MASSACHUSETTS

Blue Cross Blue Shield of Massachusetts is an Independent Licensee of the Blue Cross and Blue Shield Association

Medical Policy

Transcranial Magnetic Stimulation as a Treatment of Depression and Other Psychiatric/Neurologic Disorders

Table of Contents

Policy Number: 297

BCBSA Reference Number: 2.01.50 (For Plan internal use only)
NCD/LCD: Local Coverage Determination (LCD): Transcranial Magnetic Stimulation (L33398)

Related Policies

- Outpatient Psychotherapy, #423
- Vagus Nerve Stimulation, #474
- Treatment of Tinnitus, #267
- Deep Brain Stimulation, #473

Policy

Commercial Members: Managed Care (HMO and POS), PPO, and Indemnity,

Repetitive transcranial magnetic stimulation (rTMS) or deep transcranial magnetic stimulation (dTMS) of the brain using an FDA-cleared device and modality may be considered **MEDICALLY NECESSARY** as a treatment of major depressive disorder when **all** of the following conditions (1-3) have been met:

1. Confirmed diagnosis of severe major depressive disorder (single or recurrent) documented by standardized rating scales that reliably measure depressive symptoms; and
2. Any one of the following (a, b, c, or d):
    a. Failure of 4 trials of psychopharmacologic agents including 2 different agent classes and 2 augmentation trials; or
    b. Inability to tolerate a therapeutic dose of medications as evidenced by 4 trials of psychopharmacologic agents with distinct side effects; or
    c. History of response to rTMS in a previous depressive episode (at least 3 months since the prior episode); or
    d. Is a candidate for electroconvulsive therapy; further, electroconvulsive therapy would not be clinically superior to rTMS (eg, in cases with psychosis, acute suicidal risk, catatonia or life-threatening inanition rTMS should NOT be used); and
3. Failure of a trial of a psychotherapy known to be effective in the treatment of major depressive disorder of an adequate frequency and duration, without significant improvement in depressive symptoms, as documented by standardized rating scales that reliably measure depressive symptoms.

Repetitive transcranial magnetic stimulation (rTMS) or deep transcranial magnetic stimulation (dTMS) for major depressive disorder that does not meet the criteria listed above is considered **INVESTIGATIONAL**.

Continued treatment with repetitive transcranial magnetic stimulation (rTMS) or deep transcranial magnetic stimulation (dTMS) or of the brain as maintenance therapy is considered **INVESTIGATIONAL**.

Repetitive transcranial magnetic stimulation (rTMS) or deep transcranial magnetic stimulation (dTMS) of the brain is considered **INVESTIGATIONAL** as a treatment of all other psychiatric/neurologic disorders, including but not limited to bipolar disorder, schizophrenia, obsessive-compulsive disorder, or migraine headaches.

Repetitive transcranial magnetic stimulation (rTMS) or deep transcranial magnetic stimulation (dTMS) should be performed using a U.S. Food and Drug Administration cleared device in appropriately selected patients, by physicians who are adequately trained and experienced in the specific techniques used. A treatment course should not exceed 5 days a week for 6 weeks (total of 30 sessions), followed by a 3-week taper of 3 TMS treatments in week 1, 2 TMS treatments the next week, and 1 TMS treatment in the last week.

Contraindications to repetitive TMS include:

a. Seizure Disorder or any history of seizure with increased risk of future seizure; or
b. Presence of acute or chronic psychotic symptoms or disorders (eg, schizophrenia, schizophreniform or schizoaffective disorder) in the current depressive episode; or)
c. Neurologic conditions that include epilepsy, cerebrovascular disease, dementia, increased intracranial pressure, having a history of repetitive or severe head trauma, or with primary or secondary tumors in the central nervous system; or
d. Presence of an implanted magnetic-sensitive medical device located within 30 centimeters from the TMS magnetic coil or other implanted items including but not limited to a cochlear implant, implanted cardioverter defibrillator, pacemakers, vagus nerve stimulator or metal aneurysm clips or coils, staples, or stents.

Medicare HMO Blue℠ and Medicare PPO Blue℠ Members

Medical necessity criteria and coding guidance for **Medicare Advantage members living in Massachusetts** can be found through the link(s) below.

Local Coverage Determinations (LCDs) for National Government Services, Inc.

Local Coverage Determination (LCD): Transcranial Magnetic Stimulation (L33398)

Note: To review the specific LCD, please remember to click “accept” on the CMS licensing agreement at the bottom of the CMS webpage.

Prior Authorization Information

Inpatient

- For services described in this policy, precertification/preauthorization **IS REQUIRED** for all products if the procedure is performed **inpatient**.

Outpatient

- For services described in this policy, see below for products where prior authorization **might be required** if the procedure is performed **outpatient**.

	Outpatient
Commercial Managed Care (HMO and POS)	Prior authorization is **required**. Providers must submit the following form: Repetitive Transcranial Magnetic Stimulation (rTMS) Request Form
Commercial PPO and Indemnity	Prior authorization is **not required**.

Medicare HMO Blue℠	Prior authorization is **required**.
Medicare PPO Blue℠	Prior authorization is **required**.

Requesting Prior Authorization Using Authorization Manager
Providers will need to use Authorization Manager to submit initial authorization requests for services. Authorization Manager, available 24/7, is the quickest way to review authorization requirements, request authorizations, submit clinical documentation, check existing case status, and view/print the decision letter. For commercial members, the requests must meet medical policy guidelines.

To ensure the service request is processed accurately and quickly:
- Enter the facility's NPI or provider ID for where services are being performed.
- Enter the appropriate surgeon's NPI or provider ID as the servicing provider, *not* the billing group.

Authorization Manager Resources
Refer to our Authorization Manager page for tips, guides, and video demonstrations.

CPT Codes / HCPCS Codes / ICD Codes

Inclusion or exclusion of a code does not constitute or imply member coverage or provider reimbursement. Please refer to the member's contract benefits in effect at the time of service to determine coverage or non-coverage as it applies to an individual member.

Providers should report all services using the most up-to-date industry-standard procedure, revenue, and diagnosis codes, including modifiers where applicable.

The following codes are included below for informational purposes only; this is not an all-inclusive list.

The above medical necessity criteria MUST be met for the following codes to be covered for Commercial Members: Managed Care (HMO and POS), PPO, Indemnity, Medicare HMO Blue and Medicare PPO Blue:

CPT Codes

CPT codes:	Code Description
90867	Therapeutic repetitive transcranial magnetic stimulation (TMS) treatment; initial, including cortical mapping, motor threshold determination, delivery and management
90868	Therapeutic repetitive transcranial magnetic stimulation (TMS) treatment; subsequent delivery and management, per session
90869	Therapeutic repetitive transcranial magnetic stimulation (TMS) treatment; subsequent motor threshold re-determination with delivery and management

The following ICD Diagnosis Codes are considered medically necessary when submitted with the CPT codes above if medical necessity criteria are met:

ICD-10 Diagnosis Codes

ICD-10-CM Diagnosis codes:	Code Description
F32.2	Major depressive disorder, single episode, severe without psychotic features
F33.2	Major depressive disorder, recurrent severe without psychotic features

Description

Transcranial Magnetic Stimulation
Transcranial magnetic stimulation (TMS), introduced in 1985 as a new method of noninvasive stimulation of the brain, involves placement of a small coil over the scalp, passing a rapidly alternating current

through the coil wire, which produces a magnetic field that passes unimpeded through the scalp and bone, resulting in electrical stimulation of the cortex. Transcranial magnetic stimulation was initially used to investigate nerve conduction (eg, TMS over the motor cortex will produce a contralateral muscular-evoked potential). The motor threshold, which is the minimum intensity of stimulation required to induce a motor response, is empirically determined for each person by localizing the site on the scalp for optimal stimulation of a hand muscle, then gradually increasing the intensity of stimulation. Interest in the use of TMS as a treatment for depression was augmented by the development of a device that could deliver rapid, repetitive stimulation. Imaging studies had shown a decrease in the activity of the left dorsolateral prefrontal cortex in depressed patients, and early studies suggested that high-frequency (eg, 5 to 10 Hz) TMS of the left dorsolateral prefrontal cortex had antidepressant effects. In contrast to electroconvulsive therapy (ECT), TMS does not require general anesthesia and does not generally induce a convulsion. Repetitive TMS (rTMS) is also being tested as a treatment for a variety of other psychiatric and neurologic disorders.

Conventional TMS delivers repeated electromagnetic pulses to induce prolonged modulation of neural activity, typically applied over the dorsolateral prefrontal cortex. High-frequency rTMS (usually ≥10 Hz) induces an increase in neural activity whereas low-frequency TMS (usually ≤1 Hz) has the opposite effect. If both procedures are performed in the same session, the intervention is described as bilateral rTMS.

A variety of TMS modalities have been developed, which differ on parameters including stimulation intensity, frequency, pattern, and site of the brain stimulation. Deep TMS employs an H-coil helmet design to encompass a broader surface area and stimulate deeper brain structures than conventional TMS. Theta burst stimulation is administered at lower intensities and shorter intervals than conventional rTMS.

Summary

Transcranial magnetic stimulation (TMS) is a noninvasive method of delivering electrical stimulation to the brain. The technique involves the placement of a small coil over the scalp and passing a rapidly alternating current through the coil wire. The electrical current produces a magnetic field that passes unimpeded through the scalp and bone and stimulates neuronal function. Repetitive TMS is being evaluated for the treatment of treatment-resistant depression (TRD) and other psychiatric and neurologic disorders. A variety of TMS modalities have been developed, which differ on parameters including stimulation intensity, frequency, pattern, and site of the brain stimulation. In conventional TMS, high frequency stimulation is delivered over the left dorsolateral prefrontal cortex (DLPFC) or low frequency stimulation over the right DLPFC. In bilateral TMS, both procedures are performed in the same session. Deep TMS employs an H-coil helmet designed to encompass a broader surface area and stimulate deeper brain structures than conventional TMS. Theta burst stimulation is administered at lower intensities and shorter intervals than conventional TMS.

For individuals who have treatment-resistant depression (TRD) who receive transcranial magnetic stimulation (TMS), the evidence includes a large number of sham-controlled randomized controlled trials (RCTs) and meta-analyses of these trials. Relevant outcomes are symptoms, functional outcomes, and quality of life. Meta-analyses found improved response rates and rates of remission for conventional TMS and theta burst stimulation compared with sham TMS. Additionally, a head-to-head trial showed noninferiority of theta burst stimulation to conventional TMS, with no difference in the incidence of adverse events. Meta-analyses have concluded that the effect of TMS on average depression scores is smaller than the effect of electroconvulsive therapy (ECT) on TRD and that the mean improvement in depression scores with TMS did not reach the minimal clinically important difference; however, clinically meaningful improvements were noted in a subgroup of studies using higher frequency pulses. One potential area of benefit for TMS is in accelerating or enhancing the response to antidepressant medications, and there is some evidence that TMS, when given in conjunction with the initiation of pharmacologic therapy, improves the response rate compared with pharmacologic therapy alone. The effect of TMS appears to be less robust when it is given in combination with a stable dose of antidepressant medication. Meta-analyses have also found that the efficacy of TMS decreases with longer follow-up, though some studies have reported a persistent response up to 6 months in some

patients. There is limited evidence to compare the effects of these treatments on cognition, although the adverse events of TMS appear to be minimal. While meta-analyses have reported that the effect of TMS is smaller than the effect of ECT on TRD, because TMS does not require general anesthesia or induce seizures, some individuals may decline ECT so the balance of incremental benefits and harms associated with TMS may be reasonable compared with ECT. Based on the short-term benefit observed in RCTs and the lack of alternative treatments aside from ECT in patients with TRD, TMS may be considered a treatment option in patients with TRD who meet specific criteria. The evidence is sufficient to determine that the technology results in an improvement in the net health outcome.

For individuals who have migraine headaches who receive TMS, the evidence includes a systematic review (n=8 trials) and a sham-controlled RCT of 201 patients conducted for submission to the Food and Drug Administration (FDA) for clearance in 2013. Relevant outcomes are symptoms, functional outcomes, and quality of life. The systematic review found that repetitive TMS (rTMS) reduced migraine pain intensity and frequency compared to sham; it was unclear whether patients were receiving background pharmacotherapy. The trial results were limited by the 46% dropout rate and the use of a post hoc analysis. No recent studies have been identified with these devices. The evidence is insufficient to determine that the technology results in an improvement in the net health outcome.

For individuals who have obsessive compulsive disorder (OCD) who receive TMS, the evidence includes a number of small-to-moderate sized, sham-controlled, double-blind RCTs and meta-analyses of these studies. Relevant outcomes are symptoms, functional outcomes, and quality of life. A meta-analysis of 15 RCTs (N=483 patients, range 18 to 65 patients) conducted in 2016 found a benefit of TMS on patient-reported OCD symptom severity at time points ranging from 2 to 6 weeks, but there was substantial variability in the stimulation parameters, including the cortical region that was stimulated and the frequency of stimulation. A meta-analysis conducted in 2021 included 26 RCTs. The primary analysis found a significant effect of rTMS compared to sham on OCD symptoms, but the effect seemed to last only until 4 weeks after the last treatment. The RCT that was the basis of FDA clearance of deep TMS for treatment of OCD compared deep TMS to sham in 99 patients for 6 weeks, with an additional 4 weeks of follow-up as a secondary outcome. Using a modified intention-to-treat (ITT) analysis (n=94), there was a larger mean decrease from baseline (improvement) on the Yale-Brown Obsessive Compulsive Scale (YBOCS) score (the primary efficacy outcome) in the active treatment group (-6.0 points) than the sham group (-2.8 points), translating to a moderate effect size of 0.69. At 6 weeks, the response rate was 38.1% in the active treatment group compared to 11.1% in the sham group (p=.003), as measured by a 30% or greater increase in the YBOCS. The difference in the primary outcome measure between active and sham groups was not statistically significant in the ITT analysis. There was a benefit for TMS on clinician-reported measures of improvement, but no significant difference between groups on patient-reported disability and impairment. Additional trials with sufficient sample size and follow-up duration are needed to confirm these results. The evidence is insufficient to determine that the technology results in an improvement in the net health outcome.

For individuals who have psychiatric or neurological disorders other than depression, migraine, or OCD (eg, bipolar disorder, generalized anxiety disorder, panic disorder, posttraumatic stress disorder, schizophrenia, substance use disorder and craving, amyotrophic lateral sclerosis, chronic pain, epilepsy, fibromyalgia, Parkinson disease, stroke recovery) who receive TMS, the evidence includes numerous small RCTs and meta-analyses of these randomized trials. Relevant outcomes are symptoms, functional outcomes, and quality of life. The trials included in the meta-analyses are typically small and of low methodologic quality. In addition, stimulation parameters have not been established, and trial results are heterogeneous. There are no large, high-quality trials for any of these conditions demonstrating efficacy or the durability of any treatment effects. The evidence is insufficient to determine that the technology results in an improvement in the net health outcome.

Policy History

Date	Action
12/2023	Annual policy review. Description, summary, and references updated. Policy statements unchanged.
9/2023	Policy clarified to include prior authorization requests using Authorization Manager.

12/2022	Annual policy review. Policy statements unchanged.
12/2021	Annual policy review. Policy clarified to specify using an FDA-cleared device and modality. Policy statements otherwise unchanged.
1/2021	Medicare information removed. See MP #132 Medicare Advantage Management for local coverage determination and national coverage determination reference.
12/2020	Annual policy review. Description, summary and references updated. Policy statements unchanged.
8/2020	Local Coverage Determination (LCD): Transcranial Magnetic Stimulation (L33398) added.
1/2020	Prior authorization requirement for Medicare HMO and PPO Blue clarified. Effective 1/1/2020.
11/2019	Annual policy review. Description, summary and references updated. Policy statements unchanged.
3/22/2019	Prior authorization requirement for Medicare HMO Blue clarified. Effective 1/1/2019.
11/2018	Annual policy review. Description, summary and references updated. Policy statements unchanged.
8/2018	Annual policy review. Intent of policy statements unchanged. Prior authorization information clarified. Title changed. Effective 8/1/2018.
5/2015	New medical necessary indications described (coverage for deep rTMS added). Effective 5/1/2015.
12/2014	New investigational indications described (non-coverage for deep rTMS added). Effective 12/1/2014.
9/2014	Updated Medicare LCD. Effective 8/15/2014.
5/2014	Updated Coding section with ICD10 procedure and diagnosis codes. Effective 10/2015.
7/2013	New medically necessary indications described for Commercial. Effective 7/1/2013.
3/2013	New medical policy, reflecting ongoing non-coverage of rTMS for commercial products, and new coverage criteria for Medicare Advantage products. Effective 3/17/2013.

Information Pertaining to All Blue Cross Blue Shield Medical Policies

Click on any of the following terms to access the relevant information:
Medical Policy Terms of Use
Managed Care Guidelines
Indemnity/PPO Guidelines
Clinical Exception Process
Medical Technology Assessment Guidelines

References

1. FDA Briefing Document Psychopharmacologic Drugs Advisory Committee (PDAC) and Drug Safety and Risk Management (DSaRM) Advisory Committee Meeting February 12, 2019. https://www.fda.gov/media/121376/download. Accessed September 26, 2022.
2. Zimmerman M, Chelminski I, Posternak M. A review of studies of the Montgomery-Asberg Depression Rating Scale in controls: implications for the definition of remission in treatment studies of depression. Int Clin Psychopharmacol. Jan 2004; 19(1): 1-7. PMID 15101563
3. Center for Drug Evaluation and Research Application Number: 211243Orig1s000 Summary Review https://www.accessdata.fda.gov/drugsatfda_docs/nda/2019/211243Orig1s000SumR.pdf. Accessed August 18, 2023.
4. Alphs L, Fu D-J, Williamson D, et al. Validation and mapping of the Suicidal Ideation and Behavior Assessment Tool (SIBAT). (abstract W88) Neuropsychopharmacology. 2018;43:S427S428.
5. Gross M, Nakamura L, Pascual-Leone A, et al. Has repetitive transcranial magnetic stimulation (rTMS) treatment for depression improved? A systematic review and meta-analysis comparing the recent vs. the earlier rTMS studies. Acta Psychiatr Scand. Sep 2007; 116(3): 165-73. PMID 17655557

6. Schutter DJ. Antidepressant efficacy of high-frequency transcranial magnetic stimulation over the left dorsolateral prefrontal cortex in double-blind sham-controlled designs: a meta-analysis. Psychol Med. Jan 2009; 39(1): 65-75. PMID 18447962
7. Sehatzadeh Sh, Tu HA, Palimaka S, et al. Repetitive Transcranial Magnetic Stimulation for Treatment-Resistant Depression: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. Ont Health Technol Assess Ser. 2016; 16(5): 1-66. PMID 27099642
8. Brunoni AR, Chaimani A, Moffa AH, et al. Repetitive Transcranial Magnetic Stimulation for the Acute Treatment of Major Depressive Episodes: A Systematic Review With Network Meta-analysis. JAMA Psychiatry. Feb 01 2017; 74(2): 143-152. PMID 28030740
9. Voigt JD, Leuchter AF, Carpenter LL. Theta burst stimulation for the acute treatment of major depressive disorder: A systematic review and meta-analysis. Transl Psychiatry. May 28 2021; 11(1): 330. PMID 34050123
10. Blumberger DM, Vila-Rodriguez F, Thorpe KE, et al. Effectiveness of theta burst versus high-frequency repetitive transcranial magnetic stimulation in patients with depression (THREE-D): a randomised non-inferiority trial. Lancet. Apr 28 2018; 391(10131): 1683-1692. PMID 29726344
11. Food and Drug Administration. 510(k) Summary: Brainsway deep TMS System (K122288). 2013; https://www.accessdata.fda.gov/cdrh_docs/pdf12/k122288.pdf. Accessed August 18, 2023.
12. Kedzior KK, Reitz SK, Azorina V, et al. Durability of the antidepressant effect of the high-frequency repetitive transcranial magnetic stimulation (rTMS) In the absence of maintenance treatment in major depression: a systematic review and meta-analysis of 16 double-blind, randomized, sham-controlled trials. Depress Anxiety. Mar 2015; 32(3): 193-203. PMID 25683231
13. Dunner DL, Aaronson ST, Sackeim HA, et al. A multisite, naturalistic, observational study of transcranial magnetic stimulation for patients with pharmacoresistant major depressive disorder: durability of benefit over a 1-year follow-up period. J Clin Psychiatry. Dec 2014; 75(12): 1394-401. PMID 25271871
14. Richieri R, Guedj E, Michel P, et al. Maintenance transcranial magnetic stimulation reduces depression relapse: a propensity-adjusted analysis. J Affect Disord. Oct 2013; 151(1): 129-35. PMID 23790811
15. Connolly KR, Helmer A, Cristancho MA, et al. Effectiveness of transcranial magnetic stimulation in clinical practice post-FDA approval in the United States: results observed with the first 100 consecutive cases of depression at an academic medical center. J Clin Psychiatry. Apr 2012; 73(4): e567-73. PMID 22579164
16. Janicak PG, Nahas Z, Lisanby SH, et al. Durability of clinical benefit with transcranial magnetic stimulation (TMS) in the treatment of pharmacoresistant major depression: assessment of relapse during a 6-month, multisite, open-label study. Brain Stimul. Oct 2010; 3(4): 187-99. PMID 20965447
17. Saltychev M, Juhola J. Effectiveness of high-frequency repetitive transcranial magnetic stimulation (rTMS) in migraine - a systematic review and meta-analysis. Am J Phys Med Rehabil. Jan 14 2022. PMID 35034064
18. Food and Drug Administration. De Novo classification request for cerena transcranial magnetic stimulator (TMS) device. 2013; https://www.accessdata.fda.gov/cdrh_docs/reviews/K130556.pdf. Accessed August 18, 2023.
19. Goodman WK, Price LH, Rasmussen SA, et al. The Yale-Brown Obsessive Compulsive Scale. I. Development, use, and reliability. Arch Gen Psychiatry. Nov 1989; 46(11): 1006-11. PMID 2684084
20. Storch EA, De Nadai AS, Conceicao do Rosario M, et al. Defining clinical severity in adults with obsessive-compulsive disorder. Compr Psychiatry. Nov 2015; 63: 30-5. PMID 26555489
21. Farris SG, McLean CP, Van Meter PE, et al. Treatment response, symptom remission, and wellness in obsessive-compulsive disorder. J Clin Psychiatry. Jul 2013; 74(7): 685-90. PMID 23945445
22. Trevizol AP, Shiozawa P, Cook IA, et al. Transcranial Magnetic Stimulation for Obsessive-Compulsive Disorder: An Updated Systematic Review and Meta-analysis. J ECT. Dec 2016; 32(4): 262-266. PMID 27327557
23. Liang K, Li H, Bu X, et al. Efficacy and tolerability of repetitive transcranial magnetic stimulation for the treatment of obsessive-compulsive disorder in adults: a systematic review and network meta-analysis. Transl Psychiatry. May 28 2021; 11(1): 332. PMID 34050130

24. Carmi L, Tendler A, Bystritsky A, et al. Efficacy and Safety of Deep Transcranial Magnetic Stimulation for Obsessive-Compulsive Disorder: A Prospective Multicenter Randomized Double-Blind Placebo-Controlled Trial. Am J Psychiatry. Nov 01 2019; 176(11): 931-938. PMID 31109199
25. Perera MPN, Mallawaarachchi S, Miljevic A, et al. Repetitive Transcranial Magnetic Stimulation for Obsessive-Compulsive Disorder: A Meta-analysis of Randomized, Sham-Controlled Trials. Biol Psychiatry Cogn Neurosci Neuroimaging. Oct 2021; 6(10): 947-960. PMID 33775927
26. U.S. Food and Drug Administration. De novo classification request for Brainsway Deep Transcranial Magnetic Stimulation System. 2018; https://www.accessdata.fda.gov/cdrh_docs/reviews/DEN170078.pdf. Accessed August 18, 2023.
27. Konstantinou G, Hui J, Ortiz A, et al. Repetitive transcranial magnetic stimulation (rTMS) in bipolar disorder: A systematic review. Bipolar Disord. Feb 2022; 24(1): 10-26. PMID 33949063
28. Tee MMK, Au CH. A Systematic Review and Meta-Analysis of Randomized Sham-Controlled Trials of Repetitive Transcranial Magnetic Stimulation for Bipolar Disorder. Psychiatr Q. Dec 2020; 91(4): 1225-1247. PMID 32860557
29. Cui H, Jiang L, Wei Y, et al. Efficacy and safety of repetitive transcranial magnetic stimulation for generalised anxiety disorder: A meta-analysis. Gen Psychiatr. 2019; 32(5): e100051. PMID 31673675
30. Li H, Wang J, Li C, et al. Repetitive transcranial magnetic stimulation (rTMS) for panic disorder in adults. Cochrane Database Syst Rev. Sep 17 2014; (9): CD009083. PMID 25230088
31. Mantovani A, Aly M, Dagan Y, et al. Randomized sham controlled trial of repetitive transcranial magnetic stimulation to the dorsolateral prefrontal cortex for the treatment of panic disorder with comorbid major depression. J Affect Disord. Jan 10 2013; 144(1-2): 153-9. PMID 22858212
32. Trevizol AP, Barros MD, Silva PO, et al. Transcranial magnetic stimulation for posttraumatic stress disorder: an updated systematic review and meta-analysis. Trends Psychiatry Psychother. Jan-Mar 2016; 38(1): 50-5. PMID 27074341
33. He H, Lu J, Yang L, et al. Repetitive transcranial magnetic stimulation for treating the symptoms of schizophrenia: A PRISMA compliant meta-analysis. Clin Neurophysiol. May 2017; 128(5): 716-724. PMID 28315614
34. Dougall N, Maayan N, Soares-Weiser K, et al. Transcranial magnetic stimulation (TMS) for schizophrenia. Cochrane Database Syst Rev. Aug 20 2015; (8): CD006081. PMID 26289586
35. Guan HY, Zhao JM, Wang KQ, et al. High-frequency neuronavigated rTMS effect on clinical symptoms and cognitive dysfunction: a pilot double-blind, randomized controlled study in Veterans with schizophrenia. Transl Psychiatry. Feb 25 2020; 10(1): 79. PMID 32098946
36. Kumar N, Vishnubhatla S, Wadhawan AN, et al. A randomized, double blind, sham-controlled trial of repetitive transcranial magnetic stimulation (rTMS) in the treatment of negative symptoms in schizophrenia. Brain Stimul. May 2020; 13(3): 840-849. PMID 32289715
37. Zhuo K, Tang Y, Song Z, et al. Repetitive transcranial magnetic stimulation as an adjunctive treatment for negative symptoms and cognitive impairment in patients with schizophrenia: a randomized, double-blind, sham-controlled trial. Neuropsychiatr Dis Treat. 2019; 15: 1141-1150. PMID 31190822
38. Zhu L, Zhang W, Zhu Y, et al. Cerebellar theta burst stimulation for the treatment of negative symptoms of schizophrenia: A multicenter, double-blind, randomized controlled trial. Psychiatry Res. Nov 2021; 305: 114204. PMID 34587567
39. Jansen JM, Daams JG, Koeter MW, et al. Effects of non-invasive neurostimulation on craving: a meta-analysis. Neurosci Biobehav Rev. Dec 2013; 37(10 Pt 2): 2472-80. PMID 23916527
40. Chang CH, Liou MF, Liu CY, et al. Efficacy of Repetitive Transcranial Magnetic Stimulation in Patients With Methamphetamine Use Disorder: A Systematic Review and Meta-Analysis of Double-Blind Randomized Controlled Trials. Front Psychiatry. 2022; 13: 904252. PMID 35711590
41. Fang J, Zhou M, Yang M, et al. Repetitive transcranial magnetic stimulation for the treatment of amyotrophic lateral sclerosis or motor neuron disease. Cochrane Database Syst Rev. May 31 2013; (5): CD008554. PMID 23728676
42. O'Connell NE, Wand BM, Marston L, et al. Non-invasive brain stimulation techniques for chronic pain. Cochrane Database Syst Rev. Apr 11 2014; (4): CD008208. PMID 24729198
43. O'Connell NE, Marston L, Spencer S, et al. Non-invasive brain stimulation techniques for chronic pain. Cochrane Database Syst Rev. Apr 13 2018; 4: CD008208. PMID 29652088

44. Jiang X, Yan W, Wan R, et al. Effects of repetitive transcranial magnetic stimulation on neuropathic pain: A systematic review and meta-analysis. Neurosci Biobehav Rev. Jan 2022; 132: 130-141. PMID 34826512
45. Chen R, Spencer DC, Weston J, et al. Transcranial magnetic stimulation for the treatment of epilepsy. Cochrane Database Syst Rev. Aug 11 2016; (8): CD011025. PMID 27513825
46. Mishra A, Maiti R, Mishra BR, et al. Effect of Repetitive Transcranial Magnetic Stimulation on Seizure Frequency and Epileptiform Discharges in Drug-Resistant Epilepsy: A Meta-Analysis. J Clin Neurol. Jan 2020; 16(1): 9-18. PMID 31942753
47. Su YC, Guo YH, Hsieh PC, et al. Efficacy of Repetitive Transcranial Magnetic Stimulation in Fibromyalgia: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. J Clin Med. Oct 12 2021; 10(20). PMID 34682790
48. Saltychev M, Laimi K. Effectiveness of repetitive transcranial magnetic stimulation in patients with fibromyalgia: a meta-analysis. Int J Rehabil Res. Mar 2017; 40(1): 11-18. PMID 27977465
49. Chou YH, Hickey PT, Sundman M, et al. Effects of repetitive transcranial magnetic stimulation on motor symptoms in Parkinson disease: a systematic review and meta-analysis. JAMA Neurol. Apr 2015; 72(4): 432-40. PMID 25686212
50. Shirota Y, Ohtsu H, Hamada M, et al. Supplementary motor area stimulation for Parkinson disease: a randomized controlled study. Neurology. Apr 09 2013; 80(15): 1400-5. PMID 23516319
51. Li R, He Y, Qin W, et al. Effects of Repetitive Transcranial Magnetic Stimulation on Motor Symptoms in Parkinson's Disease: A Meta-Analysis. Neurorehabil Neural Repair. Jul 2022; 36(7): 395-404. PMID 35616427
52. Hao Z, Wang D, Zeng Y, et al. Repetitive transcranial magnetic stimulation for improving function after stroke. Cochrane Database Syst Rev. May 31 2013; (5): CD008862. PMID 23728683
53. Le Q, Qu Y, Tao Y, et al. Effects of repetitive transcranial magnetic stimulation on hand function recovery and excitability of the motor cortex after stroke: a meta-analysis. Am J Phys Med Rehabil. May 2014; 93(5): 422-30. PMID 24429509
54. Li Y, Qu Y, Yuan M, et al. Low-frequency repetitive transcranial magnetic stimulation for patients with aphasia after stoke: A meta-analysis. J Rehabil Med. Sep 2015; 47(8): 675-81. PMID 26181486
55. Qiao J, Ye QP, Wu ZM, et al. The Effect and Optimal Parameters of Repetitive Transcranial Magnetic Stimulation on Poststroke Dysphagia: A Meta-Analysis of Randomized Controlled Trials. Front Neurosci. 2022; 16: 845737. PMID 35573312
56. Zhang L, Xing G, Fan Y, et al. Short- and Long-term Effects of Repetitive Transcranial Magnetic Stimulation on Upper Limb Motor Function after Stroke: a Systematic Review and Meta-Analysis. Clin Rehabil. Sep 2017; 31(9): 1137-1153. PMID 28786336
57. Graef P, Dadalt MLR, Rodrigues DAMDS, et al. Transcranial magnetic stimulation combined with upper-limb training for improving function after stroke: A systematic review and meta-analysis. J Neurol Sci. Oct 15 2016; 369: 149-158. PMID 27653882
58. Murphy TK, Lewin AB, Storch EA, et al. Practice parameter for the assessment and treatment of children and adolescents with tic disorders. J Am Acad Child Adolesc Psychiatry. Dec 2013; 52(12): 1341-59. PMID 24290467
59. McClintock SM, Reti IM, Carpenter LL, et al. Consensus Recommendations for the Clinical Application of Repetitive Transcranial Magnetic Stimulation (rTMS) in the Treatment of Depression. J Clin Psychiatry. Jan/Feb 2018; 79(1). PMID 28541649
60. VA/DoD Clinical Practice Guideline. (2022). The Management of Major Depressive Disorder. Washington, DC: U.S. Government Printing Office. https://www.healthquality.va.gov/guidelines/MH/mdd/VADoDMDDCPGFinal508.pdf. Accessed August 18, 2023.
61. National Institute for Health and Care Excellence (NICE). Repetitive transcranial magnetic stimulation for depression [IPG542]. 2015; https://www.nice.org.uk/guidance/ipg542. Accessed August 18, 2023.
62. National Institute for Health and Care Excellence (NICE). Transcranial magnetic stimulation for treating and preventing migraine [IPG477]. 2014; https://www.nice.org.uk/guidance/ipg477. Accessed August 15, 2023.
63. National Institute for Health and Care Excellence (NICE). Transcranial magnetic stimulation for obsessive-compulsive disorder [IPG676]. 2020; https://www.nice.org.uk/guidance/ipg676. Accessed August 16, 2023.

64. National Institute for Health and Care Excellence (NICE). Transcranial magnetic stimulation for auditory hallucinations [IPG680]. 2020; https://www.nice.org.uk/guidance/ipg680/chapter/1-Recommendations. Accessed August 17, 2023.
65. Leung A, Shirvalkar P, Chen R, et al. Transcranial Magnetic Stimulation for Pain, Headache, and Comorbid Depression: INS-NANS Expert Consensus Panel Review and Recommendation. Neuromodulation. Apr 2020; 23(3): 267-290. PMID 32212288