Robot-Assisted Deep Brain Stimulation Surgery

- Robot-assisted deep brain stimulation with intraoperative CT imaging and frameless registration module: a new gold-standard?
- A systematic review and meta-analysis of robot-assisted deep brain stimulation: comparative insights with conventional techniques
- Utilization of Intraoperative Navigation in Stereotactic Neurosurgery
- Stereotactic robot-assisted MRI-guided laser interstitial thermal therapy thalamotomy for medically intractable Holmes tremor: a pilot study and literature review
- Safety and efficiency of deep brain stimulation in the elderly patients with Parkinson's disease
- Efficacy and safety of robot-assisted deep brain stimulation for Parkinson's disease: a meta-analysis
- Unilateral deep brain stimulation (DBS) of nucleus ventralis intermedius thalami (Vim) for the treatment of post-traumatic tremor in children: a multicentre experience
- Evaluation of 3D C-Arm Fluoroscopy versus Diagnostic CT for Deep Brain Stimulation Stereotactic Registration and Post-Operative Lead Localization

Definition

Robot-assisted deep brain stimulation (DBS) is a neurosurgical technique where a robotic system guides the implantation of electrodes into deep brain structures (e.g., subthalamic nucleus, globus pallidus internus) with high precision. It is primarily used to treat movement disorders such as Parkinson’s disease, essential tremor, and dystonia.

⚙ Key Components

Component	Description
Surgical Robot	Systems like **Neuromate** (Renishaw) or **ROSA** (Zimmer Biomet) provide submillimetric guidance.
Imaging Integration	Intraoperative **cone-beam CT** (e.g., Medtronic O-Arm) or **MRI** allows real-time verification.
Frameless Registration	Devices like **NeuroLocate** enable accurate registration without a rigid stereotactic frame.
Planning Software	Preoperative fusion of high-resolution MRI and CT scans allows accurate trajectory planning.

Advantages

- High targeting accuracy (submillimetric)
- Reduced surgical time
- Reproducible workflow
- Frameless system increases patient comfort
- Real-time electrode verification with imaging

⚠ Limitations

- High cost of equipment and maintenance
- Steep learning curve for the surgical team
- Limited clinical evidence of superiority over frame-based methods
- Potential overreliance on technology instead of surgical expertise

Current Evidence

Study Type	General Findings
Case Series	Improved workflow and technical precision
Comparative	Mixed outcomes; minor advantages over traditional methods in some reports
Meta-Analyses	Limited by heterogeneity and lack of high-quality randomized trials

Common Targets

- Subthalamic Nucleus (STN)
- Globus Pallidus Internus (GPi)
- Ventral Intermediate Nucleus of the Thalamus (VIM)

Clinical Indications

- Advanced Parkinson's disease, refractory to medication
- Disabling essential tremor
- Primary dystonia
- Investigational use in refractory OCD and Tourette syndrome

Conclusion

Robot-assisted DBS is a technologically advanced alternative to traditional frame-based stereotaxy. It offers enhanced accuracy and intraoperative imaging verification, but **does not yet have strong evidence to support clinical superiority**. It is a **promising tool**, but **not a new gold standard—yet**.

Ho et al. first report of application of frameless robotic-assistance with the Mazor Renaissance platform (Mazor Robotics Ltd, Caesarea, Israel) for DBS surgery, and the findings revealed that an initial experience is safe and can have a positive impact on operative efficiency, accuracy, and safety [1].

Robot-assisted stereotactic implantation of DBS electrodes in the pediatric age group is a safe and accurate surgical method. Greater accuracy was present in the cohort of Furlanetti et al. in comparison to previous studies in which conventional stereotactic frame-based techniques were used. Robotic DBS surgery and neuroradiological advances may result in further improvement in surgical targeting and, consequently, in better clinical outcome in the pediatric population [2].

Robot-Assisted Deep Brain Stimulation for Parkinson's disease

Robot-Assisted Deep Brain Stimulation for Parkinson's disease.

Technical Notes

In a technical note Defrance et al. from the Hôpital Sainte-Anne, Paris, France, detail the current surgical workflow for DBS implantation, combining the Neuromate robot (Renishaw), the NeuroLocate frameless registration module, and intraoperative cone-beam CT imaging using the O-Arm system (Medtronic).

They conclude that this approach provides a safe, efficient, and reproducible alternative to traditional methods, supporting its broader adoption in modern functional neurosurgery [3].

Type of Study

- Descriptive technical workflow
- No patient data, outcomes, or comparative metrics
- Level V evidence (expert opinion)
- Not a clinical study

⚠ Major Concerns

1. No Clinical Data

- No series, no operative time metrics, no outcome rates
- No comparison to frame-based DBS
- Fails to provide even basic targeting accuracy

2. Misleading “Gold-Standard” Claim

- The title implies validated superiority without presenting data
- Contradicts multiple studies showing equivalence—not superiority—of robotic DBS

3. Lack of Technical Depth

- Ignores critical issues:
  1. Frameless registration errors
  2. Brain shift and intraoperative movement
  3. Imaging fusion challenges
- Offers no troubleshooting or limitations of devices

4. No Comparative Context

- No mention of existing accuracy data from frame-based or robotic systems
- Omits findings from peer-reviewed robotic DBS studies (e.g., targeting errors ~1.0 mm)

5. Weak Evidence Tier

- No hypothesis
- No methods section fitting Evidence-Based Medicine Standards
- Unqualified as research—best categorized as a surgical protocol note

6. Opaque Conflicts of Interest

- Promotes commercial technologies (Renishaw, Medtronic)
- No financial disclosures
- Strong appearance of **industry bias**

Reality Check Table

CLAIM	REALITY
“New gold standard”	No supporting data or trials
“Improved accuracy & safety”	No statistical evidence or patient outcomes provided
“Efficient & reproducible workflow”	Not benchmarked against traditional methods
“Justifies broader adoption”	No cost analysis, no risk-benefit assessment, no follow-up data

Final Verdict

This article is a **thinly veiled promotional piece**, dressed as peer-reviewed science. It lacks data, ignores known challenges, and inflates its claims beyond justification.

It should have been published as a Technical Note—not an article—if at all. A cautionary example of how **academic journals can become conduits for commercial evangelism** under the guise of innovation.

[1]

Ho AL, Pendharkar AV, Brewster R, Martinez DL, Jaffe RA, Xu LW, Miller KJ, Halpern CH. Frameless

Robot-Assisted Deep Brain Stimulation Surgery: An Initial Experience. Oper Neurosurg (Hagerstown). 2019 Oct 1;17(4):424-431. doi: 10.1093/ons/opy395. PMID: 30629245.

2)

Furlanetti L, Ellenbogen J, Gimeno H, Ainaga L, Narbad V, Hasegawa H, Lin JP, Ashkan K, Selway R. Targeting accuracy of robot-assisted deep brain stimulation surgery in childhood-onset dystonia: a single-center prospective cohort analysis of 45 consecutive cases. J Neurosurg Pediatr. 2021 Apr 16:1-11. doi: 10.3171/2020.10.PEDS20633. Epub ahead of print. PMID: 33862592.

3)

Defrance G, Domenech P, Pallud J, Zanello M. Robot-assisted deep brain stimulation with intraoperative CT imaging and frameless registration module: a new gold-standard? Acta Neurochir (Wien). 2025 Jun 13;167(1):168. doi: 10.1007/s00701-025-06581-w. PMID: 40512288.