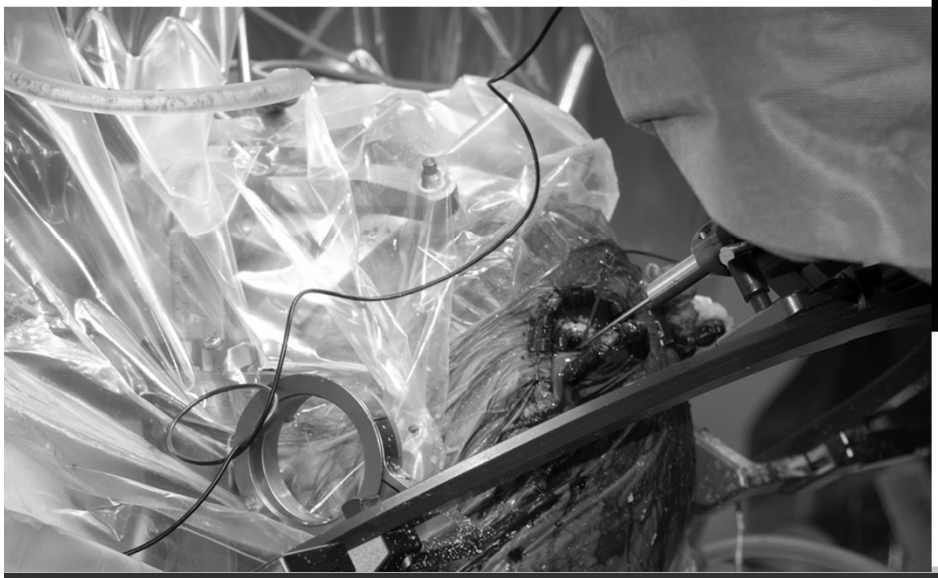
- Patient is prepped in sterile fashion
- Frame reference arc is placed and coordinates are set
- Entry sites marked on scalp and half circle incisions are made around each planned entry site.





Surgery

- Incisions are made
- Burr holes are made at the entry sites on the skull
- Dura is opened
- Electrodes are passed to target on both sides



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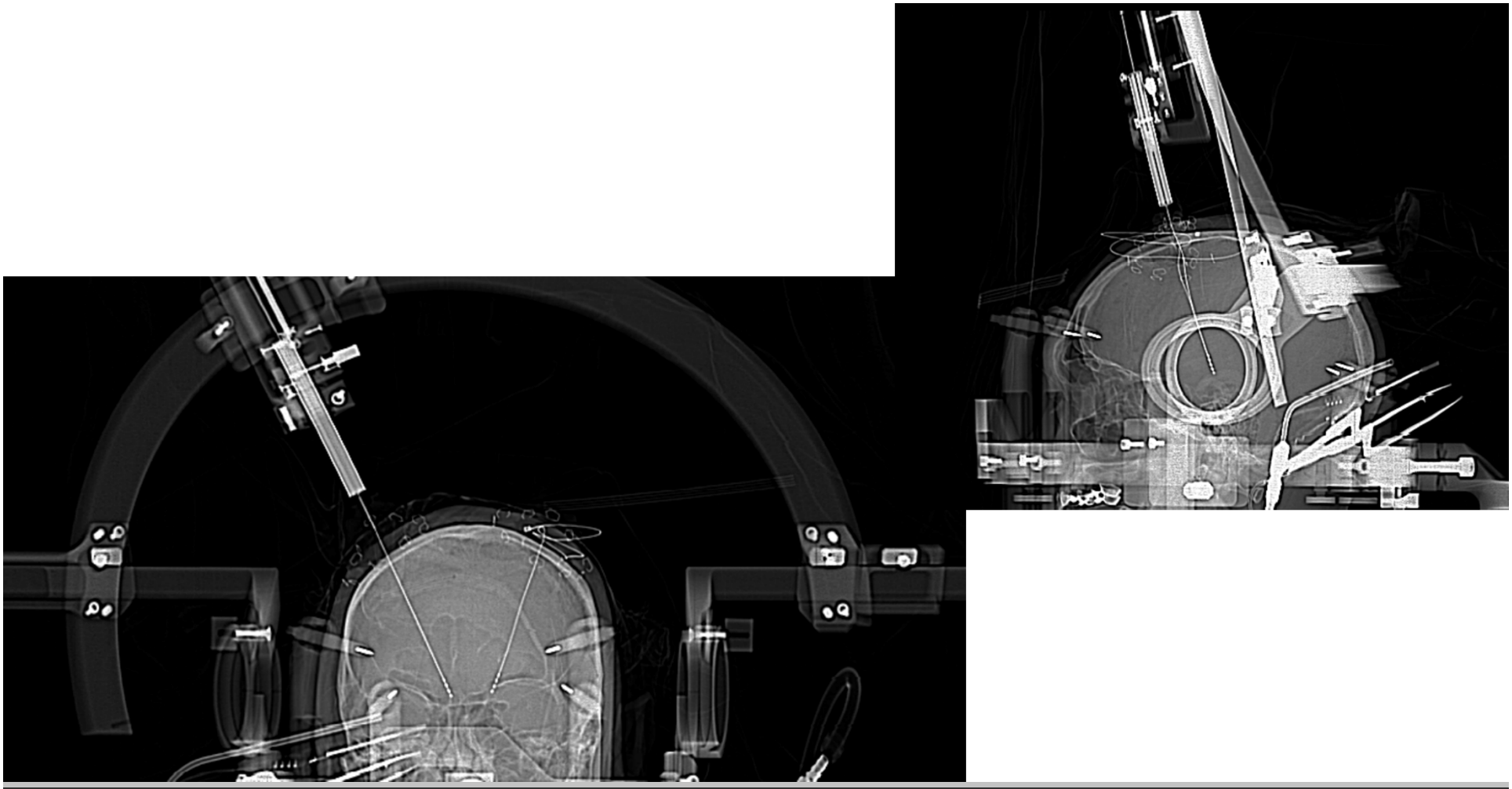
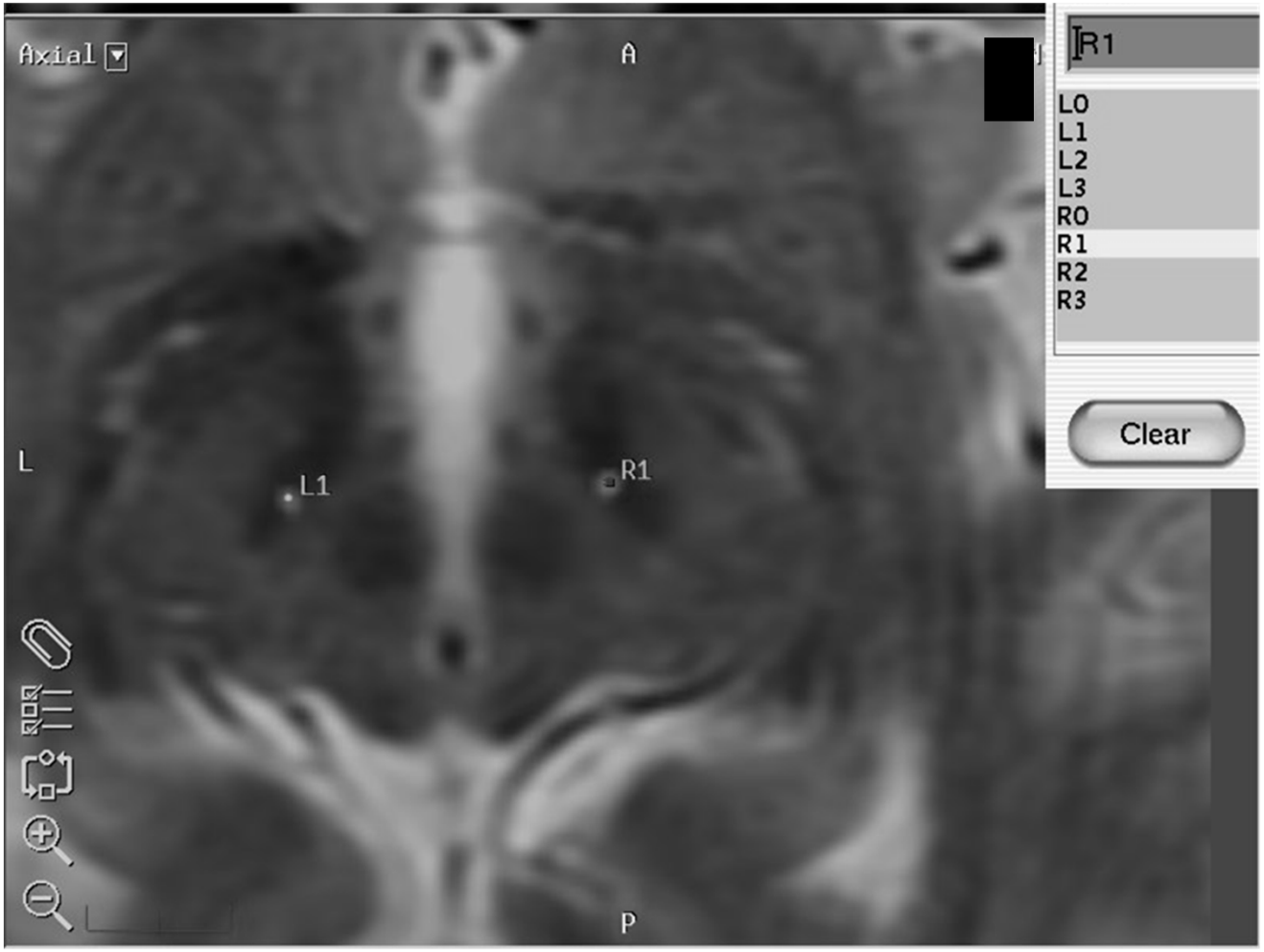


Surgery

- Test stimulation with DBS electrodes to ensure no obvious motor contractions
- Once both DBS electrodes are in place, the O-arm CT is repeated
- If electrodes are 2mm or more off of plan, they are immediately replaced
- CT is also evaluated to ensure no acute hemorrhage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Surgery

- Once lead location is satisfactory, leads are secured at the skull and the leads are tucked under the skin posteriorly
- Incisions are closed (usually with staples)
- Patient taken out of frame
- Patient repositioned for implanted pulse generator (battery) placement

Surgery

Second Stage

- Leads attached to extension cable and tunneled down neck to chest
- Battery implanted below the clavicle
- Incisions closed and anesthesia stopped
- Transferred to ICU

Postop

- Stimulator will be OFF
- Patients frequently have some symptom improvement, even with the stimulator off, from a "micro-lesion" effect

Postop

- Goal is for most patient's to go home on POD #1, with most of the rest going home POD #2
- For PD patients > 75 years old will plan for discharge POD #2
- Some may need short stay in rehab

Postop

- Seen by neurosurgery 10-14 days postop for wound check/staple removal
- Seen by neurology at 3-4 weeks to start programming
- Frequent visits for the first 3-6 months to optimize programming, medications titrated down as DBS titrated up

Postop

- Patients can often decrease their daily levodopa equivalents by about 50%, which can help with medication side effects (most stay on some levodopa)
- Batteries last on average 3-5 years if non-rechargeable and 15 years if rechargeable.

Comparing Awake DBS versus Asleep DBS

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Patients' Perioperative Experience of Awake Deep-Brain Stimulation for Parkinson Disease

Eoin Mulroy[1], Nigel Robertson[2], Lorraine Macdonald[1], Arnold Bok[3], Mark Simpson[1]

WORLD NEUROSURGERY

- Survey of patients undergoing Awake DBS
- "Roughly one half the patients reported experiencing pain during the procedure (severe in 40%)"
- "Stereotactic frame placement and burr hole drilling were the most unpleasant parts of the procedure…(48%)"
- "noise of the drill also seemed especially unpleasant"

Asleep DBS

- Assumptions:
  - We can identify an anatomic target on preoperative imaging
  - Accuracy of lead placement will correlate with effectiveness of DBS therapy
  - Outcomes will be at least equivalent to Awake DBS

Awake vs Asleep DBS

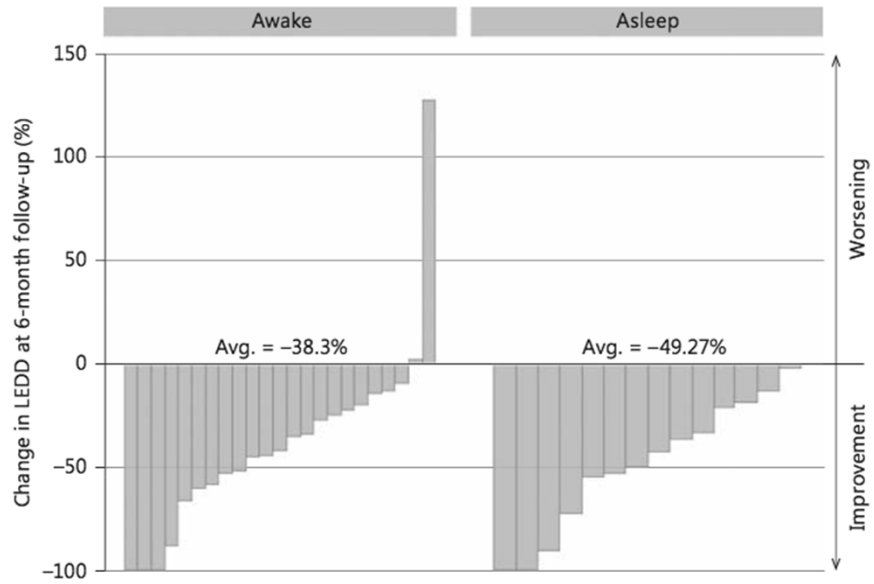
- No randomized controlled trials
- Difficulty with accrual due to patients not wanting to be randomized when both surgical options explained in detail
- Reliant on case series at institutions that perform both and meta-analyses

Stereotactic and Functional Neurosurgery

Awake Neurophysiologically Guided versus Asleep MRI-Guided STN DBS for Parkinson Disease: A Comparison of Outcomes Using Levodopa Equivalents

Sara Saleh[a] Kyle I. Swanson[a, b] Wendell B. Lake[a, b] Karl A. Sillay[c–e]

Similar reduction in medications between asleep and awake DBS



Awake versus asleep deep brain stimulation for Parkinson's disease: a critical comparison and meta-analysis

Allen L Ho,[1] Rohaid Ali,[1] Ian D Connolly,[1] Jaimie M Henderson,[1] Rohit Dhall,[2] Sherman C Stein,[3] Casey H Halpern[1]

Asleep DBS results in fewer lead passes, fewer bleeds, and fewer infections

Outcome category	Awake			Asleep			Difference (p Value)*
	n	Mean	SD	n	Mean	SD	
No of passes/lead	2123	2.10	0.69	620	1.40	0.44	**0.006**
% ICH/lead	3547	1.1	0.3	626	0.3	0.0	**<0.001**
% Infection/lead	3404	1.4	0.0	626	0.7	0.0	**<0.001**
Time/case (min)	427	272.4	92.5	432	253.7	82.3	0.748

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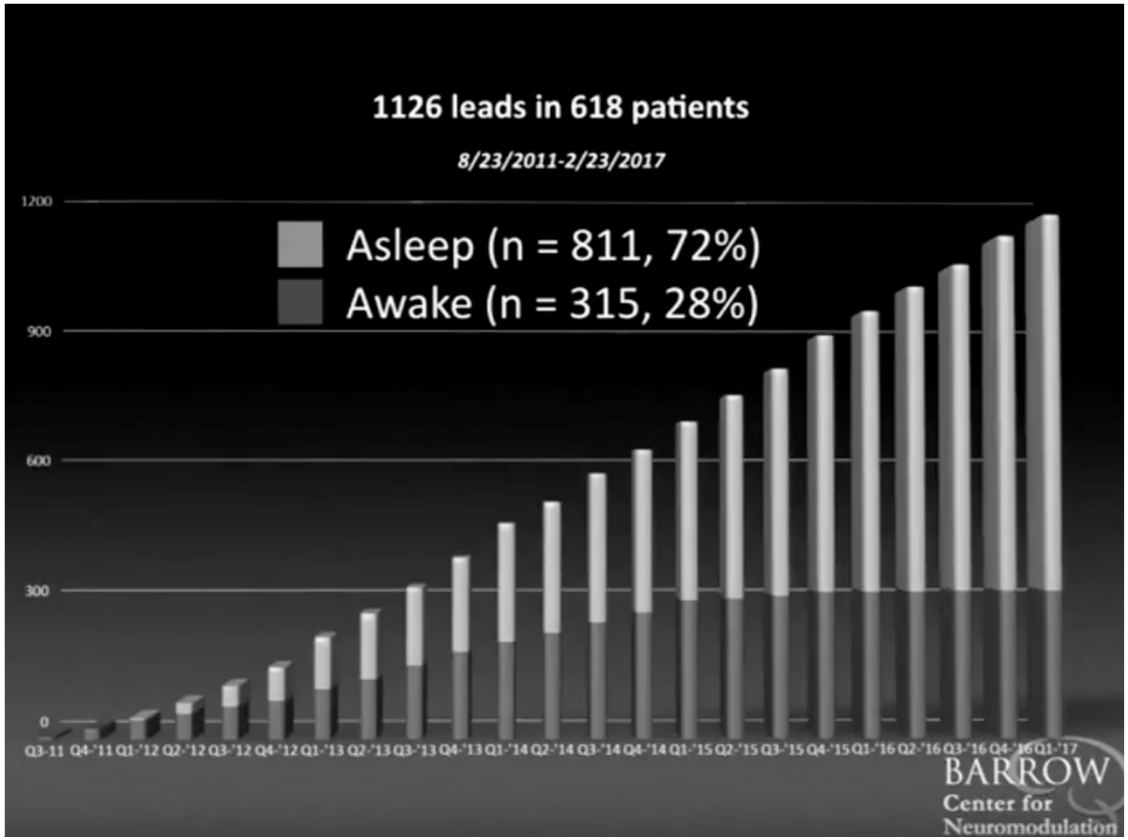
No difference in performance outcomes between awake and asleep DBS

DBS outcomes —pooled values

% improvement postoperatively	Awake			Asleep			Differenc
	n	Mean	SD	n	Mean	SD	
UPDRS II 'off' med	1047	47.4	20.1	162	45.8	28.5	0.923
UPDRS III 'off' med	4931	46.7	27.4	510	51.1	16.6	0.494
UPDRS III 'on' med	3018	20.4	10.6	326	20	8.6	0.936

Asleep versus Awake DBS at BNI

Busiest DBS program in USA



New DBS developments

- Longer rechargeable battery life (15 years)
- Directional lead contacts to fine tune stimulation
- Brain activity recording and closed loop stimulation

Conclusions

DBS is an elective surgery designed to improve quality of life

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Conclusions

DBS is not experimental, complication rates are low, and DBS is underutilized

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Conclusions

Asleep DBS surgery provides a less daunting option for patients needing DBS

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Questions?

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