ERRATUM

Open-loop deep brain stimulation for the treatment of epilepsy: a systematic review of clinical outcomes over the past decade (2008–present)

TO THE READERSHIP: An error appeared in the article by Zhou et al. (Zhou JJ, Chen T, Farber SH, et al: Open-loop deep brain stimulation for the treatment of epilepsy: a systematic review of clinical outcomes over the past decade [2008–present]. *Neurosurg Focus* 45[2]:E5, 2018).

In the left column of Table 1, the first group named “Amygdala” was incorrect. This group should be “ANT” for “anterior nucleus of the thalamus.” Also, for the study by Krishna et al. (2016), the DBS response rate of 11/14 has been changed to 11/16 to reflect the original article. The corrected table appears on the following pages.

The article has been corrected online as of November 1, 2018.

Gillian Shasby

Director of Publications

Journal of Neurosurgery Publishing Group, Charlottesville, VA

INCLUDE WHEN CITING

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TABLE 1. Summary of literature review findings

Target/Authors & Year	Study Type	No. of Pts	Target	Stimulation Parameters	FU Duration	DBS Response Rate	Other Outcomes	Adverse Events
ANT								
Lim et al., 2008	CS	4	Bilat ANT	4–5 V; 90–110 Hz; 60–90 μ sec; continuous/ intermittent	2 yrs	50% (2/4)		1 pt developed asymptomatic hemorrhage; 1 pt developed erosion of extension wire through scalp, requiring surgical repair
Andrade et al., 2010	CS	1	ANT	Not described	9.5–10 yrs	50% (1/2)	No changes in behavior or cognitive status	None described
Fisher et al., 2010 (SANTE trial)	RCT	110	Bilat ANT	5 V; 145 Hz; 90 μ sec; intermittent (1 on, 5 off)	24 mos	53% (43/81)	Stimulated participants were more likely to report depression or memory impairment as adverse events during the blinded phase	12.7% of pts developed infections (7.3% stimulator pocket, 5.5% lead extensions, 1.8% bur hole), & 8.2% required removal of hardware; 8.2% of pts required lead repositioning; 4.5% of pts developed asymptomatic hemorrhage; 1 participant developed status epilepticus associated w/ stimulation
Lee et al., 2012	CS	15	Bilat ANT	1.5–3.1 V; 100–185 Hz; 90–150 μ sec; continuous	24–67 mos	87% (13/15)		1 pt developed wound infection requiring explantation
Oh et al., 2012	CS	9	Bilat ANT	1.5–3.1 V; 100–185 Hz; 90–150 μ sec; continuous	Mean 15.9 mos	78% (7/9)	Improved performance in verbal fluency tasks & delayed verbal memory after ANT DBS; improvement not correlated to Sz reduction. No significant changes in IQ, MMSE score, information processing, or executive function. No significant cognitive decline after DBS	None described
Penn et al., 2012	CR	1	Bilat ANT	Not described	10 mos	NA		Pt developed Twiddler syndrome, requiring revision of IPG & extension wires. After revision op, pt developed a wound infection requiring explantation
Hartikainen et al., 2014	CT	12	Bilat ANT	5 mA; 145 Hz; continuous	NA	NA	ANT DBS stimulation increased the frequency of commission errors & slowed reaction time in the presence of threat-related distractors	None described
Bucurenciu et al., 2015	CR	1	Bilat ANT	3–7.5 V; 145–180 Hz; 90–120 μ sec; intermittent (1 min on, 5 mins off to 20 sec on, 20 sec off)	11 mos	NA	Stimulation voltages >3 V were associated w/ subclinical Szs in the anterior & temporal regions	None described

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Target/Authors & Year	Study Type	No. of Pts	Target	Stimulation Parameters	FU Duration	DBS Response Rate	Other Outcomes	Adverse Events
<i>ANT (continued)</i>								
Cukiert et al., 2015	CS	6	ANT	5 V; 130 Hz; 300 μ sec; continuous	Up to 6 mos after battery depletion	100% (9/9)	1 pt did not experience increased Sz frequency after battery depletion; 5 pts experienced increased Sz frequency after battery depletion, 3 of whom had lower Sz frequency than at pre-DBS baseline, while 2 returned to pre-DBS baseline	None described
Piacentino et al., 2015	CS	6	ANT	4 V; 140 Hz; 90 μ sec; not specified	24 mos	50% (3/6)	1 pt died 40 days postop due to a myocardial infarction (unrelated to op)	None described
Salanova et al., 2015 (SANTE study w/ 5-yr FU)	CS	74	Bilat ANT	Not described	5 yrs	69% (51/74)	Significant improvement in neuropsychological testing at 5 yrs, specifically in attention, executive function, depression, tension/anxiety, total mood disturbance, & subjective cognitive function. Significant improvement in QOL (QOLIE-31) at 5 yrs	Implant site infection in 12.7% of pts; 9 required full/partial system explantation. Lead not w/in target in 8.2% of pts
Van Gompel et al., 2015	CS	2	Bilat ANT (stimulation) + bilat HCP (recording)	4 V; 7–8 Hz; 90 μ sec; intermittent (0.4 on, 0.1 off) or continuous	12 wks	100% (2/2)		None described
Voges et al., 2015	CS	9	ANT	4 V; 145 Hz; 90 μ sec; intermittent (1 on, 5 off)	1–21 mos	44% (4/9)	2 pts excluded because of technical artifacts; remaining 7 pts demonstrated DBS-related arousal w/ maximal voltage. At 5 V, DBS-related arousal occurred w/ 14.0%–67.0% of all DBS stimuli. Reduction of DBS voltage to btwn 1 & 4 V led to decrease in DBS-related arousals to btwn 9.0% & 33.0% of all stimuli. Reduction of nocturnal DBS voltages resulted in no worsening of Sz frequency & incomplete/complete remission of neuropsychiatric symptoms	None described
Franco et al., 2016	CS	2	ANT	5 V; 145 Hz; 90 μ sec; continuous	12–18 mos	100% (2/2)	Both pts experienced new-onset or worsening depressive symptoms after ANT DBS	None described

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TABLE 1. Summary of literature review findings

Target/Authors & Year	Study Type	No. of Pts	Target	Stimulation Parameters	FU Duration	DBS Response Rate	Other Outcomes	Adverse Events
ANT (continued)								
Krishna et al., 2016	CS	16	ANT	2.4–7 V; >100 Hz; 90 μ sec; not specified	1–14 yrs (mean 4.3 $\pm$ 3.8)	69% (11/16)		1 pt developed a deep infection requiring explantation; 1 developed a superficial infection requiring wound revision; 1 experienced severe postop agitation requiring cessation of stimulation
Lehtimäki et al., 2016	CS	15	Bilat ANT	5 V; 140 Hz; 90 μ sec; intermittent (1 on, 5 off)	5 yrs	67% (10/15)		None described
Sweeney-Reed et al., 2016	CS	8	Unilat/ bilat ANT/ DMNT	Not described	6 mos	50% (4/8)		None described
Lee et al., 2017	CR	1	Bilat ANT	8 V; 145 Hz; 120 μ sec; continuous	45 days	NA	Immediate resolution of RSE after DBS placement & stimulation; 100% decrease in GTCS & "head nodding" events & 90% decrease in staring episodes & myoclonic jerks during FU	None described
Valentín et al., 2017	CS	1	Bilat ANT	Not described	12–48 mos	100% (1/1)	Pt w/ bilat ANT DBS developed increased aggression	None described
Tröster et al., 2017 (SANTÉ trial w/ 7-yr FU)	RCT	67	Bilat ANT	Not described	7 yrs	NA	Stimulated participants were more likely to report depression or memory impairment as adverse events, but no objective cognitive decline or worsening of depression was observed in this group during the blinded phase. No overall cognitive decline or worsening of depression scores was observed 7 yrs into the open-label period. Self-reported depression & memory impairment adverse events were not associated w/ reliable changes on objective neuropsychological measures or overall 7-yr neurobehavioral outcome	See Fisher et al., 2010 ¹⁵
CMT								
Cukiert et al., 2009	CS	4	Bilat CMT	2 V; 130 Hz; 300 μ sec; continuous	1–2 yrs	100% (4/4)	Clinically relevant increase in attention level in 4/4 pts after CMT DBS	None described

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TABLE 1. Summary of literature review findings

Target/Authors & Year	Study Type	No. of Pts	Target	Stimulation Parameters	FU Duration	DBS Response Rate	Other Outcomes	Adverse Events
CMT (continued)								
Valentín et al., 2012	CR	1	Bilat CMT	5 V; 6 Hz; 90 μ sec; continuous	6 mos	NA	Immediate resolution of tonic-clonic Sz's & epileptiform discharges after DBS placement & stimulation. Further resolution of myoclonic jerks 4 wks after initiation of DBS	Electrodes explanted at 6 mos due to infection
Cukiert et al., 2015	CS	2	CMT	5 V; 130 Hz; 300 μ sec; continuous	Up to 6 mos after battery depletion	100% (2/2)	1 pt did not experience increased Sz frequency after battery depletion; 1 pt experienced increased Sz frequency after battery depletion, but the frequency was lower than pre-DBS baseline	None described
Valentín et al., 2013	CT	11	Bilat CMT	5 V; 60–130 Hz; 90 μ sec; continuous	12–66 mos	64% (7/11)		1 pt required device explantation because of infection; 1 experienced transient agraphia immediately after implantation
Son et al., 2016	CS	14	Unilat/bilat CMT	2.2 $\pm$ 0.41 V; 129.3 $\pm$ 2.7 Hz; 124.4 $\pm$ 23.0 μ sec; continuous	9–25 mos	79% (11/14)	No correlation btwn calculated coordinates & percentage of Sz reduction	1 pt required lead repositioning
Lehtimäki et al., 2017	CR	1	Bilat CMT	7 V; 180 Hz; 150 μ sec; continuous	7 mos	NA	Resolution of RSE w/ high-frequency stimulation combined w/ S-ketamine infusion; RSE returned when stimulation switched from continuous to intermittent but resolved again w/ continuous stimulation; 2–4 focal Sz's per mo on continuous stimulation (baseline frequency not noted)	None described
Valentín et al., 2017	CS	2	Bilat CMT	Not described	12–48 mos	50% (1/2)		None described
HCP								
McLachlan et al., 2010	CT	2	Bilat HCP	0.5+ V; 185 Hz; 90 μ sec; continuous	12 mos	NA	Subjective memory improvement in 1 pt during stimulation period	None described
Boex et al., 2011	CS	8	Unilat/bilat HCP/AMG	0.5–2 V; 130 Hz; 450 μ sec; continuous	12–74 mos	75% (6/8)	Reversible memory impairments w/ high-voltage or quadripolar stimulation in 2 pts; otherwise, no significant neuropsychological outcomes	None described

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TABLE 1. Summary of literature review findings

Target/Authors & Year	Study Type	No. of Pts	Target	Stimulation Parameters	FU Duration	DBS Response Rate	Other Outcomes	Adverse Events
<i>HCP (continued)</i>								
Miatton et al., 2011	CS	10	Unilat/bilat HCP/AMG	1–2.5 V; 130 Hz; 450 μ sec; continuous	6 mos	70% (7/10)	Pts w/ both unilat & bilat HCP/AMG DBS reported significantly fewer somatic complaints & feelings of insufficient mental/physical functioning. Unilat HCP/AMG DBS in dominant hemisphere was associated w/ significantly lower verbal IQ. No overall pattern of change in cognitive measures w/ DBS	None described
Bondallaz et al., 2013	CS	8	HCP	0.5–2 V; 130 Hz; 450 μ sec; continuous	10–74 mos	75% (6/8)		1 pt required reimplantation of an electrode due to lead fracture
Vonck et al., 2013	CS	11	Unilat/bilat HCP/AMG	1–6 V; 130 Hz; 450 μ sec; continuous +/- day/night cycling	67–120 mos	82% (9/11)		1 pt had asymptomatic intracranial hemorrhage; 1 pt required cable revision due to hardware failure; 1 pt required pulse generator removal due to local infection
Cukiert et al., 2014	CS	9	Unilat/bilat HCP	1–3.5 V; 130 Hz; 300 μ sec; continuous	15–50 mos	78% (7/9)		1 pt required explantation due to infection related to trauma directly to the generator
Cukiert et al., 2015	CS	1	1	2 V; 130 Hz; 300 μ sec; continuous	Up to 6 mos after battery depletion	100% (1/1)	Sz frequency increased after battery depletion but was lower than pre-DBS baseline	None described
Jin et al., 2016	CS	3	Bilat HCP	1–2.5 V; 130–170 Hz; 450 μ sec; continuous	26–43 mos	100% (3/3)	No postop neuropsychological deterioration at 1 yr as measured by Wechsler Adult Intelligence Scale & Wechsler Memory Scale	None described
Lim et al., 2016	CS	5	Unilat/bilat HCP	Low frequency: 1–6 V; 3–5 Hz; 90–120 μ sec; intermittent (1 on, 5 off)	30–42 mos	60% (3/5)		None described
Cukiert et al., 2017	RCT	16	Unilat/bilat HCP	2 V; 130 Hz; 300 μ sec; continuous	8 mos	87.5% (7/8)		2 pts presented w/ local wound erosions & were treated successfully w/ antibiotics
<i>Other</i>								
Franzini et al., 2008	CS	4	Bilat pHyp (2) unilat CZi (2)	pHyp: 1.5–3.5 V; 185 Hz; 90 μ sec; continuous	6 mos–5 yrs	75% (3/4)	2 pts who had significant behavior comorbidity before pHyp DBS experienced dramatic improvement in disruptive behavior	None described

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TABLE 1. Summary of literature review findings

Target/Authors & Year	Study Type	No. of Pts	Target	Stimulation Parameters	FU Duration	DBS Response Rate	Other Outcomes	Adverse Events
<i>Other (continued)</i>								
Wille et al., 2011	CS	5	Bilat SNr/STN ± bilat VIM	1–4 V; 100–160 Hz; 60–120 µsec; continuous	12–42 mos	NA	Improvement in HRQoL in 4/5 pts, predominantly in overall, energy/fatigue, & emotional well-being domains	1 pt developed hardware failure due to unilat electrode dislocation
Capecci et al., 2012	CS	2	Bilat STN	2–3 V; 130 Hz; 60 µsec; continuous ± day/night cycling	12–48 mos	50% (1/2)	Both pts exhibited neuropsychological decline w/ DBS, including worsening attention, apathy, & mood changes. No improvement in functional status or QOL noted in either case	None described
Koubeissi et al., 2013	CS	11	Fornix	8 mA/phase; 5Hz; 0.2 µsec; 4-hr sessions	48 hrs	NA	LFS of the fornix resulted in a significant increase in MMSE scores, mostly due to improvement in delayed recall scores	None described
Schmitt et al., 2014	CS	5	Bilat NAC + bilat ANT	5 V; 125 Hz; 90 µsec; intermittent (1 on, 5 off)	6 mos	40% (2/5)	No significant differences in neuropsychological measures at 6 mos: 1 pt experienced resolution of major depressive symptoms after NAC DBS & 2 pts developed new-onset generalized anxiety disorder after DBS	None described
Benedetti-Isaac et al., 2015	CS	5	Bilat pHyp	3 V; 185 Hz; 90 µsec; intermittent (1 on, 5 off)	2 mos–4 yrs (mean 2.83 yrs)	100% (5/5)		None described
Kowski et al., 2015	CT	4	Bilat NAC + bilat ANT	5 V; 125 Hz; 90 µsec; intermittent (1 on, 5 off)	15 mos	75% (3/4)		1 pt developed subcutaneous infection requiring explantation & reimplantation at a later date

AMG = amygdala; CR = case report; CS = case series; CT = crossover trial; CZI = caudal zone incerta; DMNT = dorsomedial nuclei of the thalamus; FU = follow-up; GTCS = generalized tonic-clonic seizure; HRQoL = health-related quality of life; IPG = implantable pulse generator; MMSE = Mini-Mental State Examination; NA = not available; NAC = nucleus accumbens; pHyp = posterior hypothalamus; Pt = patient; QOL = quality of life; QOLIE-31 = Quality of Life in Epilepsy Inventory-31; RCT = randomized controlled trial; RSE = refractory status epilepticus; SNr = substantia nigra pars reticulata; STN = subthalamic nucleus; Sz = seizure; VIM = ventral intermediate nucleus of the thalamus.