Coordinates and Surgical Process of DBS

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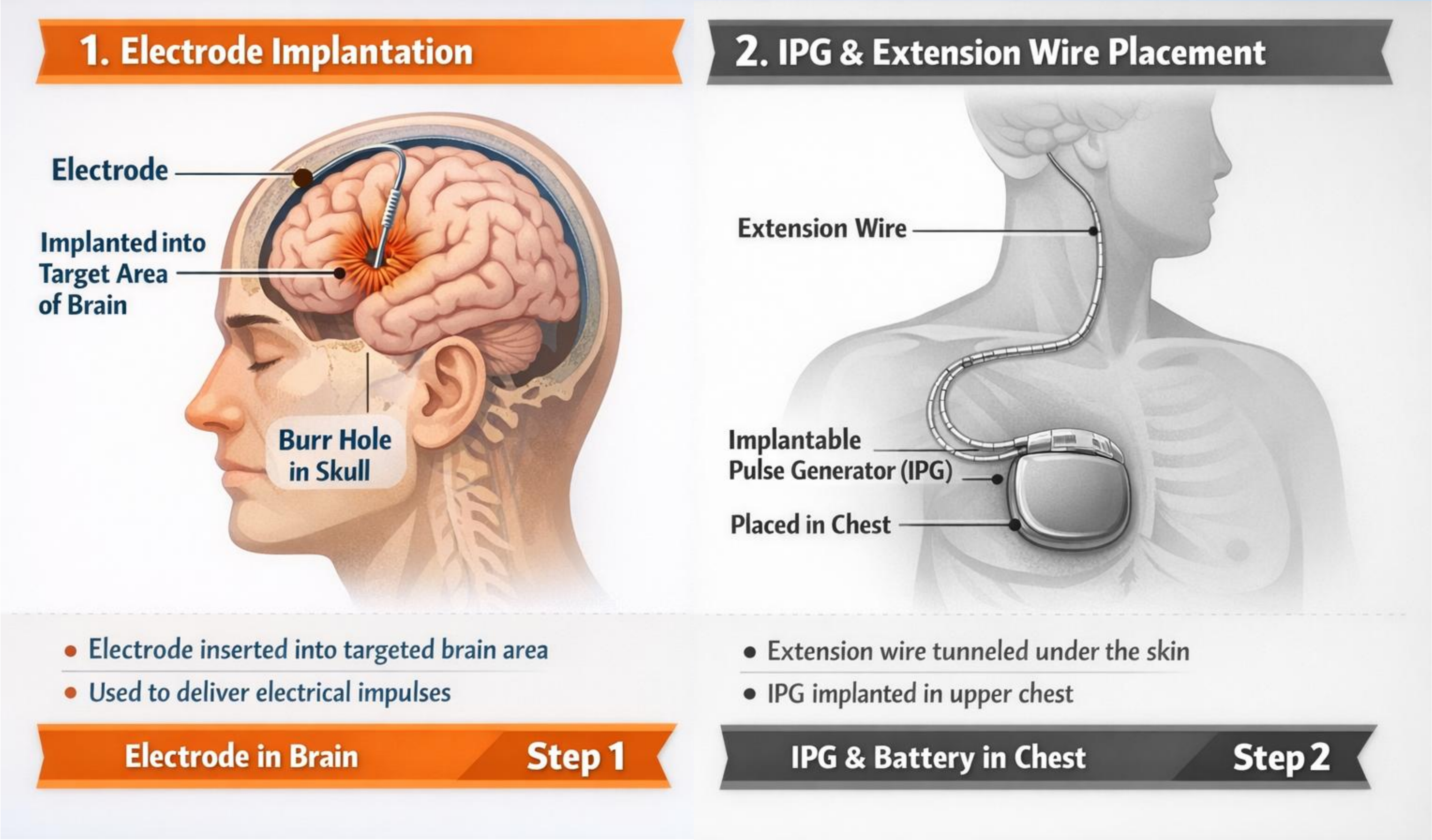
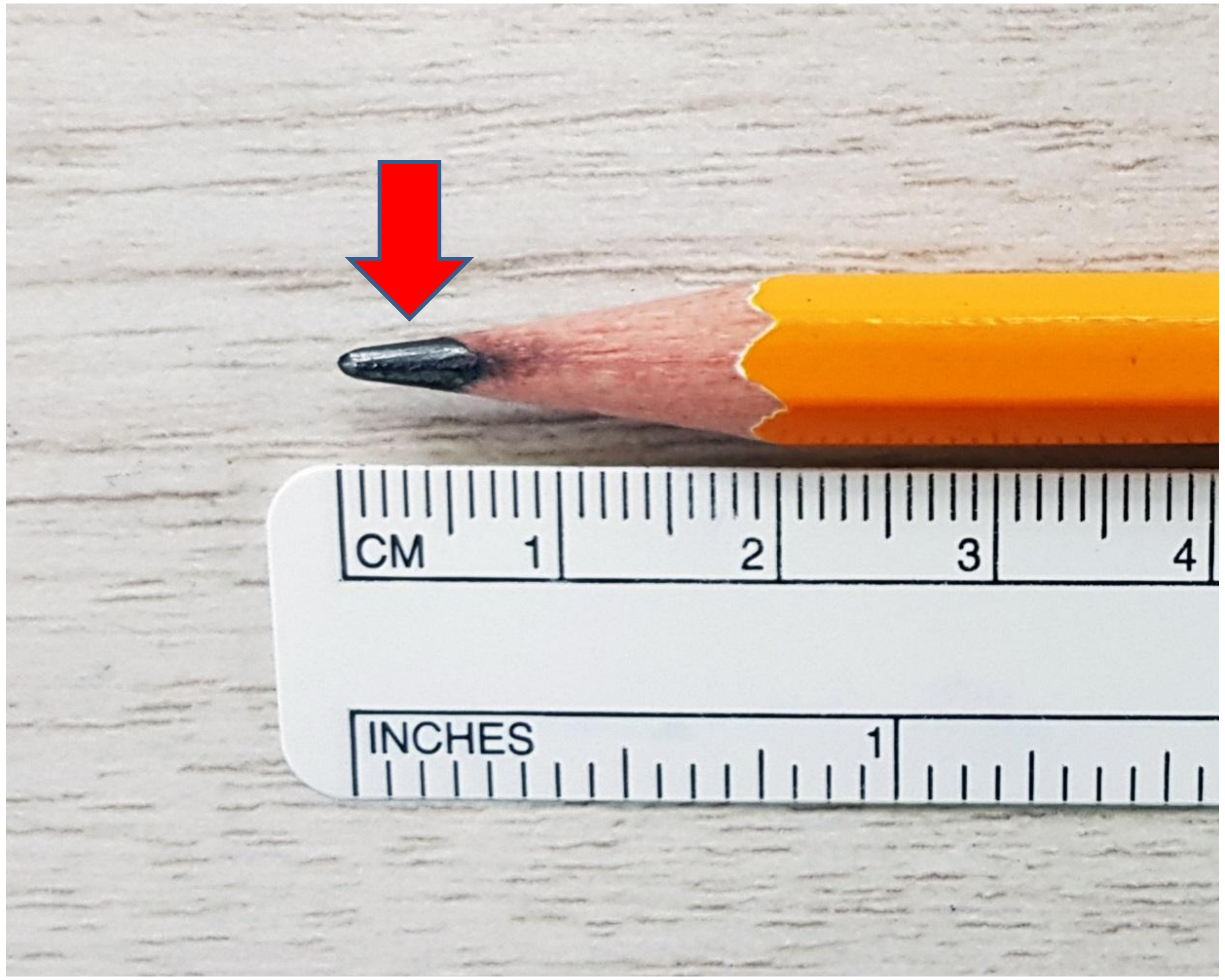
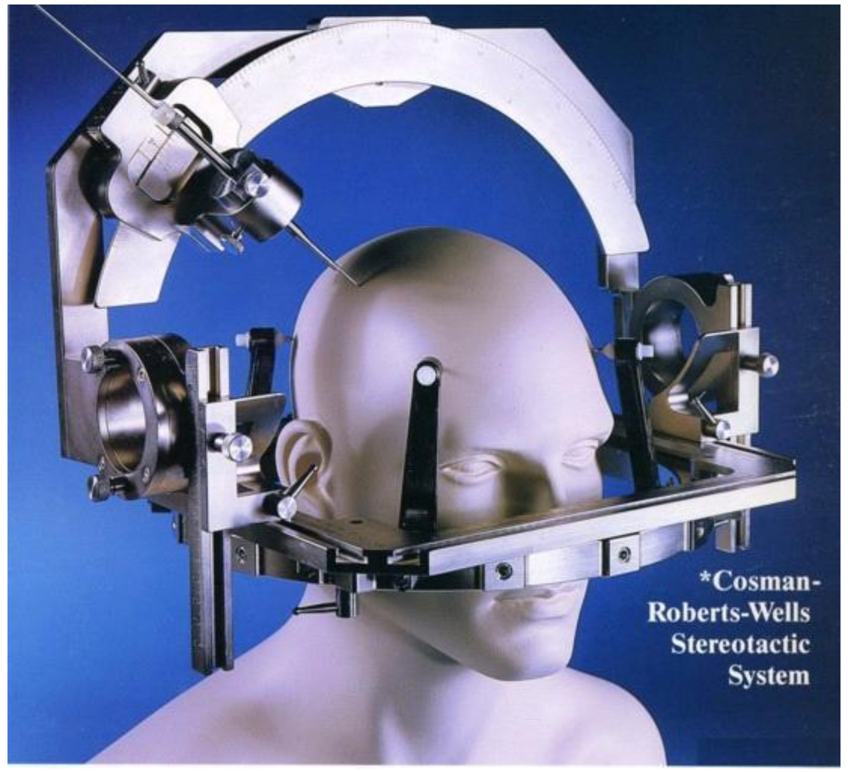
School for Device-Aided Therapies in Parkinson's Disease
Bangkok, Thailand | May 6-7, 2026

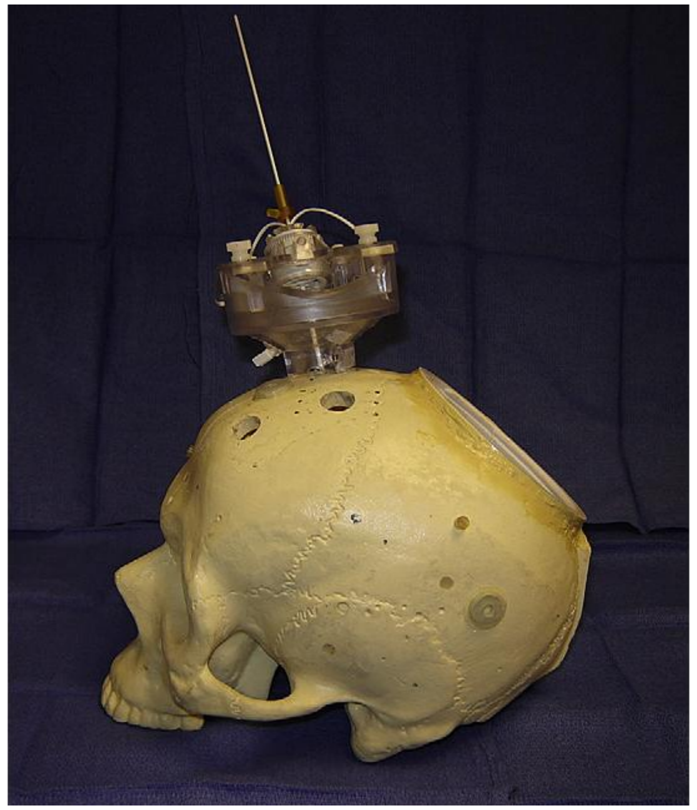
International Parkinson and Movement Disorder Society Asian & Oceanian Section

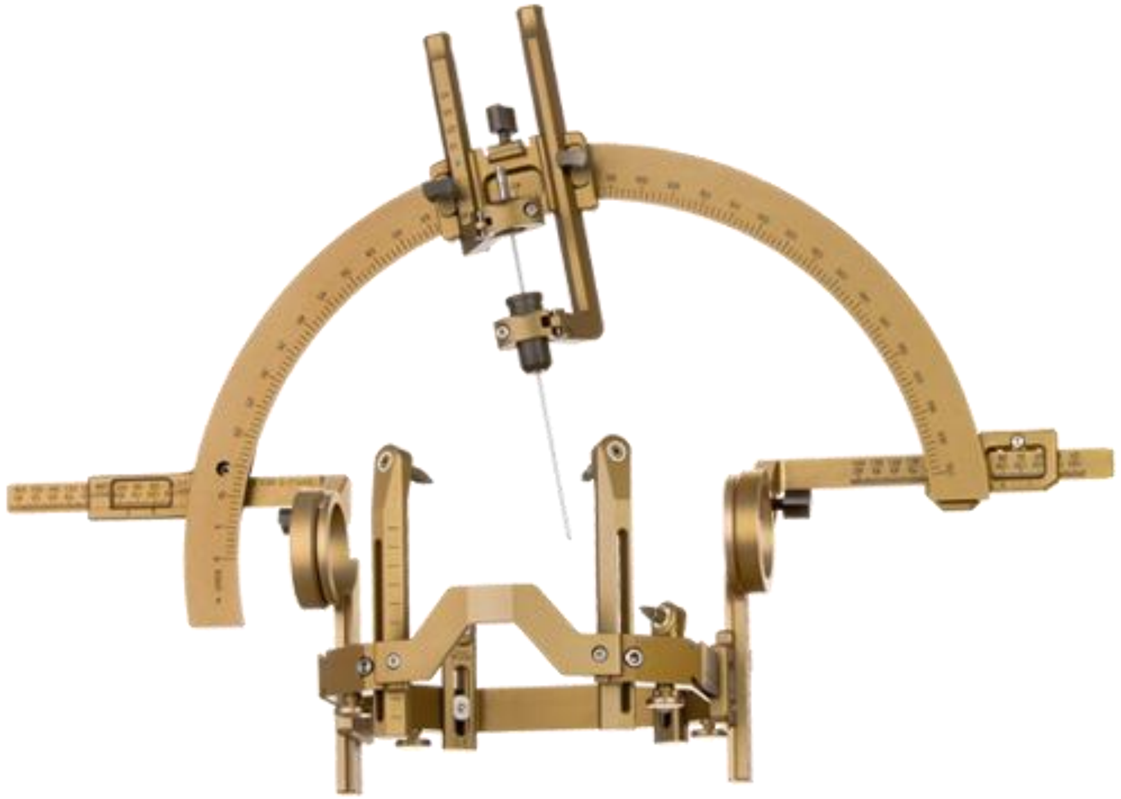

1. Electrode Implantation
Electrode
Implanted into Target Area of Brain
Burr Hole in Skull
Electrode inserted into targeted brain area
Used to deliver electrical impulses
Electrode in Brain
Step 1
2. IPG & Extension Wire Placement
Extension Wire
Implantable Pulse Generator (IPG)
Placed in Chest
Extension wire tunneled under the skin
IPG implanted in upper chest
IPG & Battery in Chest
Step 2

Clinical outcomes are directly linked to the precision of DBS lead placement (submillimeter accuracy)




*Cosman-
Roberts-Wells
Stereotactic
System





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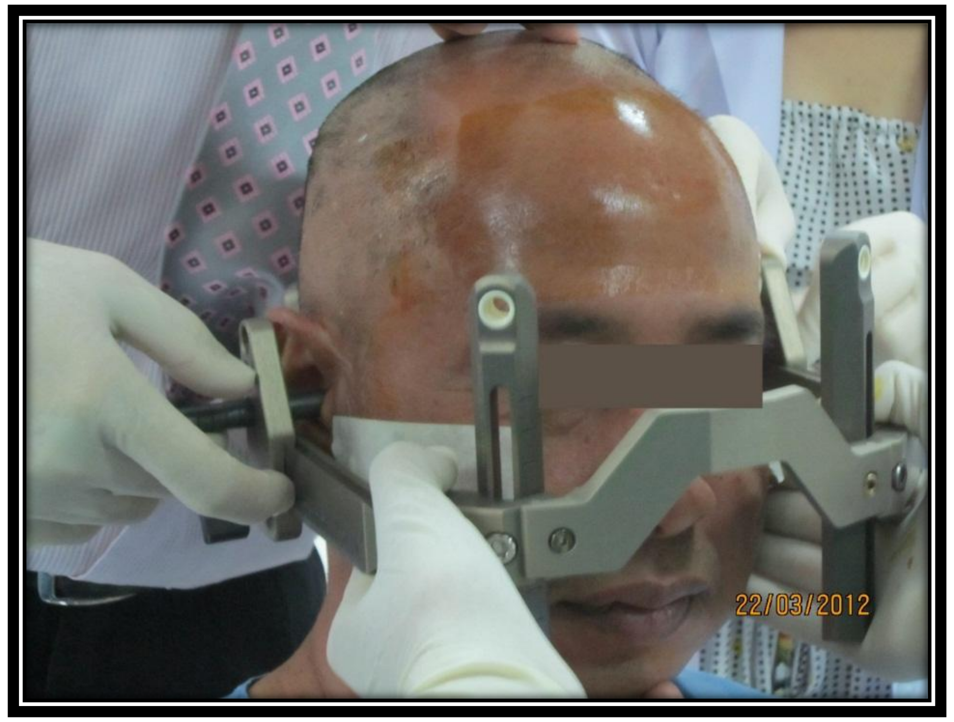

Lt Planing Frame Rt

Frame Setting (Left)		Frame Setting (Right)	
Lat(x)	111	Lat(x)	89
A-P (y)	94.5	A-P (y)	94.5
Vert(z)	116	Vert(z)	116
Ring	62	Ring	62
Arc	103.5	Arc	74

AC-PC Distance:__________

AC-PC Co-ordinators:__________

3rd Ventricular Width:__________

We have instruments to guide us to the target—but how do we identify the **TARGET** in the first place? (Vim, GPi, STN, etc.)

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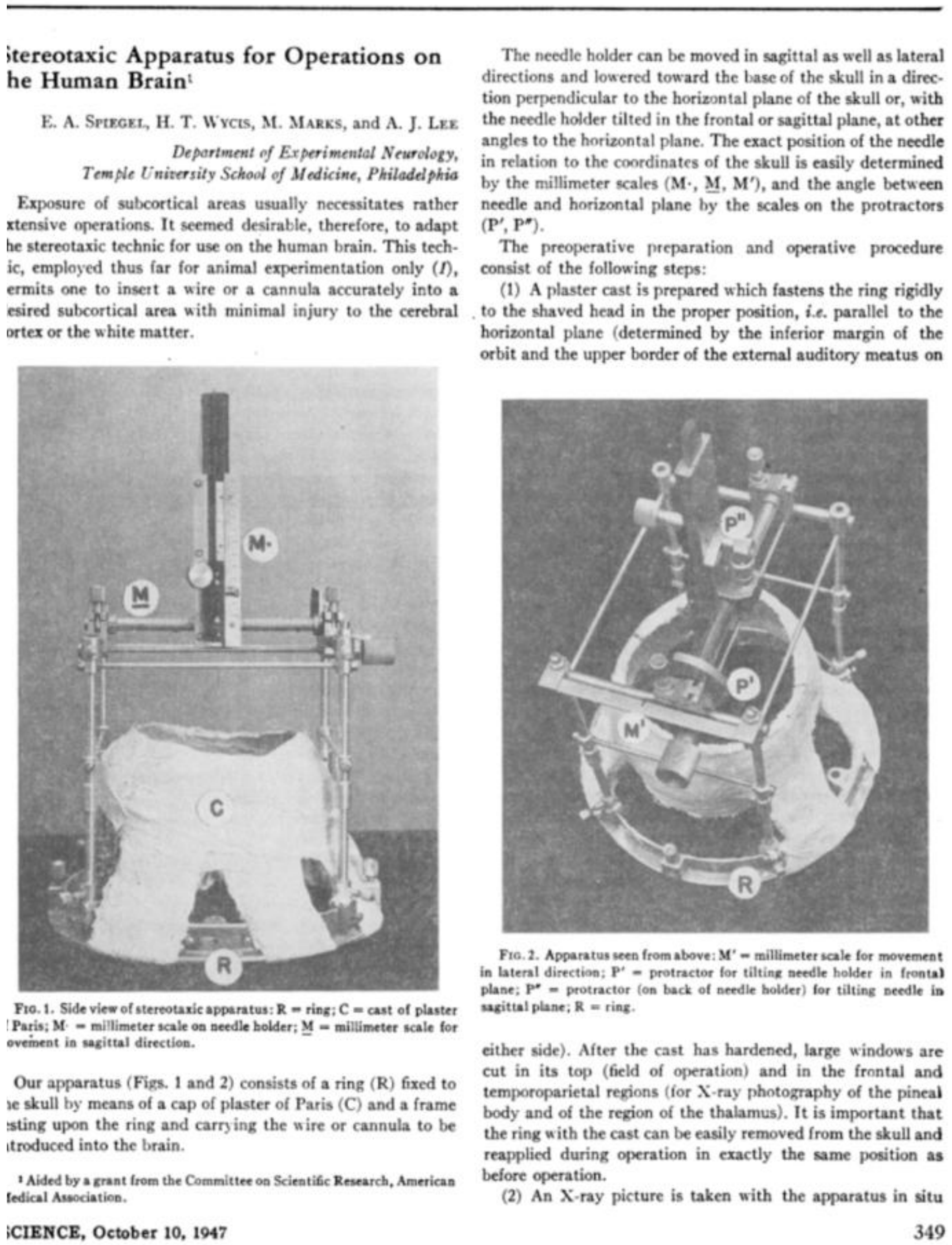


ꜱtereotaxic Apparatus for Operations on ‸he Human Brain[1]

E. A. Spiegel, H. T. Wycis, M. Marks, and A. J. Lee

Department of Experimental Neurology, Temple University School of Medicine, Philadelphia

Exposure of subcortical areas usually necessitates rather xtensive operations. It seemed desirable, therefore, to adapt he stereotaxic technic for use on the human brain. This tech-ic, employed thus far for animal experimentation only (*1*), ermits one to insert a wire or a cannula accurately into a esired subcortical area with minimal injury to the cerebral ortex or the white matter.

Fig. 1. Side view of stereotaxic apparatus: R = ring; C = cast of plaster Paris; M· = millimeter scale on needle holder; M = millimeter scale for ovement in sagittal direction.

Our apparatus (Figs. 1 and 2) consists of a ring (R) fixed to ie skull by means of a cap of plaster of Paris (C) and a frame sting upon the ring and carrying the wire or cannula to be troduced into the brain.

[1] Aided by a grant from the Committee on Scientific Research, American ledical Association.

The needle holder can be moved in sagittal as well as lateral directions and lowered toward the base of the skull in a direction perpendicular to the horizontal plane of the skull or, with the needle holder tilted in the frontal or sagittal plane, at other angles to the horizontal plane. The exact position of the needle in relation to the coordinates of the skull is easily determined by the millimeter scales (M·, M, M′), and the angle between needle and horizontal plane by the scales on the protractors (P′, P″).

The preoperative preparation and operative procedure consist of the following steps:

(1) A plaster cast is prepared which fastens the ring rigidly to the shaved head in the proper position, *i.e.* parallel to the horizontal plane (determined by the inferior margin of the orbit and the upper border of the external auditory meatus on

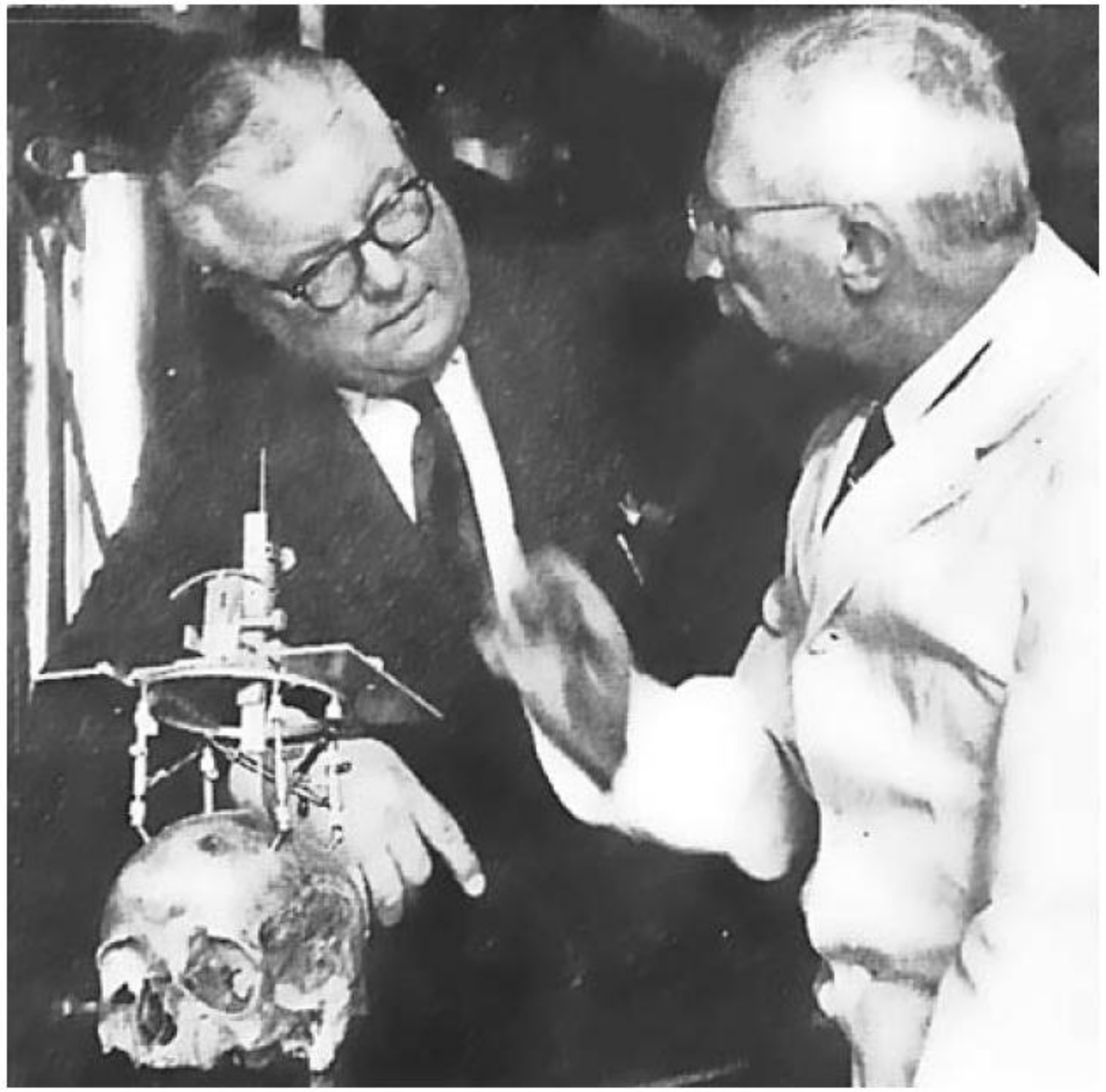
Fig. 2. Apparatus seen from above: M′ = millimeter scale for movement in lateral direction; P′ = protractor for tilting needle holder in frontal plane; P″ = protractor (on back of needle holder) for tilting needle in sagittal plane; R = ring.

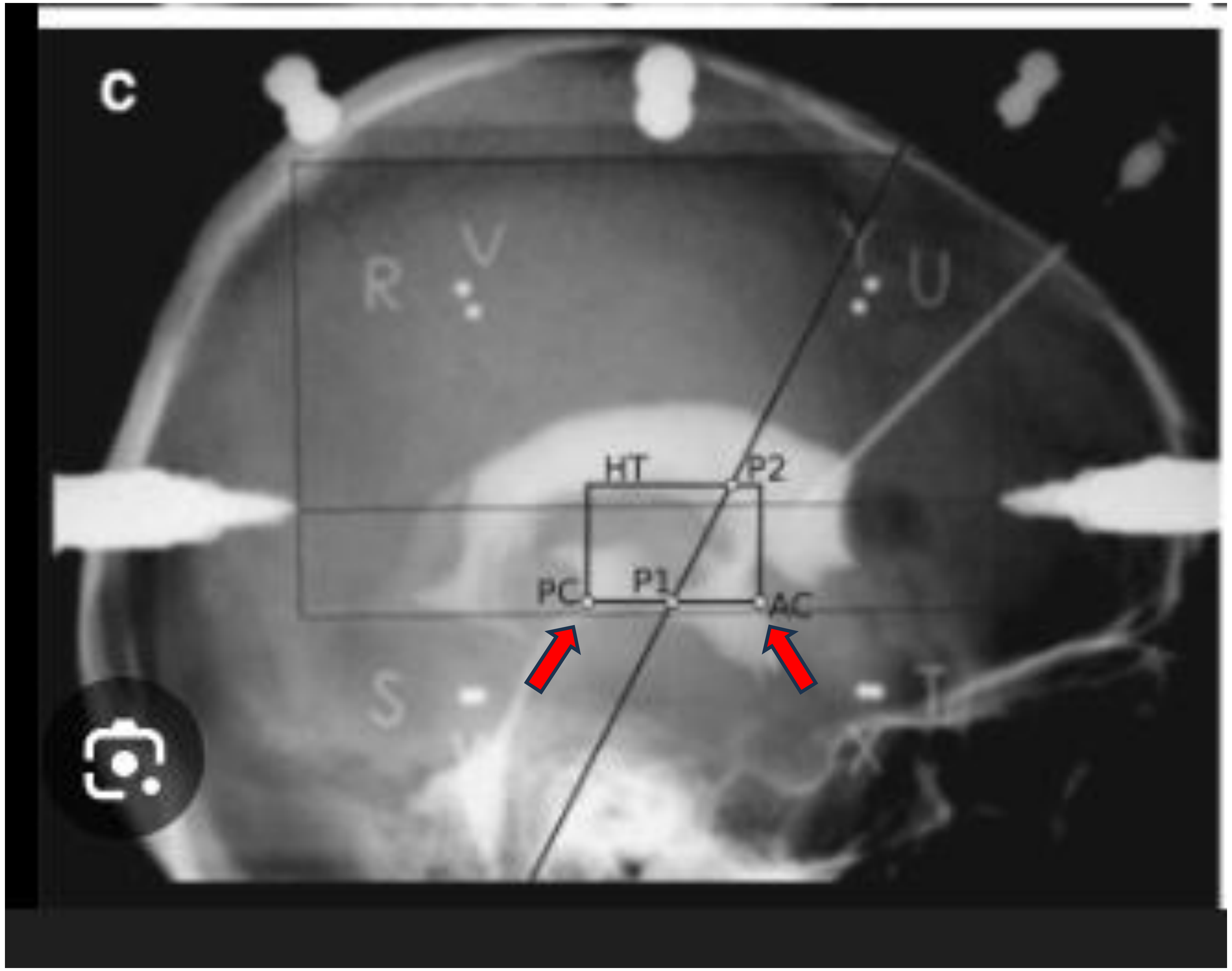
either side). After the cast has hardened, large windows are cut in its top (field of operation) and in the frontal and temporoparietal regions (for X-ray photography of the pineal body and of the region of the thalamus). It is important that the ring with the cast can be easily removed from the skull and reapplied during operation in exactly the same position as before operation.

(2) An X-ray picture is taken with the apparatus in situ

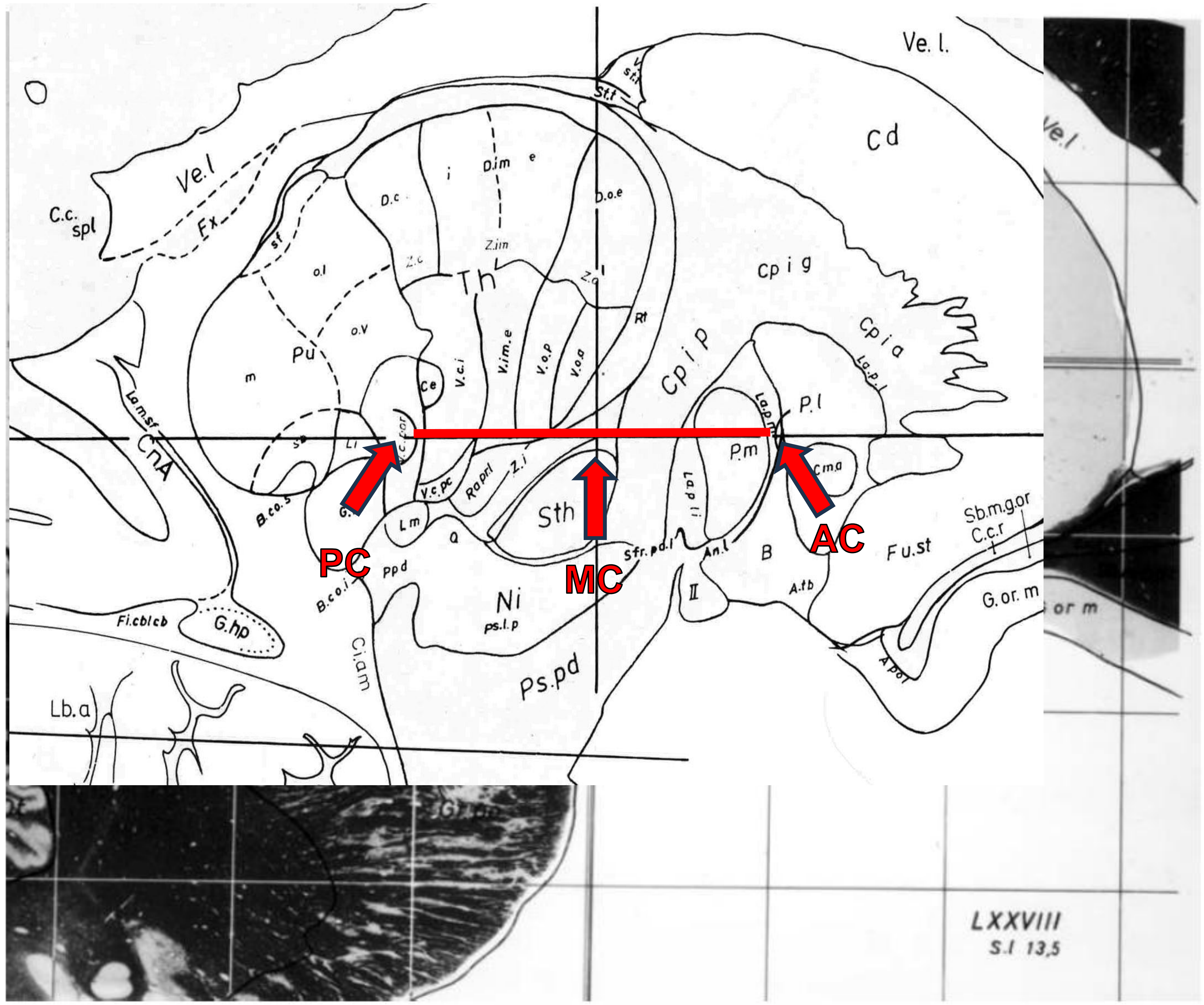
ꜱCIENCE, October 10, 1947 349

Spiegel and Wycis





C
R
V
U
HT
P2
PC
P1
AC
S



PC
MC
AC
Ve. l.
Cd
Th
Sth
Ni
Pu
Ps.pd
LXXVIII
S.l 13,5

TABLE 1: Target-derived coordinates*

Target Nucleus	Coordinates†	Corresponding Target
STN		center of motor territory of STN
vertical	−4 mm	
lat	12 mm	
AP	−3/−4 mm	
GPI		inf border of motor territory of GPI, immediately sup to optic tract
vertical	−5 mm	
lat	18 mm from lat ventricular wall	
AP	+2 mm	
VIM		labial commissure of VIM
vertical	0 or −1 mm	
lat	50% of AC-PC distance but should be <12 mm of lat ventricular wall	
AP	25–30% of AC-PC distance anterior to PC	

* The GPI and STN targets were visualized directly, and the VIM target was derived from the Schaltenbrand and Wahren atlas, utilizing the intercommissural plane and midcommissural point for reference. AC-PC = anterior commissure–posterior commissure; AP = anteroposterior; inf = inferior; sup = superior.

† Negative vertical values indicate the inferior; negative AP values indicate the posterior.

Burchiel et al. J Neurosurg. 2013;119:301-6.

Letter | Published: 09 May 1964

A Rugged, Reliable and Sterilizable Microelectrode for recording Single Units from the Brain

MER

ELWIN MARG

No. 4932 May 9, 1964 NATURE 601

Table 1. Average Daily Intake of an 'Amino-acid Imbalanced' Diet by Rats pre-fed Diets containing Various Amounts of Protein

Group	I	II	III	IV	V	VI	VII
Pre-fed diet	*L*1	*L*5	*L*6	*P*20	*P*40	*P*60	*P*80
Average g/day/animal on 'pre-fed' diet							
Days 1–3	16·4	9·9	16·0	17·4	17·7	17·6	12·9
Days 4–6	16·4	11·3	18·3	17·5	17·5	16·3	15·5
Average g/day/animal on 'leucine imbalanced' diet *L*5							
Days 7–9	9·9	14·1	11·1	11·3	15·5	16·9	18·0
Days 10–12	11·0	12·7	7·8	11·4	15·6	17·7	14·1
Days 13–15	13·9	14·7	12·4	15·3	15·3	13·7	12·6

for each group for both the 'pre-fed' diet and the 'high leucine' diet *L*5.

Pre-feeding diets high in protein clearly acts to alleviate the stress of a subsequent amino-acid load. The animals which received diets containing 40, 60 and 80 per cent casein did not exhibit the sharp decline in food intake and body-weight during the first three days on diet *L*5 that was observed in those animals pre-fed the diets with lower protein contents.

Rats fed on a diet high in leucine are known to 'adapt' to this diet after 4 or 5 days, and thereafter to resume near-normal growth. This phenomenon was observed in Groups I–IV. The food intakes of the 'adapted' animals, in these groups, all pre-fed the diets with relatively low

This work was supported in part by a grant-in-aid from the U.S. Public Health Service National Institutes of Health, *NB*–01941, and by the Fund for Research and Teaching of the Department of Nutrition, Harvard School of Public Health, Boston, Mass.

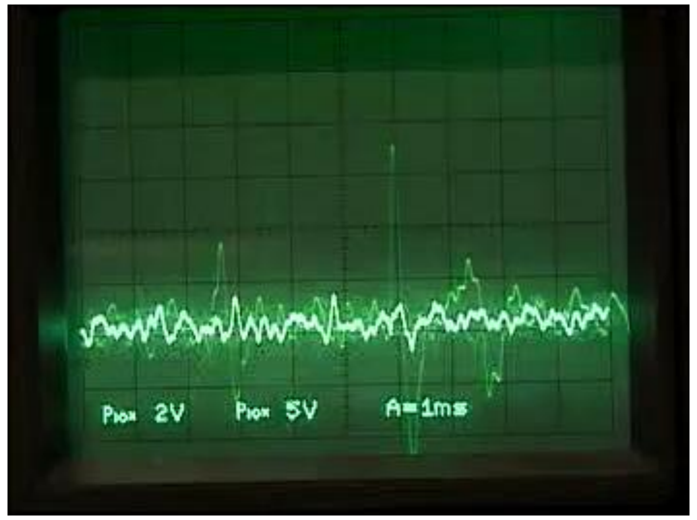
Ronald M. Krauss
Jean Mayer

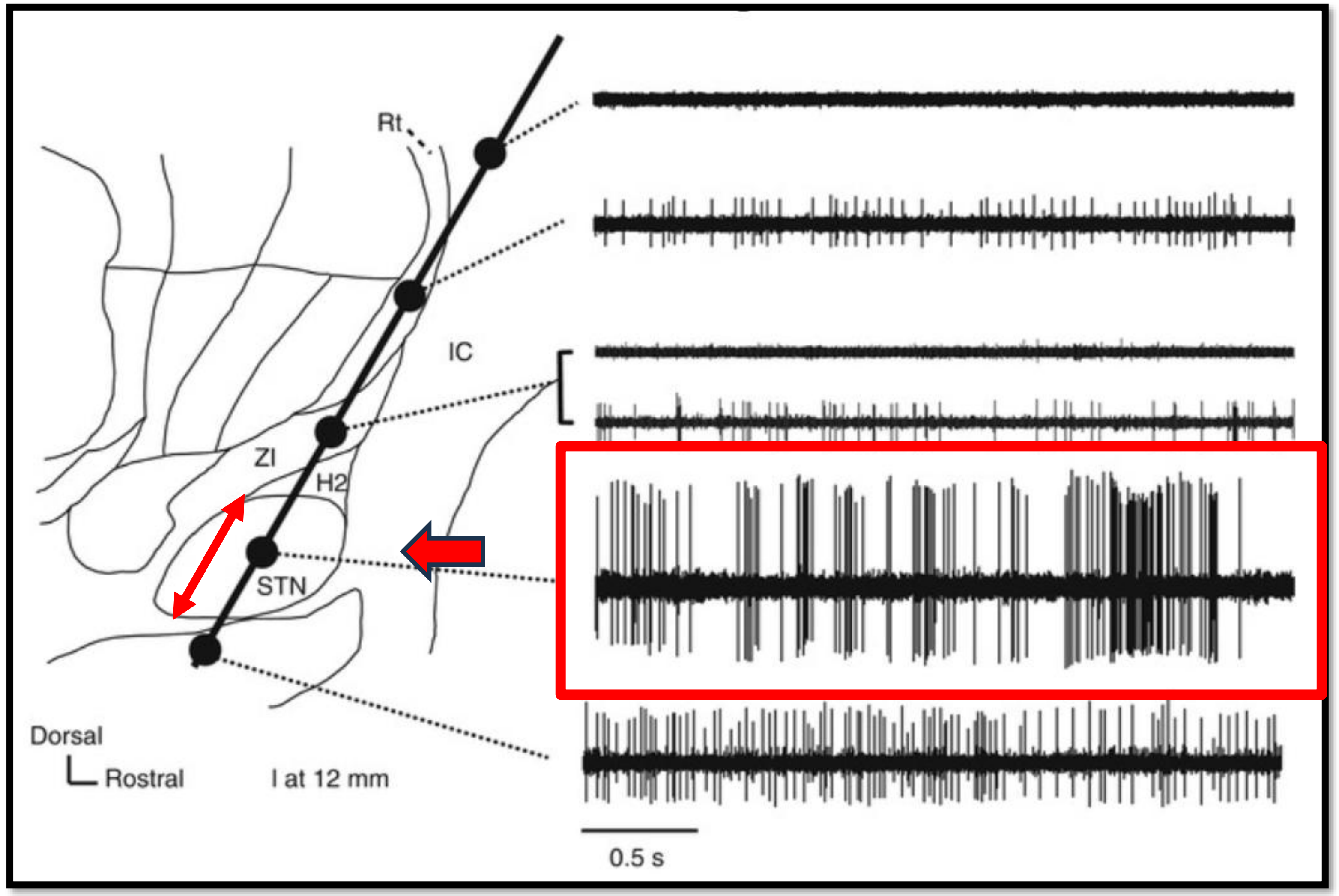
Department of Nutrition,
Harvard University School of Public Health,
Boston, Mass.

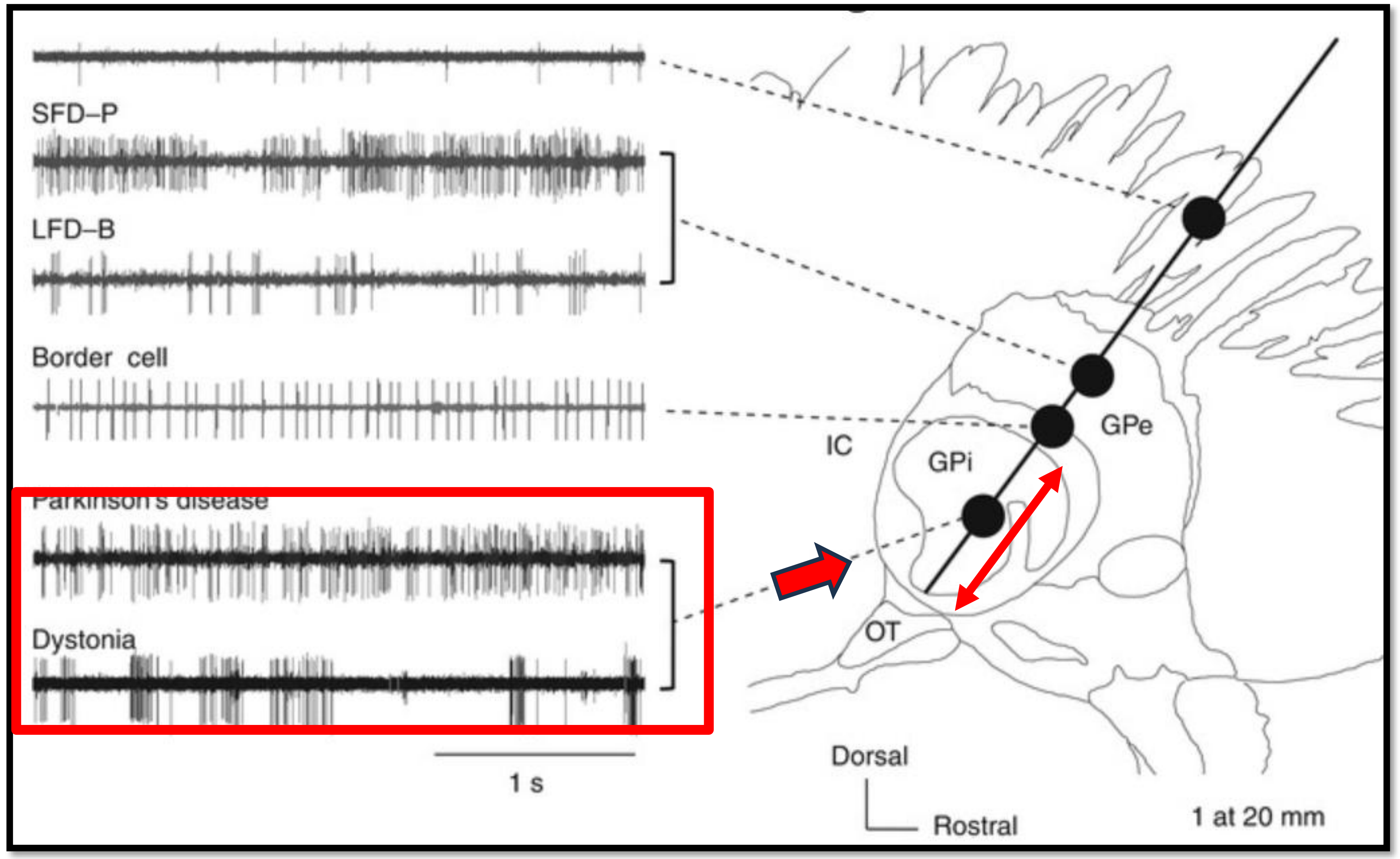
[1] Harper, A. E., Benton, D. A., and Elvehjem, C. A., *Arch. Biochem. Biophys.*, **57**, 1 (1955).
[2] Spolter, P. D., and Harper, A. E., *Amer. J. Physiol.*, **200**, 513 (1961).
[3] Krauss, R. M., and Mayer, J., *Nature*, **200**, 1213 (1963).

A Rugged, Reliable and Sterilizable Microelectrode for recording Single Units from the Brain

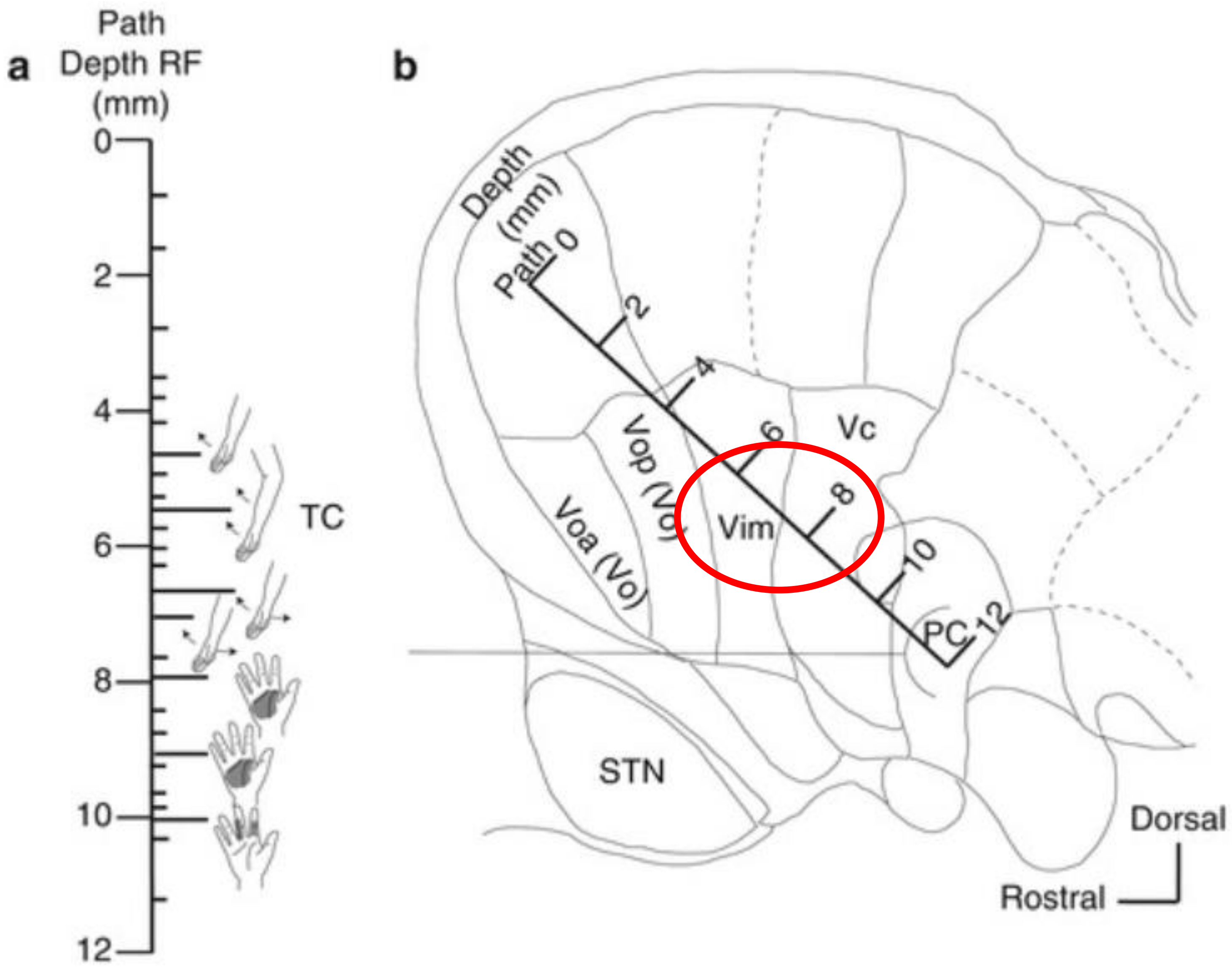
Metal microelectrodes suitable for recording externally from single cells have been reported by various authors[1–7]. None of them meets our requirements for a rugged and

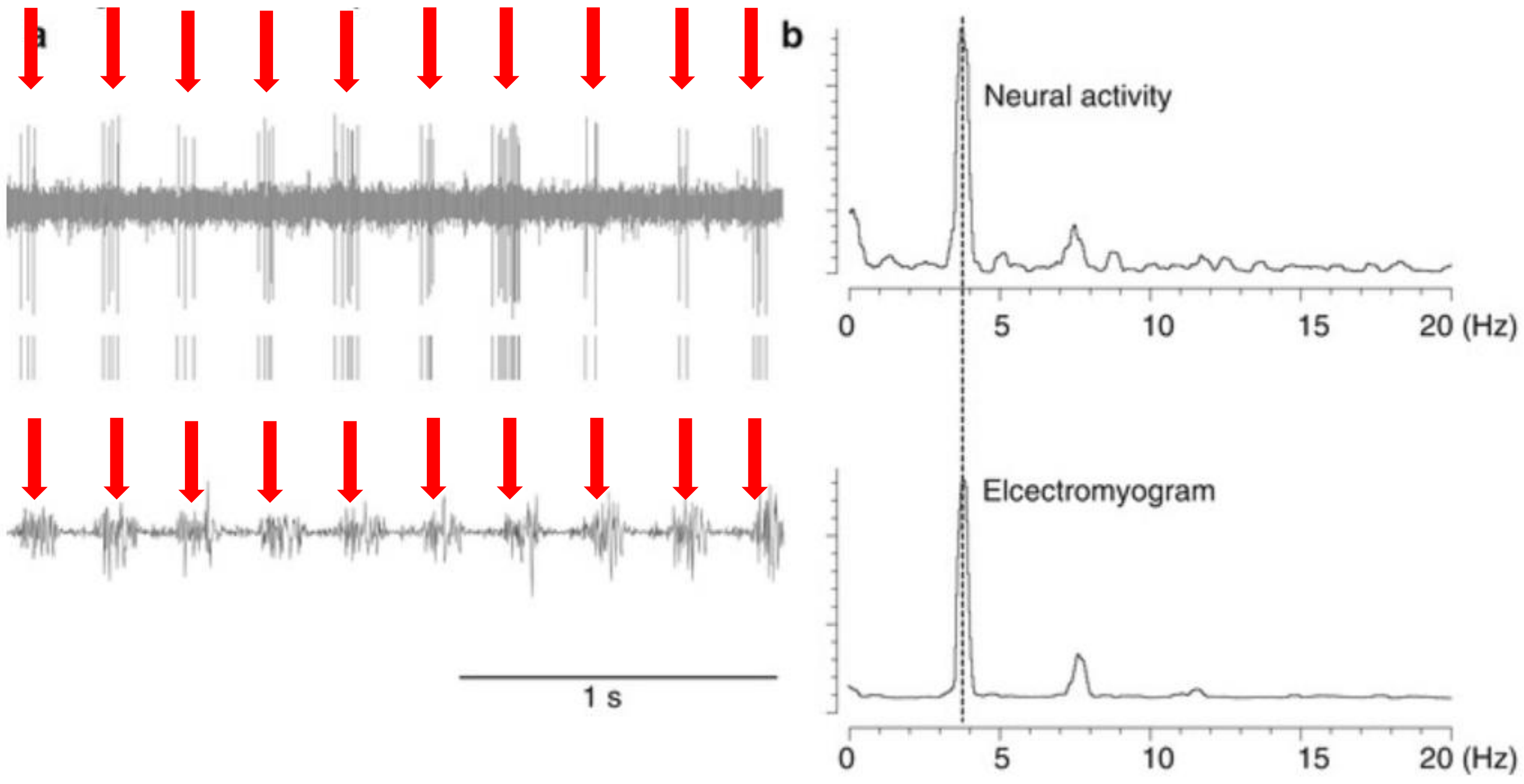






https://neupsykey.com/intraoperative-microelectrode-recording/

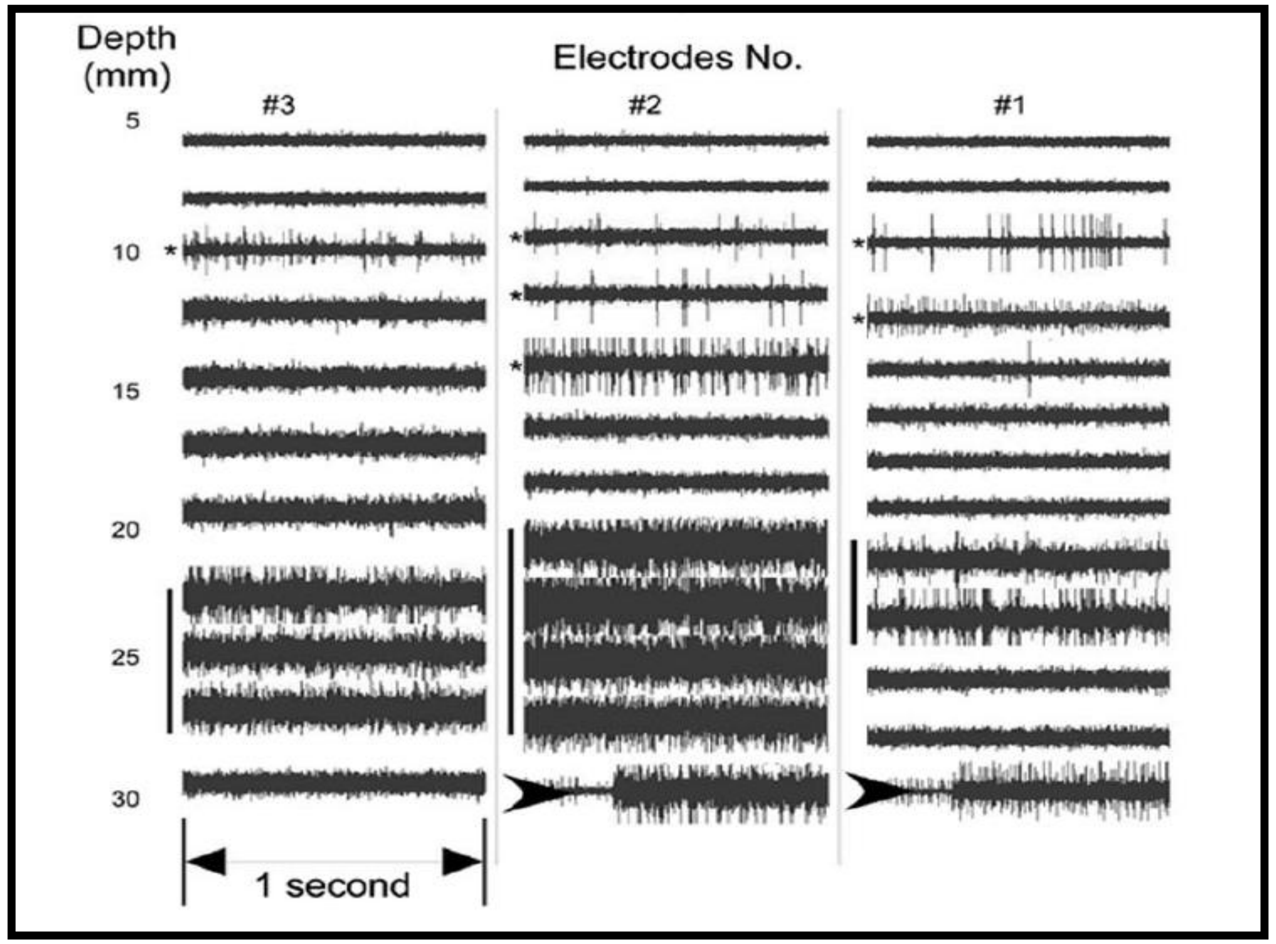




https://neupsykey.com/intraoperative-microelectrode-recording/

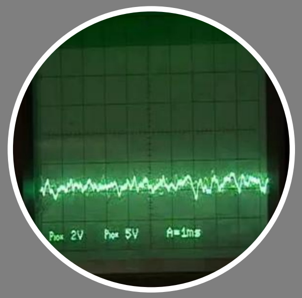
Microelectrode recording (MER)

- Confirms target location
- Defines target length
- Detects motor/sensory-driven neuronal activity



Navigation

- Radiographic Target



MER

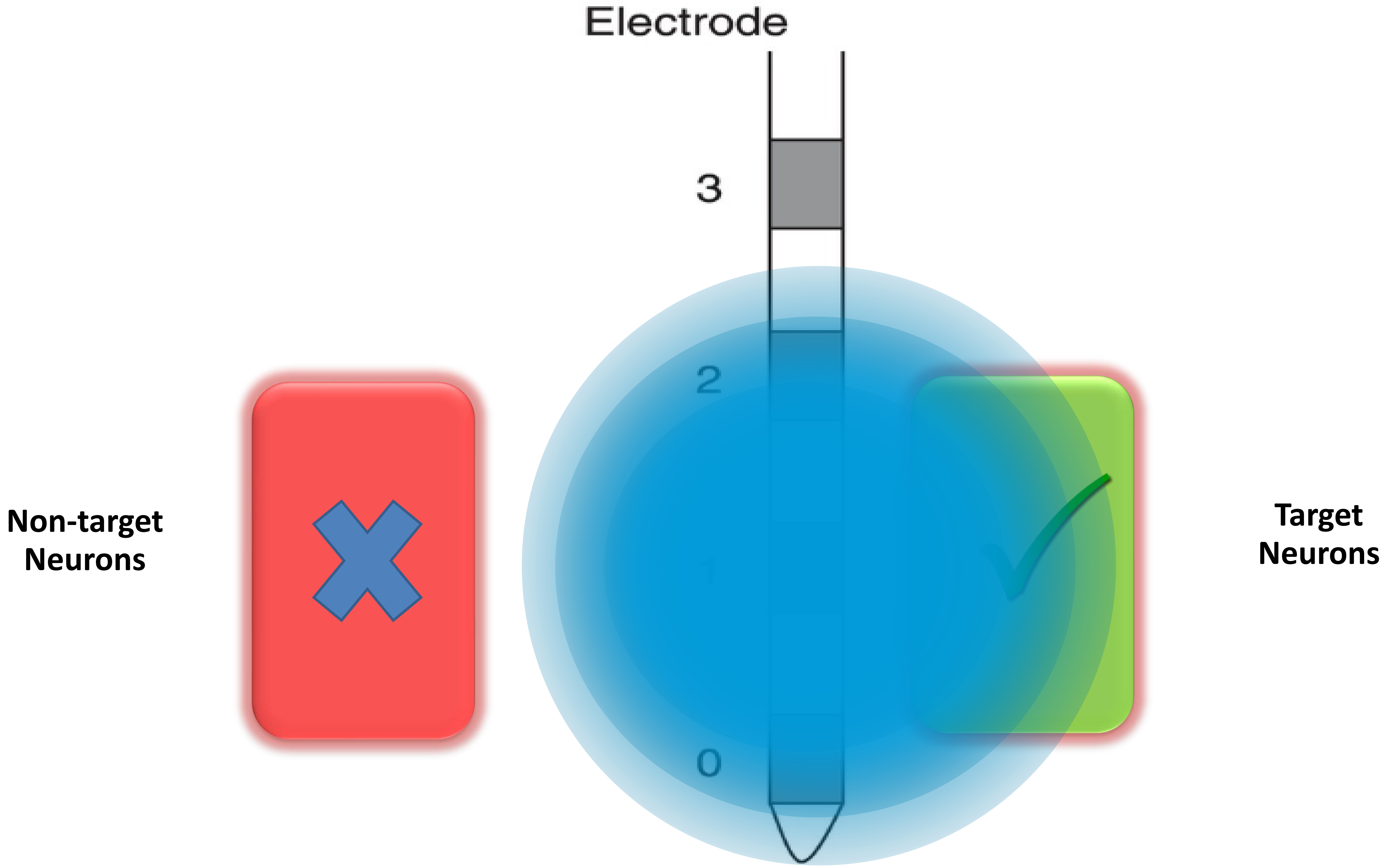
- Physiologic Target
- Target thickness
- Motor/Sensory driven neuronal activities

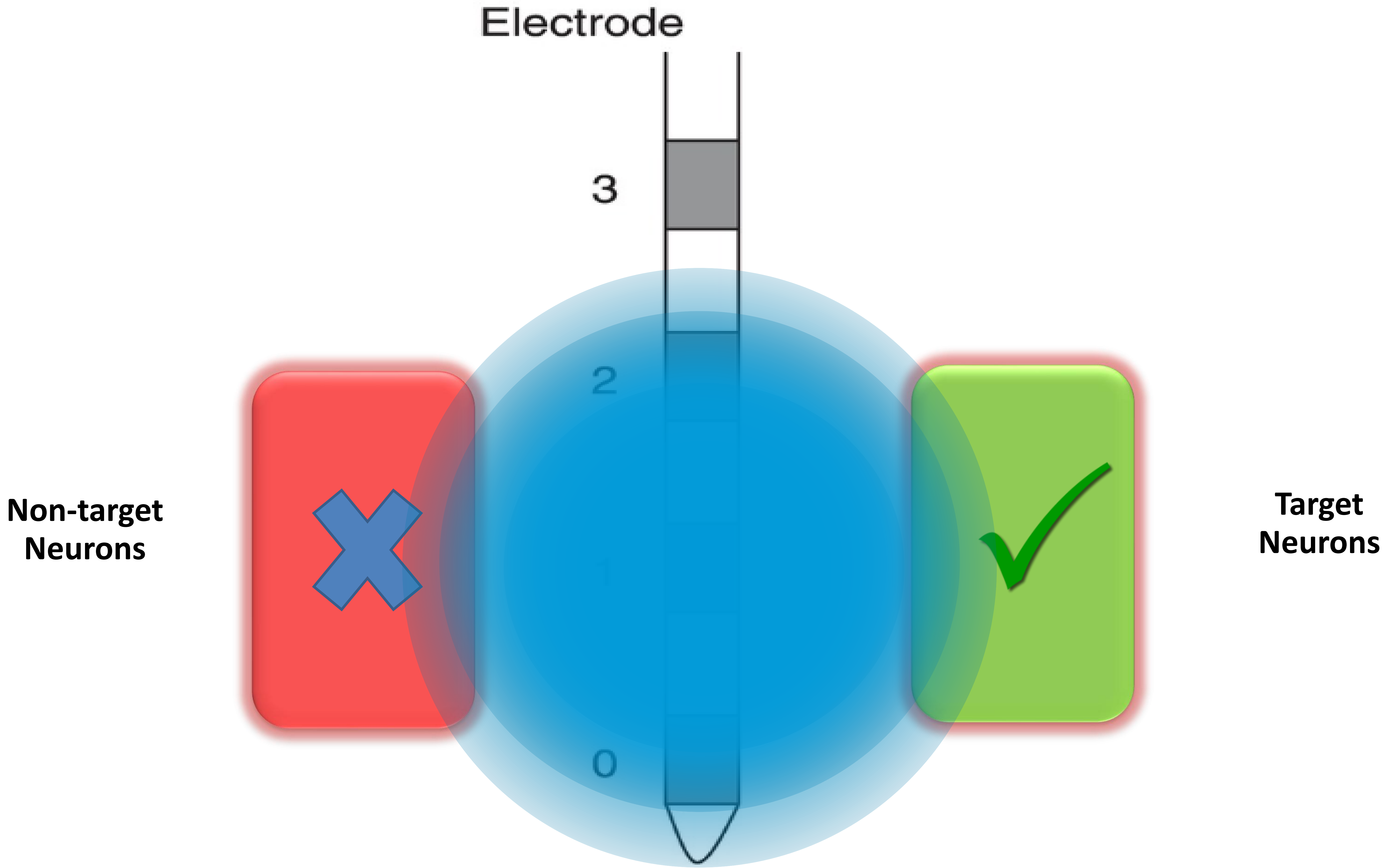
Stimulation Benefit

- Benefit yes/no
- Benefit threshold

Stimulation Side Effect

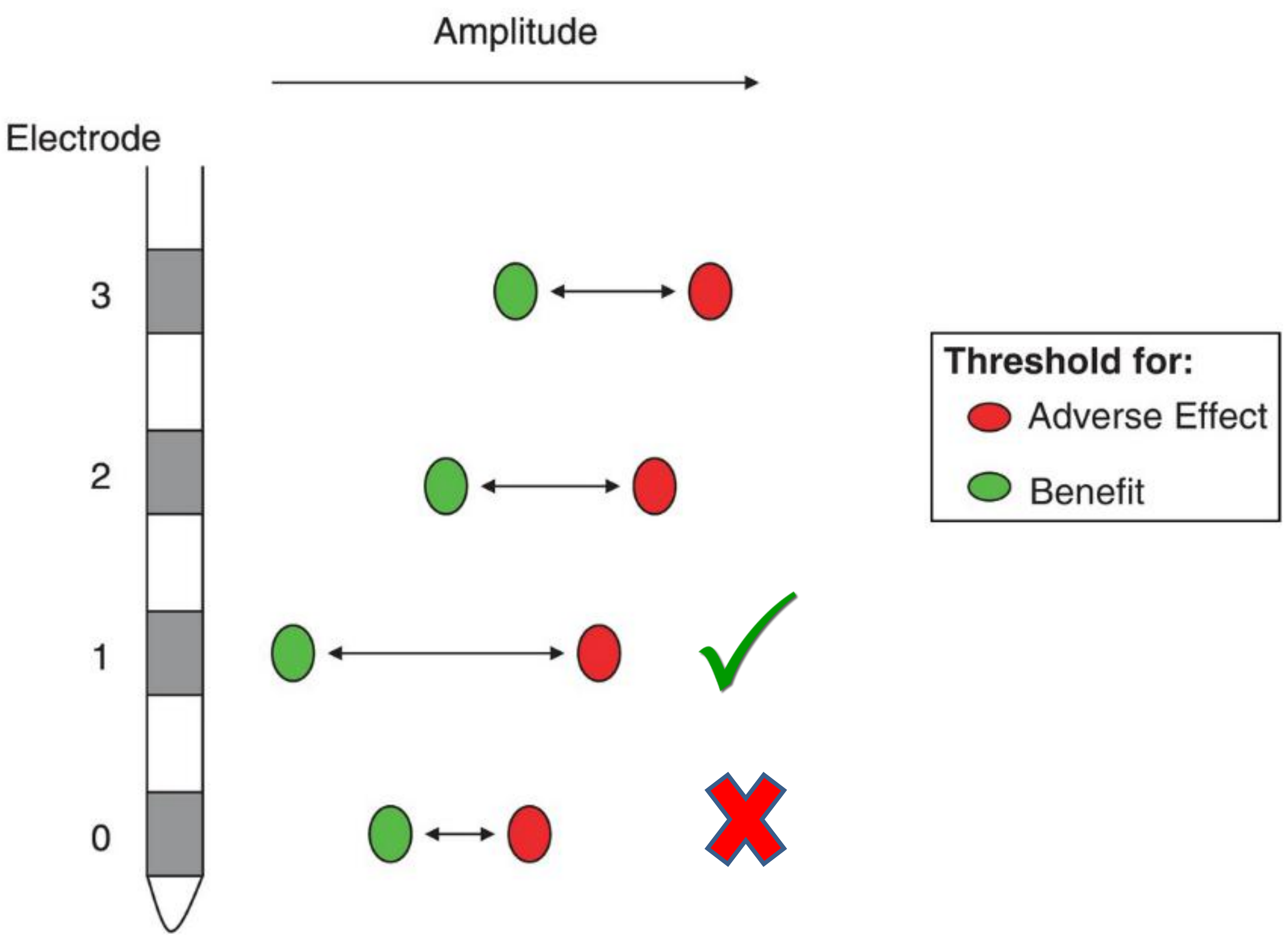
- Side effect (SE) yes/no
- SE threshold

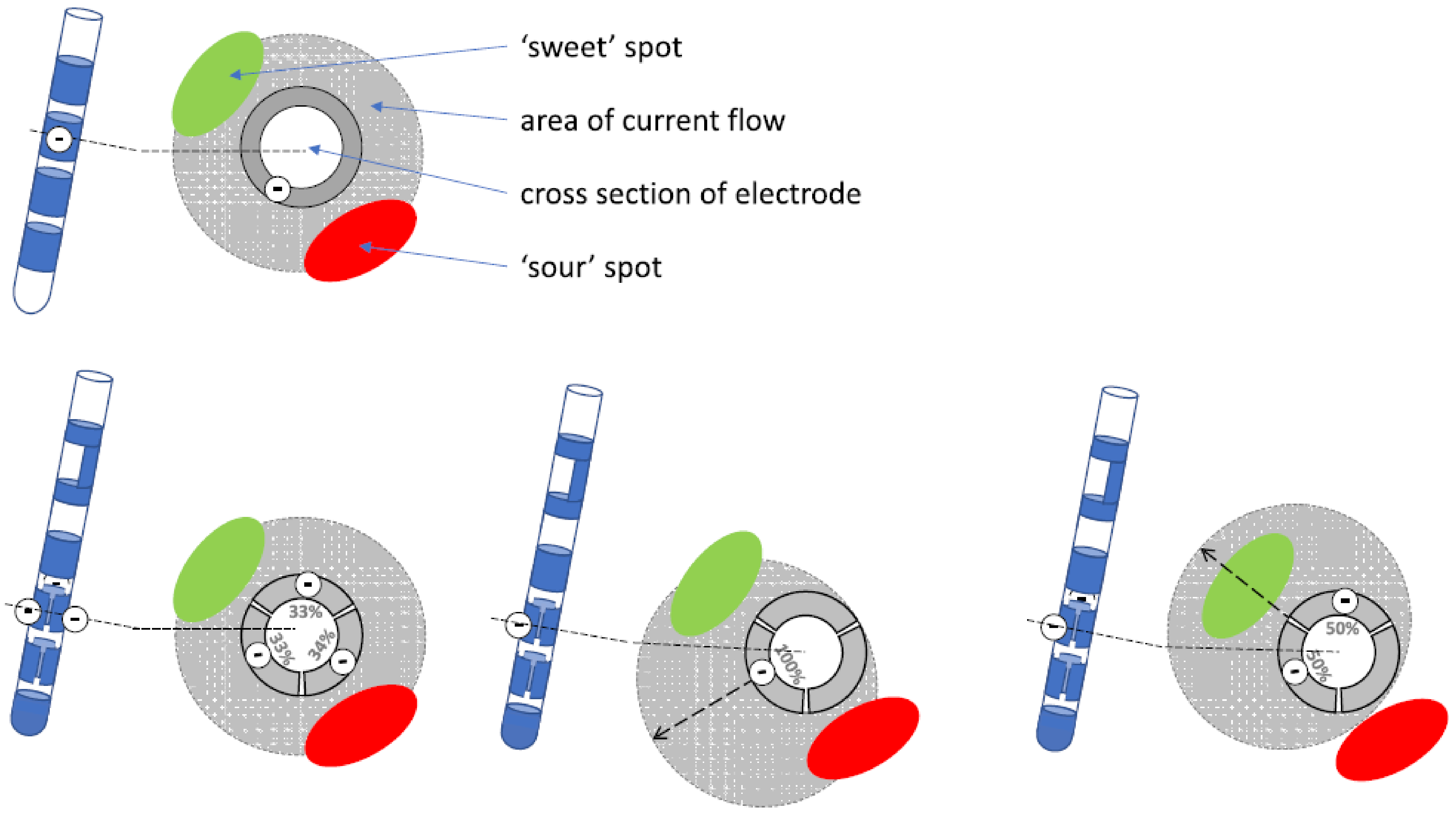

Electrode
3
2
0
Non-target Neurons
Target Neurons


Electrode
3
2
0
Non-target
Neurons
Target
Neurons

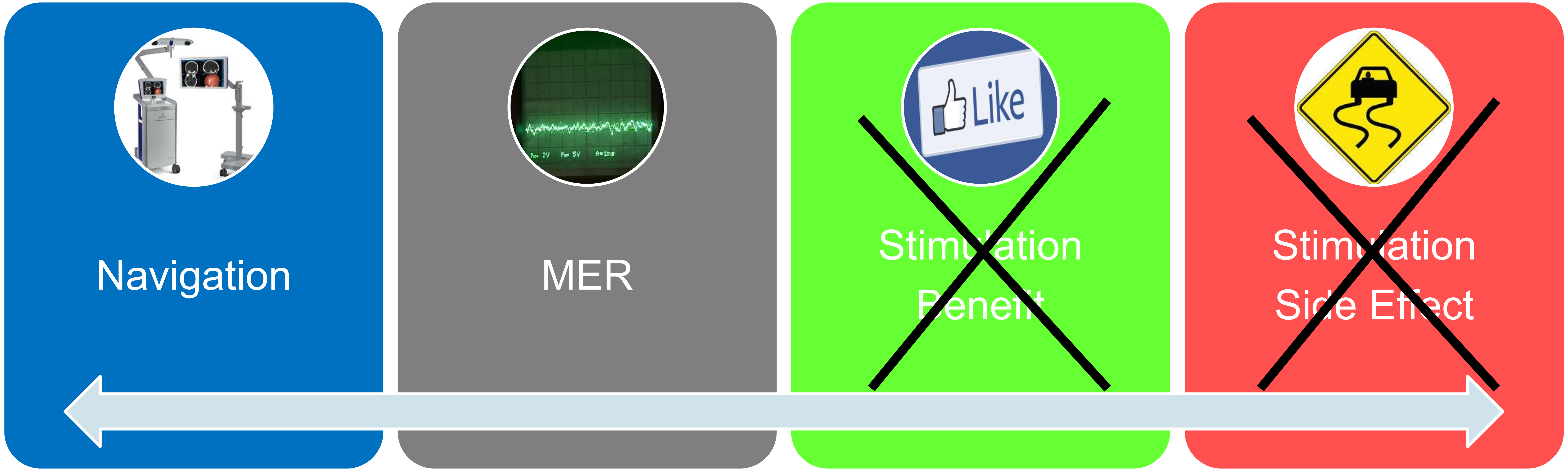
Thresholds

Electrode 1 has the largest therapeutic window





Steigerwald et al. Neurotherapeutics. 2019;16:100-104.



- Radiographic Target

- Physiologic Target
- Target thickness
- Motor/Sensory driven neuronal activities

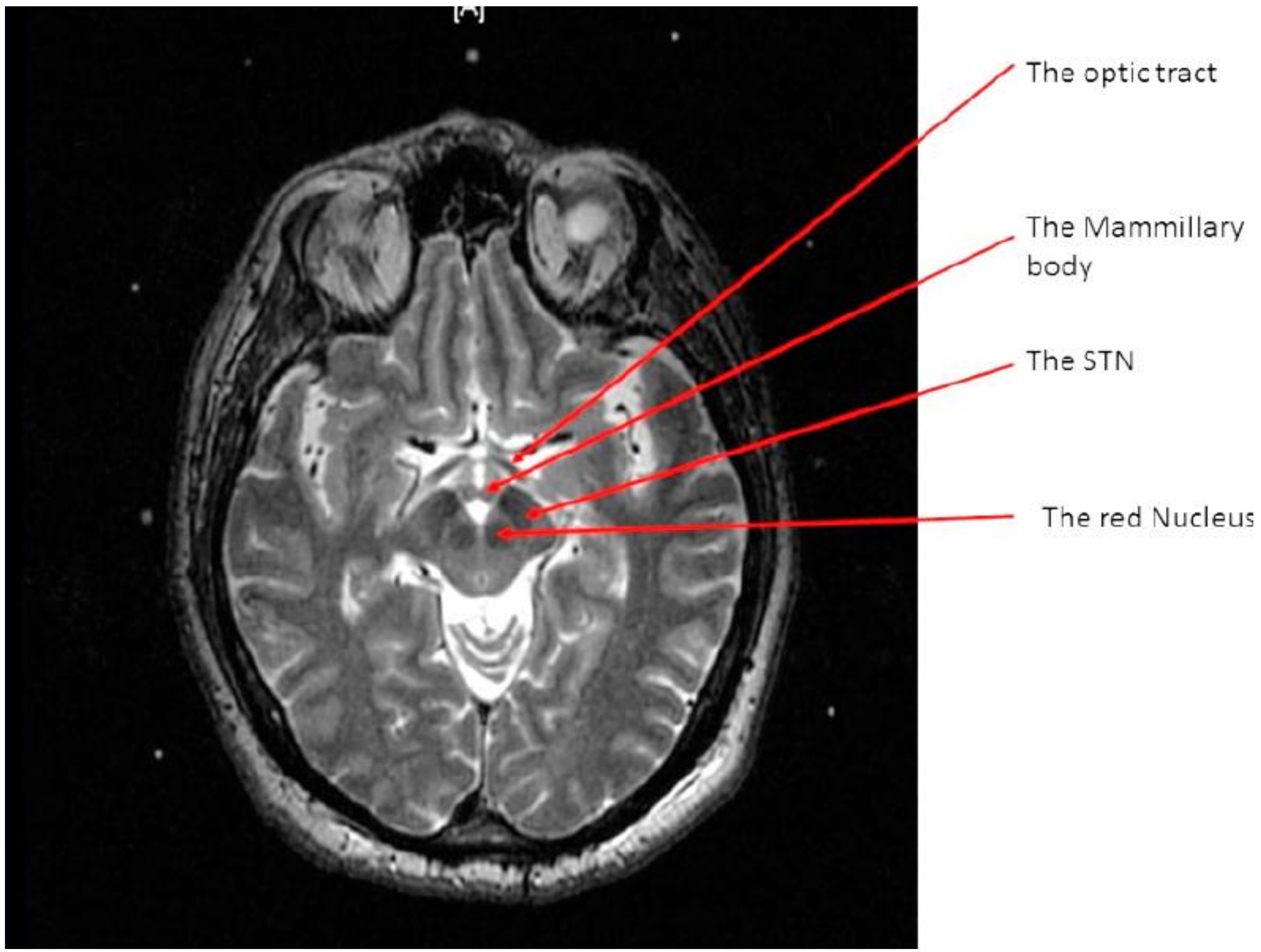
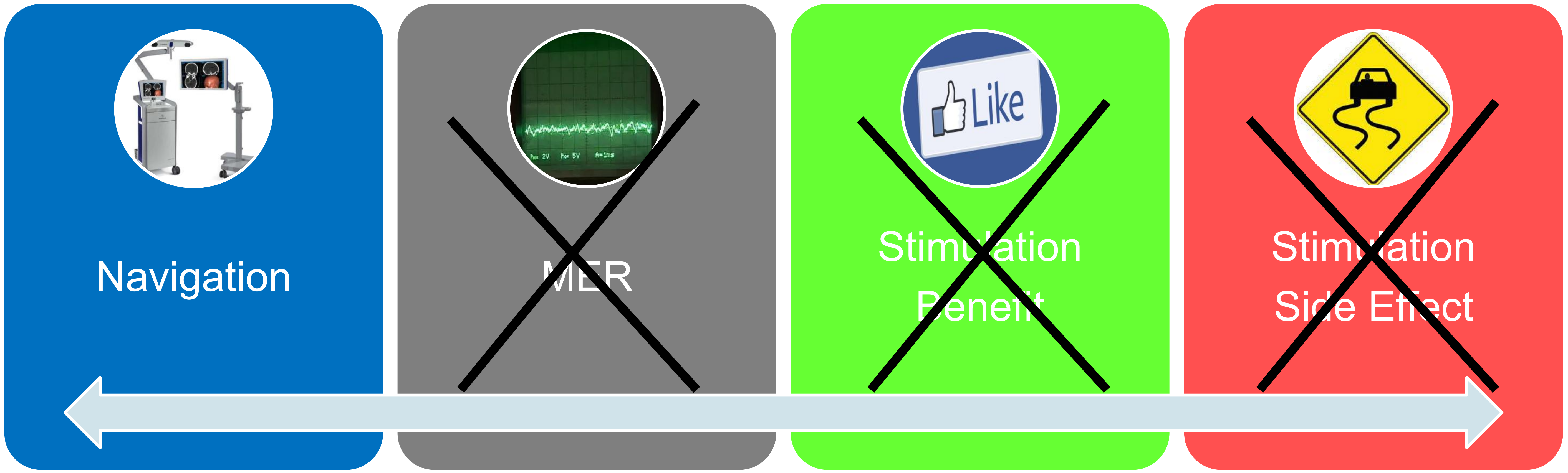


Image guided

- Based on imaging alone
- May include AI/software assistance



- Radiographic Target

Neurophysiologic guided	Imaged guided
• Limited neuroimaging	• Advanced neuroimaging
• Target localized indirectly by "general" formula	• No need for FINE TUNING
• Neurophysiologic testing provides "FINE TUNING"	• Shorter operative time
	• Greater patient comfort
	• Lower risk of hemorrhage
• Physiologic variation in targets "EXISTS"!!!!!	

Clinical Outcome of Subthalamic Stimulation in Parkinson's Disease is Improved by Intraoperative Multiple Trajectories Microelectrode Recording

Christiane Reck[1] Mohammad Maarouf[2] Lars Wojtecki[3,4] Stefan Jun Groiss[3,4] Esther Florin[1,6]
Volker Sturm[2] Gereon R. Fink[1,5] Alfons Schnitzler[3,4] Lars Timmermann[1]

Results We found a significantly better clinical outcome (Unified Parkinson's Disease Rating Scale [UPDRS] III) in patients undergoing MER compared with non-MER patients. In MER patients, DBS electrode placement was performed using the central trajectory in 73%. Another than the central trajectory was taken in 27% of the patients. No difference

Reck et al. J Neurol Surg A Cent Eur Neurosurg. 2012;73(6):377-86

JAMA Neurology | Original Investigation

General Anesthesia vs Local Anesthesia in Microelectrode Recording–Guided Deep-Brain Stimulation for Parkinson Disease

The GALAXY Randomized Clinical Trial

Rozemarije A. Holewijn, MD; Dagmar Verbaan, PhD; Pepijn M. van den Munckhof, MD, PhD;
Maarten Bot, MD, PhD; Gert J. Geurtsen, PhD; Joke M. Dijk, MD, PhD; Vincent J. Odekerken, MD, PhD;
Martijn Beudel, MD, PhD; Rob M. A. de Bie, MD, PhD; P. Rick Schuurman, MD, PhD

Table 3. Secondary Outcome Measurements

Outcome	Baseline	
	Local anesthesia (n = 56)	General anesthesia (n = 54)
No. of MER tracks left + right side (tracks: patients)		
2	3	1
3	1	0
4	20	19
5	3	4
6	28	30

Holewijn et al. JAMA Neurol. 2021;78(10):1212-19.

Contents lists available at ScienceDirect

Journal of Clinical Neuroscience

journal homepage: www.elsevier.com/locate/jocn

Clinical study

Intraoperative microelectrode recording in Parkinson's disease subthalamic deep brain stimulation: Analysis of clinical utility

Maria Inês Soares [a], Ricardo Soares-dos-Reis [a,c,d,e], Maria José Rosas [b,c], Pedro Monteiro [a,b], João Massano [a,b,c,*]

[a] Department of Clinical Neurosciences and Mental Health, Faculty of Medicine University of Porto, Porto, Portugal
[b] Movement Disorders and Functional Surgery Unit, Centro Hospitalar Universitário de São João, Porto, Portugal
[c] Department of Neurology, Centro Hospitalar Universitário de São João, Porto, Portugal
[d] Department of Biomedicine, Faculty of Medicine University of Porto, Porto, Portugal
[e] i3S – Institute for Research and Innovation in Health, Porto, Portugal

Table 2
Best microelectrode recordings, best intraoperative clinical results, and final electrode trajectory for first brain side (A) and second brain side (B).

A
First side

MER			Clinical Results			Final Position		
Anterior	Central	Lateral	Anterior	Central	Lateral	Anterior	Central	Lateral
16 (18%)	41 (46%)	32 (36%)	31 (35%)	39 (44%)	19 (21%)	31 (35%)	40 (45%)	18 (20%)

B
Second side

MER			Clinical Results			Final Position		
Anterior	Central	Lateral	Anterior	Central	Lateral	Anterior	Central	Lateral
26 (29%)	27 (30%)	37 (41%)	39 (24%)	31 (34%)	22 (24%)	38 (41%)	32 (35%)	22 (24%)

Soares et al. J Clin Neurosci. 2019;69:104-8.

BRITISH JOURNAL OF NEUROSURGERY
https://doi.org/10.1080/02688697.2021.2019677

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ORIGINAL ARTICLE

Placement accuracy of the second electrode in bilateral deep brain stimulation surgery

Krishnapundha Bunyaratavej[a], Onanong Phokaewvarangkul[b] and Piyanat Wangsawatwong[a]

[a]Division of Neurosurgery, Department of Surgery, Faculty of Medicine, Chulalongkorn University and King Chulalongkorn Memorial Hospital, Thai Red Cross Society, Bangkok, Thailand; [b]Chulalongkorn Center of Excellence for Parkinson's Disease and Related Disorders, Division of Neurology, Department of Medicine, Faculty of Medicine, Chulalongkorn University, Bangkok, Thailand

Table 1. Comparison between the first and second electrodes.

	First	Second	*p* Value
Number of MER passes, *n* (%)			
1	32 (58.2)	34 (61.8)	0.467
2	6 (10.9)	9 (16.4)	
≥3	17 (30.9)	12 (21.8)	
Final track, *n* (%)			
Center	40 (72.7)	36 (65.5)	0.773
Medial	6 (10.9)	11 (20.0)	
Lateral	4 (7.3)	4 (7.3)	
Anterior	2 (3.6)	1 (1.8)	
Posterior	1 (1.8)	2 (3.6)	
Mixed	2 (3.6)	1 (1.8)	

Bunyaratavej et al. Br J Neurosurg. 2021:1-8.

Research paper

EDITOR'S CHOICE

MRI-guided STN DBS in Parkinson's disease without microelectrode recording: efficacy and safety

T Foltynie,[1] L Zrinzo,[1,2] I Martinez-Torres,[3] E Tripoliti,[1] E Petersen,[4] E Holl,[1,5] I Aviles-Olmos,[1] M Jahanshahi,[1] M Hariz,[1,6] P Limousin[1]

J Neurol Neurosurg Psychiatry:

See Editorial Commentary,

ABSTRACT

improve safety and/or efficacy of the procedure for

All electrodes were implanted by means of a single brain penetration, except one electrode where two passes were needed. The median perpendicular targeting error between intended

156 leads-1 adjustment (0.6%)

frontiers in Neurology

ORIGINAL RESEARCH
published: 11 April 2018
doi: 10.3389/fneur.2018.00241

Check for updates

Outcomes of Interventional-MRI Versus Microelectrode Recording-Guided Subthalamic Deep Brain Stimulation

*Philip S. Lee[1], Gregory M. Weiner[1], Danielle Corson[1], Jessica Kappel[2], Yue-Fang Chang[1], Valerie R. Suski[2], Sarah B. Berman[2], Houman Homayoun[2], Amber D. Van Laar[2], Donald J. Crammond[1] and R. Mark Richardson[1,3]**

These two groups of patients, therefore, were combined for all subsequent analyses. All iMRI patients had leads placed in the planned trajectory.

42 leads-no adjustment

JNS

CLINICAL ARTICLE

J Neurosurg 129:1572–1578, 2018

Deep brain stimulation outcomes in patients implanted under general anesthesia with frame-based stereotaxy and intraoperative MRI

Caio M. Matias, MD, PhD,[2] Leonardo A. Frizon, MD,[1] Sean J. Nagel, MD,[1] Darlene A. Lobel, MD,[1] and André G. Machado, MD, PhD[1]

[1]Center for Neurological Restoration, Cleveland Clinic Neurological Institute, Cleveland, Ohio; and [2]Ribeirão Preto Medical School, University of São Paulo, Ribeirão Preto, São Paulo, Brazil

these patients, the lead was removed and replaced after correcting for the error. There was an error of 3.0 mm lateral to the intended target in one case, and an error of 2.5 mm medial and 1.0 mm posterior to the planned target in the other case. Lead revision was not deemed necessary in

64 leads- 2 adjustments (3%)

COMPARISON

Primary outcome

- UPDRS III (II, IV)
- Levodopa equivalent daily dose (LEDD)
- Quality of Life

Secondary outcome

- Lead accuracy
- OR time
- Hemorrhage
- Lead revision

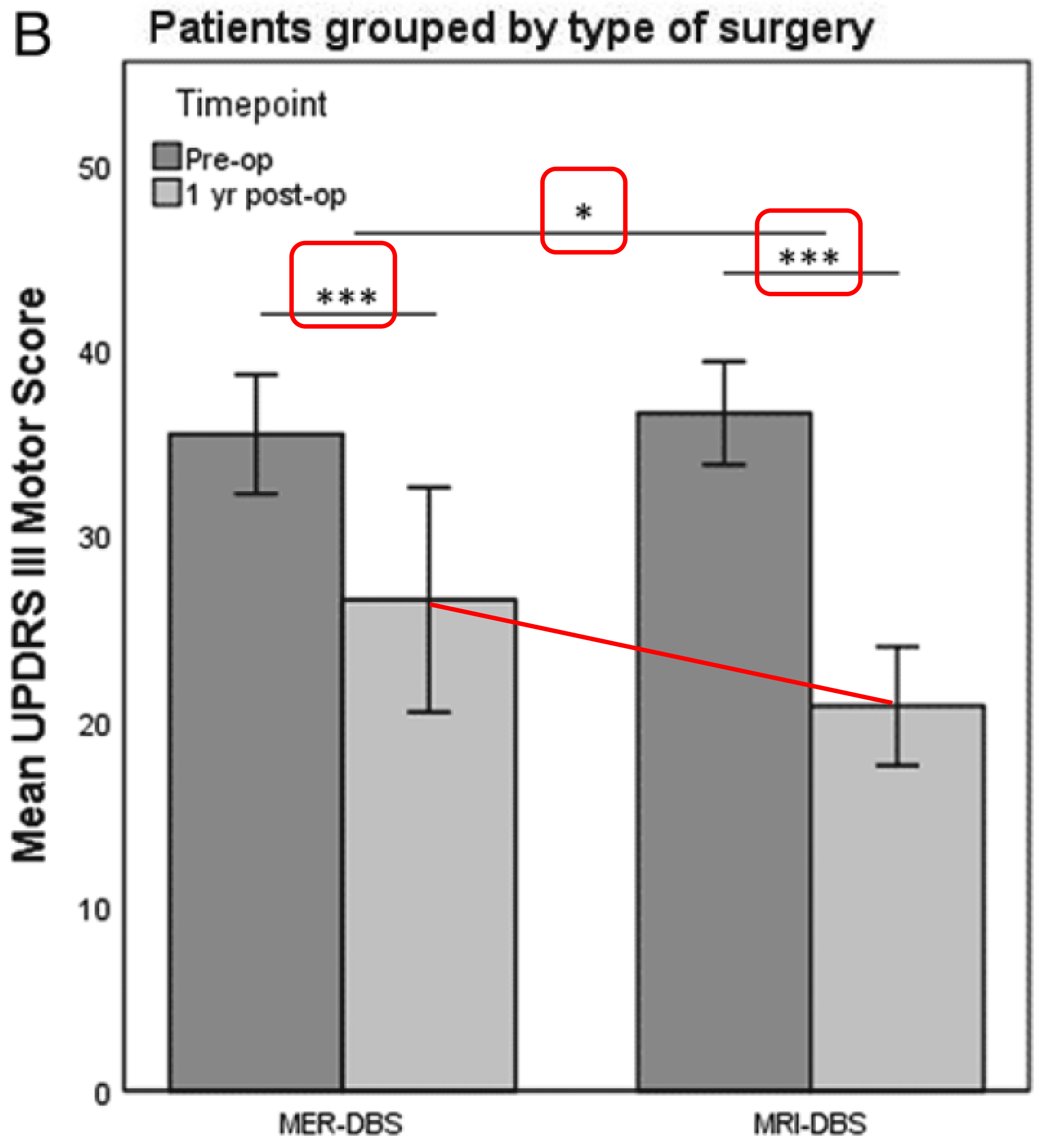

MER
IMAGE
VS
MER
IMAGE

PRIMARY OUTCOME

JNS
CLINICAL ARTICLE
J Neurosurg 134:1072–1082, 2021

Clinical outcomes of globus pallidus deep brain stimulation for Parkinson disease: a comparison of intraoperative MRI– and MER-guided lead placement

*Yarema B. Bezchlibnyk, MD, PhD,[1,2] Vibhash D. Sharma, MD,[3,4] Kushal B. Naik, MBBS, MPH,[5] Faical Isbaine, PhD,[2] John T. Gale, PhD,[2] Jennifer Cheng, MD,[2,6] Shirley D. Triche, NP,[4] Svjetlana Miocinovic, MD, PhD,[4] Cathrin M. Buetefisch, MD, PhD,[4] Jon T. Willie, MD, PhD,[2,4] Nicholas M. Boulis, MD,[2] Stewart A. Factor, DO,[4] Thomas Wichmann, MD,[4] Mahlon R. DeLong, MD,[4] and Robert E. Gross, MD, PhD[2,4]



Bezchlibnyk et al. J Neurosurg. 2020;134(3):1072-82

CrossMark

"Asleep" Deep Brain Stimulation Surgery: A Critical Review of the Literature

Tsinsue Chen, Zaman Mirzadeh, Francisco A. Ponce

Table 2. Clinical Outcomes of Patients Who Underwent Asleep Deep Brain Stimulation for Parkinson Disease

Study	Follow-up (months)	Preoperative UPDRS—III Score (Off Medication)	Postoperative UPDRS—III Score*,†	Degree of Improvement	*P* Value	Preoperative LEDD (mg)	Postoperative LEDD (mg)	Degree of Improvement	*P* Value
Starr et al., 2010[20]	9	49 ± 13	19 ±14	60%	0.0001	NR	NR	NR	NR
Foltynie et al., 2011[19]	14	51.5 ± 14.9	23.8 ± 11.2	52%	0.0001	NR	NR	NR	NR
Nakajima et al., 2011[15]	12 ± 6.1	57.9 ± 16.6	27.3 ± 11.8	65%	0.0001	1505 ± 764	764 ± 435	49.2%	<0.01
Ostrem et al., 2013[16]	6 (14 patients)	44.5	22.5	49.44%	0.001	1337 ± 482	NR	24.7%	0.003
Saleh et al., 2015[14]	5.86 ± 1.15	NR	NR	NR	NR	NR	NR	49.27%	0.0031
Mirzadeh et al., 2016[21]	6	48.4 ± 13.8	28.9 ± 12.5	40.3%	<0.0001	1207 ± 482	1,035 ± 478	14%	0.004
Ostrem et al., 2016[18]	12	40.75 ± 10.9	24.35 ± 8.8	40.2%	0.001	1072.5 ± 392	828.25 ± 492	21.13%	0.046
Sidiropoulous et al., 2016[17]	13.5 ± 3.7	Total: 39.2 STN: 37.2 GPi: 41.2	Total: 22.2 STN: 41.2 GPi: 24.3	Total: 43.4% STN: 46.2% GPi: 41%	Total: 0.001 STN: 0.03 GPi: 0.06	STN: 1458 ± 653 GPi: 920 ± 439	STN: 1337± 733 GPi: 1,088 ± 457	STN: 8.3% GPi: −18.3%	STN: 0.7 GPi: 0.5

UPDRS-III, Unified Parkinson's Disease Rating Scale motor examination subscale; LEDD, levodopa equivalent daily dose; NR, not reported; STN, subthalamic nucleus; GPi, globus pallidus interna.
*Values are mean ± SD unless indicated otherwise.
†On stimulation, off medication state.

Chen et al. World Neurosurg. 2017;105:191-198.

ORIGINAL ARTICLE

Microelectrode Recording–Guided Versus Intraoperative Magnetic Resonance Imaging–Guided Subthalamic Nucleus Deep Brain Stimulation Surgery for Parkinson Disease: A 1-Year Follow-Up Study

Xuemeng Liu[1,2], Jibo Zhang[1,2], Kai Fu[1,2], Rui Gong[1], Jincao Chen[1], Jie Zhang[1,2]

MER Image

Table 3. Comparison of UPDRS-III and PDQ-39 Scores Preoperative and 1-Year Postoperative

	UPDRS-III (Motor Score)*				PDQ-39 SI†		
Group	**Baseline**	**DBS-Off**	**DBS-On**	**Improvement (%)**	**Preoperative***	**Postoperative‡**	**Improvement (%)**
Group A	40.7 ± 15.6	39.3 ± 13.2	13.7 ± 6.5	66.3 ± 13.5	47.9 ± 10.6	24.1 ± 9.4	49.7 ± 14.3
Group B	43.5 ± 12.7	41.0 ± 11.3	15.3 ± 5.2	64.8 ± 12.7	50.1 ± 11.3	28.0 ± 9.8	44.1 ± 12.7
P value (*t* test)				0.24			0.16

MER Image

Table 4. Comparison of LEDDs and MMSE Scores Preoperatively and 1-Year Postoperative

	LEDDs			MMSE		
Group	**Preoperative**	**Postoperative**	**Improvement (%)**	**Preoperative***	**Postoperative†**	**Improvement (%)**
Group A	1021.4 ± 213.1	524.3 ± 125.2	48.7 ± 10.1	28.9 ± 8.7	30.1 ± 9.1	4.2 ± 2.1
Group B	985.1 ± 154.3	424.9 ± 89.6	56.9 ± 12.0	27.3 ± 8.1	30.3 ± 9.0	11.1 ± 3.2
P value (*t* test)			0.32			0.43

Liu et al. World Neurosurg. 2017;107:900-5.

RESEARCH PAPER

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]

Table 3 DBS outcomes —pooled values

% improvement postoperatively	Awake			Asleep			Difference (p Value)*
	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
UPDRS IV 'off' med	307	78.4	9.3	80	59.7	16.2	**0.022**
LEDD	3893	47	26.6	444	45	12.8	0.752

This table details the percentage improvement in postoperative in DBS outcomes between awake and asleep cohorts including UPDRS II score in 'off' medication conditions, UPDRS III scores in both 'off' medication and 'on' medication conditions and levodopa equivalent doses of medications.

*Significant differences shown in boldface.

DBS, deep brain stimulation; LEDD, levodopa equivalent doses; LEDD, levodopa equivalent doses; n, total number of observations (patients); UPDRS, Unified Parkinson's Disease Rating Scale.

Ho et al. J Neurol Neurosurg Psychiatry. 2018;89(7):687-91.

Clinical Study

Stereotactic and Functional Neurosurgery

Stereotact Funct Neurosurg 2019;97:381–390
DOI: 10.1159/000505079

Received: September 19, 2019
Accepted after revision: November 22, 2019
Published online: January 21, 2020

General Anesthesia versus Local Anesthesia for Deep Brain Stimulation in Parkinson's Disease: A Meta-Analysis

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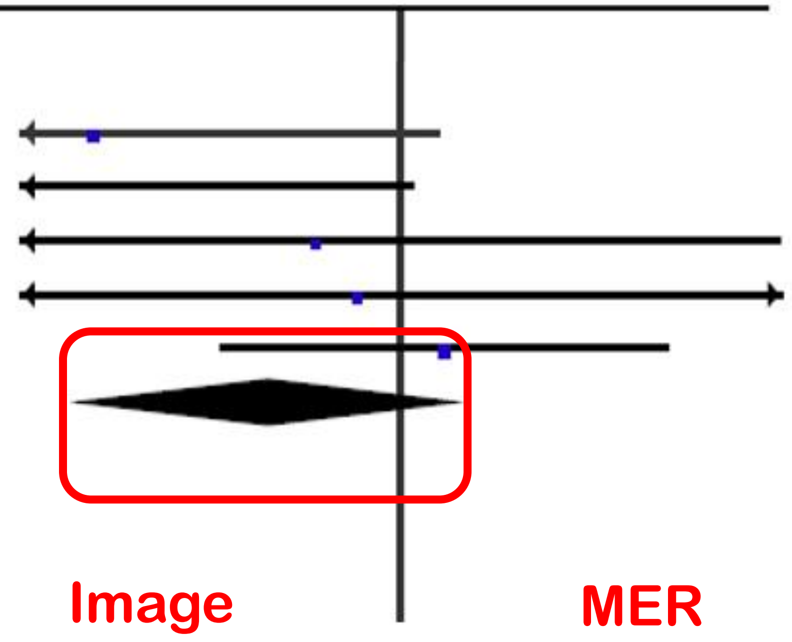
	General Anesthesia		Local Anesthesia			Odds Ratio
Study or Subgroup	Events	Total	Events	Total	Weight	M-H, Random, 95% CI
6.1.1 Adverse effects related to stimulation						
Chen, 2018	27	41	13	14	6.3%	0.15 [0.02, 1.25]
Lefranc 2017	6	13	8	8	3.5%	0.05 [0.00, 1.07]
Saleh, 2015	13	14	22	23	3.9%	0.59 [0.03, 10.27]
Sutcliffe, 2011	1	26	1	20	4.0%	0.76 [0.04, 12.95]
Tsai, 2019	14	22	8	14	11.6%	1.31 [0.33, 5.16]
Subtotal (95% CI)		**116**		**79**	**29.3%**	**0.44 [0.13, 1.49]**
Total events	61		52			

Heterogeneity: $\tau^2 = 0.57$; $\chi^2 = 5.67$, df = 4 ($p = 0.22$); $I^2 = 29\%$
Test for overall effect: $Z = 1.32$ ($p = 0.19$)

Odds Ratio
M-H, Random, 95 CI



Liu et al. Stereotact Funct Neurosurg. 2019;97(5-6):381-90.

JNS

CLINICAL ARTICLE

J Neurosurg 134:1072–1082, 2021

Clinical outcomes of globus pallidus deep brain stimulation for Parkinson disease: a comparison of intraoperative MRI– and MER-guided lead placement

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parameter. In addition, we identified the motor side-effect threshold at the active contact at the initial programming session. Interestingly, these thresholds were significantly lower in patients who underwent DBS implantation with iMRI guidance than by MER guidance (3.1 ± 0.1 V [95% CI 2.8–3.4] vs 4.1 ± 03 V [95% CI 3.4–4.6], respectively; t = 3.354, p = 0.001).

Bezchlibnyk et al. J Neurosurg. 2020;134(3):1072-1082

SECODARY OUTCOME

CrossMark

Microelectrode Recording–Guided Versus Intraoperative Magnetic Resonance Imaging–Guided Subthalamic Nucleus Deep Brain Stimulation Surgery for Parkinson Disease: A 1-Year Follow-Up Study

Xuemeng Liu[1,2], Jibo Zhang[1,2], Kai Fu[1,2], Rui Gong[1], Jincao Chen[1], Jie Zhang[1,2]

MER

Image

Table 2. Comparison of Magnitude of Electrode Discrepancy in Each Axis Between 2 Groups 7 Days Postoperative and the Passes of Microelectrode Recording or Number of Intraoperative Magnetic Resonance Imaging

Group	*x* Axis (mm)	*y* Axis (mm)	*z* Axis (mm)	MER Passes/ Number of iMRI
Group A	1.1 ± 0.2	1.3 ± 0.3	2.1 ± 0.5	1.5 ± 0.7
Group B	1.3 ± 0.4	1.2 ± 0.2	2.5 ± 0.7	1.2 ± 0.5
P value (*t* test)	0.34	0.26	0.41	

Values are mean ± SD or as otherwise indicated.

MER, microelectrode recording; iMRI, intraoperative magnetic resonance imaging.

Liu et al. World Neurosurg. 2017;107:900-5.

Table 2
Pooled value of DBS therapeutic effects and surgery-related outcomes in the main and sensitivity analysis[a].

	IMG-DBS	PHY-DBS	COMB-DBS	IMG vs PHY	IMG vs COMB	PHY vs COMB
Main analysis						
Post UPDRS "On[b]"	17.5 ± 5.00 (41)	14.8 ± 1.59 (341)	12.9 ± 1.73 (103)	0.582	0.385	0.533
Post UPDRS "Off[c]"	23.4 ± 2.74 (208)	20.4 ± 1.30 (369)	18.9 ± 1.60 (301)	0.323	0.156	0.462
Post LEDD (mg/d)	526.7 ± 121.6 (82)	607.2 ± 97.6 (483)	498.7 ± 46.5 (233)	0.606	0.830	0.316
PI UPDRS "On"	16.8 ± 7.33 (62)	28.3 ± 10.5 (389)	25.6 ± 3.43 (103)	0.369	0.277	0.807
PI UPDRS "Off"	47.2 ± 4.54 (228)	49.2 ± 8.49 (1122)	52.4 ± 2.43 (323)	0.835	0.313	0.717
PI LEDD	47.3 ± 4.39 (139)	48.9 ± 1.63 (720)	54.9 ± 2.90 (233)	0.733	0.149	0.070
PI QOL	32.6 ± 6.54 (187)	43.1 ± 5.38 (226)	40.7 ± 7.53 (83)	0.211	0.417	0.810
Surgical time (mins)	232.1 ± 17.9 (258)	361.4 ± 31.7 (278)	347.1 ± 42.9 (57)	**<0.001**	**0.008**	0.789
Target error (mm)	0.902 ± 0.094 (350)	1.297 ± 0.043 (663)	0.674 ± 0.081 (106)	**<0.001**	0.066	**<0.001**
ICH (%)	1.3 ± 0.4 (524)	2.7 ± 0.4 (2905)	3.9 ± 0.8 (406)	**0.013**	**0.004**	0.179
Infection (%)	2.6 ± 0.5 (796)	1.9 ± 0.4 (2503)	2.2 ± 0.6 (236)	0.274	0.608	0.677
Sensitivity analysis						
Post UPDRS "On"	17.5 ± 5.00 (41)	14.8 ± 1.59 (341)	14.3 ± 1.46 (128)	0.582	0.539	0.817
Post UPDRS "Off"	23.4 ± 2.74 (208)	22.9 ± 1.51 (341)	19.7 ± 1.71 (344)	0.873	0.252	0.161
Post LEDD (mg/d)	526.7 ± 121.6 (82)	607.2 ± 97.6 (483)	552.1 ± 57.8 (258)	0.606	0.850	0.627
PI UPDRS "On"	16.8 ± 7.33 (62)	28.3 ± 10.5 (389)	24.5 ± 2.23 (128)	0.369	0.315	0.723
PI UPDRS "Off"	47.2 ± 4.54 (228)	47.4 ± 7.48 (1189)	51.9 ± 2.27 (366)	0.982	0.355	0.565
PI LEDD	47.3 ± 4.39 (139)	49.0 ± 1.58 (732)	54.9 ± 2.90 (233)	0.716	0.149	0.285
PI QOL	32.6 ± 6.54 (187)	41.9 ± 4.70 (256)	40.7 ± 7.53 (83)	0.249	0.417	0.897
Surgical time (mins)	232.1 ± 17.9 (258)	361.2 ± 27.8 (310)	347.1 ± 42.9 (57)	**<0.001**	**0.008**	0.783
Target error (mm)	0.860 ± 0.091 (380)	1.297 ± 0.043 (663)	0.711 ± 0.077 (168)	**<0.001**	0.211	**<0.001**
ICH (%)	1.7 ± 0.4 (580)	3.4 ± 0.2 (3104)	3.9 ± 0.8 (406)	**<0.001**	**0.014**	0.544
Infection (%)	2.5 ± 0.5 (852)	3.0 ± 0.3 (2702)	2.2 ± 0.6 (236)	0.391	0.701	0.233

DBS: deep brain stimulation; Post: postoperative scores; PI: percentage improvement postoperatively; UPDRS: Unified Parkinson's Disease Rating Scale; LEDD: Levodopa equivalent doses; QOL: quality of life; ICH: intracerebral hemorrhage.

[a] The data are represented by "mean ± standard error (observation numbers)". The outcomes of pairwise comparison are demonstrated by p value and the significant comparisons are highlighted.

[b] "On" indicates DBS on and medication on.

[c] "Off" indicates DBS on and medication off.

Yin et al. Brain Stimul. 2019;12(4):893-900.

RESEARCH PAPER

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]

Table 2 Stimulation outcomes—pooled values

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

Ho et al. J Neurol Neurosurg Psychiatry. 2018;89(7):687-691.

JNS

CLINICAL ARTICLE

J Neurosurg 130:109–120, 2019

Clinical outcomes following awake and asleep deep brain stimulation for Parkinson disease

Tsinsue Chen, MD,[1] Zaman Mirzadeh, MD, PhD,[1] Kristina M. Chapple, PhD,[1] Margaret Lambert, BSN, RN,[1] Holly A. Shill, MD,[2] Guillermo Moguel-Cobos, MD,[2] Alexander I. Tröster, PhD,[3] Rohit Dhall, MD,[4] and Francisco A. Ponce, MD[1]

Departments of [1]Neurosurgery, [2]Neurology, and [3]Clinical Neuropsychology, Barrow Neurological Institute, St. Joseph's Hospital and Medical Center, Phoenix, Arizona; and [4]Department of Neurology, University of Arkansas for Medical Sciences, Little Rock, Arkansas

TABLE 4. DBS case and operating room times

Time	Awake		Asleep		p Value
	Mean ± SD (median [range])	No. of Patients	Mean ± SD (median [range])	No. of Patients	(mean awake vs asleep)
Case time (mins)					
Electrodes only	178.3 ± 44.8 (178 [98–258])	10	127.6 ± 46.1 (125 [73–285])	39	0.003
Electrodes + IPG	197.6 ± 65.9 (184 [112–344])	13	176.6 ± 43.1 (180 [103–310])	62	0.15
OR time (mins)					
Electrodes only	240.6 ± 64.8 (230 [161–391])	10	215.9 ± 50.7 (204 [152–384])	39	0.20
Electrodes + IPG	260.9 ± 57.6 (231 [203–361])	13	266.0 ± 60.6 (263 [140–426])	62	0.78

Nine patients with staged electrode placement procedures were excluded from this analysis.

Chen et al. J Neurosurg. 2018;130(1):109-120

		MER guided		Image guided
Primary	UPDRS	😇😇😇	=	😇😇😇
	LEDD	😇😇😇	=	😇😇😇
	Quality of life	😇😇	=	😇😇
	Rx related adverse effect	😇	⬅	😟
Secondary	Lead accuracy	😇	➡	😇😇
	OR time	😇😇	=	😇😇
	Hemorrhage	😟	➡	😇😇
	Lead revision	??		??
	Patient comfort	😟😟😟	➡	😇😇😇


HOME
DELIVERY

- Both techniques yield comparable primary outcomes
- Image-guided approaches appear to provide better secondary outcomes
- A large double-blind RCT with long-term follow-up is needed for definitive conclusions

Key points for good outcome

- Patient selection …………Poor choice……Poor result
- Patient preparation ………….Thorough explanation
- Meticulous operation ………….One mistake can ruin an entire procedure
- Strict sterile technique ………….Explantation is extremely co$$$$tly

School for Device-Aided Therapies in Parkinson's Disease

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Thank You for Your Attention