Transcranial Magnetic Stimulation-Single Pulse (e.g. eNeura SAVI Dual™)

Policy MP-080

Origination Date: 11/06/2023

Reviewed/Revised Date: 11/20/2024

Next Review Date: 11/20/2025

Current Effective Date: 11/20/2024

Disclaimer:

1. Policies are subject to change in accordance with State and Federal notice requirements.
2. Policies outline coverage determinations for U of U Health Plans Commercial, CHIP and Healthy U (Medicaid) plans. Refer to the "Policy" section for more information.
3. Services requiring prior-authorization may not be covered, if prior-authorization is not obtained.
4. This Medical Policy does not guarantee coverage or payment of the service. The service must be a benefit in the member's plan and the member must be eligible for coverage at the time of service. Additional payment guidelines may be applied that are not included in this policy.

Description:

Migraine is the most prevalent neurological disease afflicting a large part of the population across the world and ranks the 2nd leading cause of years lived with disability especially in the young and middle-aged. Up to 1/3 of migraine patients experiences aura; reversible transient focal neurological symptoms arising from the cortex or brainstem. Among patients with migraine with aura, 99% of patients report visual symptoms in at least some of their attacks, but symptoms may also include sensory, speech/language and motor symptoms and sometimes also higher cortical functions. Non-pharmacologic interventions, including single pulse transcranial magnetic stimulation, have been proposed in patients who are treatment resistant or intolerant to medications.

The eNeura SAVI Dual™ device is a single pulse transcranial magnetic stimulator, made up of a magnetic coil, power modules, software, and user interface, for the treatment of migraine headaches. This device delivers brief duration, rapidly alternating, or pulsed, magnetic fields that are externally directed at spatially discrete regions of the brain to induce electric currents for the treatment of migraine headache.

Policy Statement and Criteria

1. Commercial Plans/CHIP

U of U Health Plans covers single pulse TMS (eNeura SAVI®) when coverage requirements are met.

Criteria for Coverage (Must meet ALL)

A. Individuals >18 years of age;

B. Patient has been diagnosed with migraine headache by neurologist, headache specialist or in consultation with a neurologist;

C. Member is a candidate or on chronic migraine medications for treatment of migraine headaches.

2. Medicaid Plans

Coverage is determined by the State of Utah Medicaid program; if Utah State Medicaid has no published coverage position and InterQual criteria are not available, the U of U Health Plans Commercial criteria will apply. For the most up-to-date Medicaid policies and coverage, please visit their website at: https://medicaid.utah.gov/utah-medicaid-official-publications/ or the Utah Medicaid code Look-Up tool

CPT/HCPCS codes covered by Utah State Medicaid may still require further evaluation to determine medical necessity for coverage.

Clinical Rationale

An overview of 7 relevant SRs, of which 4 were of moderate quality and 3 were of low quality was completed according to AMSTAR 2 (a critical appraisal tool for systematic reviews). All SRs had low risk of bias in assessing relevance, synthesis and findings, and study eligibility criteria as evaluated by ROBIS. The identification and selection of studies, 4 SRs (57.1%) had low risk of bias. The PRISMA reporting standards were generally comprehensive, but some limitations were observed in the assessments, pooled results, evidence reliability, registration and protocols, and funding sources. The GRADE levels ranged from moderate to low, with 10 outcomes of moderate quality and 6 outcomes of low quality. The main reason for the low quality of evidence was the small sample size and high heterogeneity of the available studies. The authors concluded that transcranial magnetic stimulation (TMS) may improve migraine severity and frequency, but the current evidence is limited due to methodological flaws and heterogeneity. Therefore, future studies should standardize use, assess side effects, and compare with other treatments.

A 2022 scoping review (Calabro et al) evaluated TMS as a migraine management strategy for both attack treatment and prevention. This review presented 16 among single-pulse TMS (sTMS) (to manage episodic and chronic migraine) and repetitive TMS (rTMS) randomized clinical trials (to manage chronic migraine). The data suggest that TMS may be adopted as add-on therapy in those patients who are refractory to pharmacological therapy only with special arrangements for individualized treatment strategies or research. There are still limited clinical research programs and meta-analysis to promote routinely TMS employment, as TMS has been shown either to have no significant effects for any

outcome or to be effective for migraine. These diverging conclusions depend on several biasing factors, including the lack of reliable, large, sham-controlled clinical trials, the dyshomogeneity in study designs (including the area of stimulation, the frequency of stimulation, the number of pulses, pulse intensity, and the number of sessions), patient selection criteria (migraine w/o aura, episodic and chronic migraine; TMS contraindication), and the lack of outcomes homogeneity and long-term real-world efficacy data. The authors found no strong evidence to suggest the application of TMS in migraine as there are few available randomized trials. Therefore, these data cannot be generalized to all migraine patients. The authors concluded that the response rate for TMS does not seem to be superior to that of preventive drug treatment. However, there are several promising data on the prophylactic role of TMS in migraine, as also recognized by the FDA, which approved some TMS devices for the migraine attack treatment. Thus, further more robust randomized trials are needed to confirm TMSs usefulness in migraine management, for both acute attack and prophylactic treatment, along with being able to identify those patients who may benefit from TMS independently of pharmacological treatments (i.e., using TMS as an alternative and not only as an add-on treatment).

A 2021 systematic review (Ailani et al) sought to incorporate recent research findings, expert consensus, and patient perspectives into updated guidance on the use of new acute and preventive treatments for migraine in adults. The American Headache Society (AHS) previously published a Consensus Statement on the use of newly introduced treatments for adults with migraine. This update, which is based on the expanded evidence base and emerging expert consensus concerning post-approval usage, provides practical recommendations in the absence of a formal guideline and involved four steps: (1) review of data about the efficacy, safety, and clinical use of migraine treatments introduced since the previous Statement was published; (2) incorporation of these data into a proposed update; (3) review and commentary by the Board of Directors of the AHS and patients and advocates associated with the American Migraine Foundation; (4) consideration of these collective insights and integration. Since the last Consensus Statement, newly introduced acute treatments include two small-molecule calcitonin gene-related peptide (CGRP) receptor antagonists (ubrogepant, rimegepant); a serotonin (5-HT1F) agonist (lasmiditan); a nonsteroidal anti-inflammatory drug (celecoxib oral solution); and a neuromodulatory device (remote electrical neuromodulation). New preventive treatments include an intravenous anti-CGRP ligand monoclonal antibody (eptinezumab). Several modalities, including neuromodulation (electrical trigeminal nerve stimulation, noninvasive vagus nerve stimulation, single-pulse transcranial magnetic stimulation) and biobehavioral therapy (cognitive behavioral therapy, biofeedback, relaxation therapies, mindfulness-based therapies, acceptance and commitment therapy) may be appropriate for either acute and/or preventive treatment. The integration of new treatments into clinical practice should be informed by the potential for benefit relative to established therapies, as well as by the characteristics and preferences of individual patients.

A 2019 systematic review (Stilling et al) analyzed the use of transcranial magnetic stimulation (TMS) and transcranial direct current stimulation (tDCS) for the treatment of specific headache disorders (i.e., migraine, tension, cluster, posttraumatic). Thirty-four studies were included: 16 rTMS, 6 TMS (excluding rTMS), and 12 tDCS with the inclusion criteria consisting of adults 18-65 with primary or secondary headaches that had TMS and tDCS applied as headache treatment, were compared by sham or alternative standard of care, and only cohort, case-control, and randomized controlled trials [RCT] study types. A structured synthesis was performed due to heterogeneity of participants and methods. The majority investigated treatment for migraine (19/22 TMS, 8/12 tDCS). Quality of evidence ranged from very low to high. The authors concluded that of all TMS and tDCS modalities, TMS is the most promising with moderate evidence that it contributes to reductions in headache frequency, duration, intensity, abortive medication use, depression, and functional impairment. However, only few studies reported

changes greater than sham treatment. Therefore, further high-quality RCTs with standardized protocols are required for each specific headache disorder to validate a treatment effect.

In 2019 an additional systematic review of clinical trials (Reuter et al) evaluated non-invasive neuromodulation therapies for migraine and cluster headache as a practical and safe alternative to pharmacologics. Comparisons of these therapies are difficult because of the heterogeneity in study designs. The scientific rigor and clinical relevance of the available data were assessed to inform clinical decisions about non-invasive neuromodulation. PubMed, Cochrane Library and ClinicalTrials.gov databases and the WHO's International Clinical Trials Registry Platform were searched for relevant clinical studies of non-invasive neuromodulation devices for migraine and cluster headache (1 January 1990 to 31 January 2018), and 71 were identified. This analysis compared study designs using recommendations of the International Headache Society for pharmacological clinical trials, the only available guidelines for migraine and cluster headache. Non-invasive vagus nerve stimulation (nVNS), single-transcranial magnetic stimulation (sTMS) and external trigeminal nerve stimulation (all with regulatory clearance) were well studied compared with the other devices, for which studies frequently lacked proper blinding, sham controls and sufficient population sizes. The review concluded that nVNS studies demonstrated the most consistent adherence to available guidelines. Studies of all neuromodulation devices should strive to achieve the same high level of scientific rigor to allow for proper comparison across devices. Device-specific guidelines for migraine and cluster headache will be soon available, but until then, adherence to current guidelines for pharmacological trials will remain a key consideration for investigators and clinicians.

In a 2017 meta-analysis of RCTs, Lan et al evaluated the efficacy of TMS on migraine. Five studies, consisting of 313 migraine patients, were identified. Single-pulse transcranial magnetic stimulation is effective for the acute treatment of migraine with aura after the first attack ($p = 0.02$). And, the efficacy of TMS on chronic migraine was not significant (OR 2.93; 95% CI 0.71-12.15; $p = 0.14$). The authors concluded that based on the studies included in the article, TMS is an effective treatment for migraine.

In one of the first published studies on single pulse TMS in 2010 randomized, double-blind, parallel-group, two-phase, sham-controlled study, Lipton et al evaluated the efficacy and safety of a new portable sTMS device for acute treatment of migraine with aura. In phase one, 267 adults aged 18-68 years (66 patients dropped out) were enrolled and met international criteria for migraine with aura, with visual aura preceding at least 30% of migraines followed by moderate or severe headache in more than 90% of those attacks. In phase two, 201 individuals were randomly allocated by computer to either sham stimulation (n=99) or sTMS (n=102). Participants were instructed to treat up to three attacks over 3 months while experiencing aura. The primary outcome was pain-free response 2 hours after the first attack, and co-primary outcomes were non-inferiority at 2 hours for nausea, photophobia, and phonophobia. Analyses were modified intention to treat and per protocol. 37 patients did not treat a migraine attack and were excluded from outcome analyses. 164 patients treated at least one attack with sTMS (n=82) or sham stimulation (n=82; modified intention-to-treat analysis set). Pain-free response rates after 2 hours were significantly higher with sTMS (32/82 [39%]) than with sham stimulation (18/82 [22%]), for a therapeutic gain of 17% (95% CI 3-31%; p=0.0179). Sustained pain-free response rates significantly favored sTMS at 24 hours and 48 hours post-treatment. Non-inferiority was shown for nausea, photophobia, and phonophobia. No device-related serious adverse events were recorded, and incidence and severity of adverse events were similar between sTMS and sham groups. Early treatment of migraine with aura by sTMS resulted in increased freedom from pain at 2 hours compared with sham stimulation, and absence of pain was sustained 24 hours and 48 hours after treatment. The authors concluded that in some patients, sTMS is effective and well tolerated for acute treatment of migraine with aura. Although the exact mechanisms of migraine remain under study, administration of sTMS in

people with migraine with aura decreases progression of the attack in some individuals. Therefore, sTMS could be a promising acute treatment for some patients with migraine with aura.

In 2010 safety assessment of sTMS, Dodick et al analyzed potential and theoretical safety concerns of TMS obtained from studies of sTMS and repetitive TMS (rTMS), with sTMS in the context of its use as a migraine treatment. The published literature was reviewed to identify adverse events that have been reported during the use of TMS; to assess its potential effects on brain tissue, the cardiovascular system, hormone levels, cognition and psychomotor tests, and hearing; to identify the risk of seizures associated with TMS; and to identify safety issues associated with its use in patients with attached or implanted electronic equipment or during pregnancy. Two decades of clinical experience with sTMS have shown it to be a low risk technique with promise in the diagnosis, monitoring, and treatment of neurological and psychiatric disease in adults. Tens of thousands of subjects have undergone TMS for diagnostic, investigative, and therapeutic intervention trial purposes with minimal adverse events or side effects. No discernable evidence exists to suggest that sTMS causes harm to humans. No changes in neurophysiological function have been reported with sTMS use. The authors concluded that the safety of sTMS in clinical practice, including as an acute migraine headache treatment, is supported by biological, empirical, and clinical trial evidence. Therefore, sTMS may offer a safe nonpharmacologic, non-behavioral therapeutic approach to the currently prescribed drugs for patients who suffer from migraine.

An initial randomized control study in 2015 by Bhola et al evaluated the outcome data for the UK post market pilot program on single pulse transcranial magnetic stimulation (sTMS) for acute migraine treatment, which commenced in June 2011 following receipt of the CE mark for the SpringTMS device. Migraine patients with and without aura treated with sTMS had an initial review (n = 426) and training call, and then participated in telephone surveys at week six (n = 331) and week 12 during a 3-month treatment period (n = 190). Of the patients surveyed with 3 month data (n = 190; episodic, n = 59; chronic, n = 131), 62 % reported pain relief, finding the device effective at reducing or alleviating migraine pain; in addition there was relief reported of associated features: nausea- 52 %; photophobia- 55 %; and phonophobia- 53 %. At 3 months there was a reduction in monthly headache days for episodic migraine, from 12 (median, 8-13 IQ range) to 9 (4-12) and for chronic migraine, a reduction from 24 (median, 16-30 IQ range) to 16 (10-30). There were no serious or unanticipated adverse events. The authors concluded that sTMS may be a valuable addition to options for the treatment of both episodic and chronic migraine.

A subsequent 2018 open-label prospective pilot study (Irwin et al) evaluated the feasibility, tolerability, and patient acceptability of sTMS for migraine prevention in adolescents aged 12-17 years. Participants used sTMS twice daily in a preventative fashion, as well as additional pulses as needed acutely. A 4-week baseline run-in period (weeks 1-4) was followed by a 12-week treatment period. Feasibility was the primary outcome. Secondary outcomes included tolerability and acceptability, as well as the change in headache days, number of moderate/severe headache days, days of acute medication use, and PedMIDAS (headache disability) scores between the run-in period (weeks 1-4) and the third month of treatment (weeks 13-16). Twenty-one participants enrolled. Nineteen completed the baseline run-in, and 12 completed the study. Using sTMS proved feasible and acceptable with overall high compliance once treatment administration was streamlined. Initially, for preventive treatment, participants were asked to give 2 pulses, wait 15 minutes, then give 2 additional pulses twice daily. This 15-minute delay proved challenging for adolescents, particularly on school days, and therefore was dropped. Study completion rate went from 4/13 (31%) to 7/8 (88%) once this change was made, P = .024. On average, participants used the device preventively between 22 and 24 days over a 28-day block. There were no serious adverse events. Two participants reported mild discomfort with device use. The authors

concluded that sTMS appears to be a feasible, well-tolerated, and acceptable nonpharmacologic preventive treatment for migraine in adolescents. However, further more robust trials are needed to determine efficacy and in designing future trials, streamlined treatment administration will be essential to minimize drop-out.

In 2020 Lloyd et al. sought to identify the mechanism of action and cortical effects from the single pulse transcranial magnetic stimulation (sTMS) treatment in migraine. Using calcium imaging and GCaMP-expressing mice, sTMS did not depolarize neurons and had no effect on vascular tone. Pre-treatment with sTMS, however, significantly affected some characteristics of the cortical spreading depression (CSD) wave, the correlate of migraine aura. sTMS inhibited spontaneous neuronal firing in the visual cortex in a dose-dependent manner and attenuated L-glutamate-evoked firing, but not in the presence of GABA(A/B) antagonists. In the CSD model, sTMS increased the CSD electrical threshold, but not in the presence of GABA(A/B) antagonists. The authors concluded that sTMS at intensities similar to those used in the treatment of migraine, unlike traditional sTMS applied in other neurological fields, does not excite cortical neurons but it reduces spontaneous cortical neuronal activity and suppresses the migraine aura biological substrate, potentially by interacting with GABAergic circuits.

Also in 2020 consensus panel review, which included multinational multidisciplinary experts, (Leung, A., et al) assessed the utilization of TMS in the treatment of neuropathic pain (NP), acute pain, primary headache disorders, posttraumatic brain injury related headaches (PTBI-HA), and comorbid depression to provide treatment recommendations and guidelines. The panel rated the overall level of evidence and recommendability for clinical implementation of TMS as: 1) high and extremely/strongly for both NP and PTBI-HA respectively; 2) moderate for postoperative pain and migraine prevention, and recommendable for migraine prevention. After extensive literature review the panel concluded that while the use of TMS for treating both pain and depression in one setting is clinically and financially sound, more studies are required to fully assess the long-term benefit of the treatment for the two highly comorbid conditions, especially with neuronavigation. They did provide recommendations and treatment guidelines for TMS in managing neuropathic pain and headaches. In addition, they also recommended further outcome and cost-effectiveness studies to assess the feasibility of the long-term clinical implementation of the treatment.

Neurostimulation methods have now been studied for more than 20 years in migraine treatment. They can be divided into invasive and non-invasive methods. In this 2021 narrative review, Evers presents non-invasive methods. The most commonly studied and used methods are vagal nerve stimulation, electric peripheral nerve stimulation, transcranial magnetic stimulation, and transcranial direct current stimulation. Other stimulation techniques, including mechanical stimulation, play only a minor role. Nearly all methods have been studied for acute attack treatment and for the prophylactic treatment of migraine. Evers concluded that the evidence of efficacy is poor for most procedures, since no stimulation device is based on consistently positive, blinded, controlled trials with a sufficient number of patients. In addition, most studies on these devices enrolled patients who did not respond sufficiently to oral drug treatment, and so the role of neurostimulation in an average population of migraine patients is unknown. In the future, it is very important to conduct large, properly blinded and controlled trials performed by independent researchers. Otherwise, neurostimulation methods will only play a very minor role in the treatment of migraine.

In a prospective, single center, open-label, real-world analysis conducted in 2022, Loyd et al assessed difficult-to-treat patients with high-frequency episodic migraine (HFEM) and chronic migraine (CM) with and without medication overuse headache (MOH), who were exposed to sTMS therapy. Patients responding to a three-month sTMS treatment, continued the treatment and were assessed again at

month 12. The cut-off outcome for treatment continuation was reduction in the monthly moderate to severe headache days (MHD) of at least 30% (headache frequency responders) and/or a >/= 4-point reduction in headache disability using the Headache Impact test-6 (HIT-6) (headache disability responders). One hundred fifty-three patients were included in the analysis (F:M = 126:27, median age 43, IQR 32.3-56.8). At month 3, 93 out of 153 patients (60%) were responders to treatment. Compared to baseline, the median reduction in monthly headache days (MHD) for all patients at month 3 was 5.0 days, from 18.0 (IQR: 12.0-26.0) to 13.0 days (IQR: 5.75-24.0) (P = 0.002, r = - 0.29) and the median reduction in monthly migraine days (MMD) was 4.0 days, from 13.0 (IQR: 8.75-22.0) to 9.0 (IQR: 4.0-15.25) (P = 0.002, r = - 0.29). Sixty-nine out of 153 patients (45%) reported a sustained response to sTMS treatment at month 12. The percentage of patients with MOH was reduced from 52% (N = 79/153) at baseline to 19% (N = 29/153) at month 3, to 8% (N = 7/87) at month 12. There was an overall median 4-point reduction in HIT-6 score, from 66 (IQR: 64-69) at baseline to 62 at month 3 (IQR: 56-65) (P < 0.001, r = - 0.51). A total of 35 mild/moderate adverse events were reported by 23 patients (15%). One patient stopped sTMS treatment due to scalp sensitivity. The authors concluded that this open label analysis suggests that sTMS may be an effective, well-tolerated treatment option for the long-term prevention of difficult-to-treat CM and HFEM.

Another study from 2022, Siebner et al examined neural elements in the cortex to determine which ones are primarily targeted with TMS. TMS is currently the method of choice to non-invasively induce neural activity in the human brain. A single transcranial stimulus induces a time-varying electric field in the brain that may evoke action potentials in cortical neurons. The spatial relationship between the locally induced electric field and the stimulated neurons determines axonal depolarization. The induced electric field is influenced by the conductive properties of the tissue compartments and is strongest in the superficial parts of the targeted cortical gyri and underlying white matter. TMS likely targets axons of both excitatory and inhibitory neurons. The propensity of individual axons to fire an action potential in response to TMS depends on their geometry, myelination and spatial relation to the imposed electric field and the physiological state of the neuron. The latter is determined by its transsynaptic dendritic and somatic inputs, intrinsic membrane potential and firing rate. Modeling work suggests that the primary target of TMS is axonal terminals in the crown top and lip regions of cortical gyri. The induced electric field may additionally excite bends of myelinated axons in the juxtacortical white matter below the gyral crown. Neuronal excitation spreads ortho- and antidromically along the stimulated axons and causes secondary excitation of connected neuronal populations within local intracortical microcircuits in the target area. Axonal and transsynaptic spread of excitation also occurs along cortico-cortical and cortico-subcortical connections, impacting on neuronal activity in the targeted network. Both local and remote neural excitation depend critically on the functional state of the stimulated target area and network. TMS also causes substantial direct co-stimulation of the peripheral nervous system. Peripheral co-excitation propagates centrally in auditory and somatosensory networks, but also produces brain responses in other networks subserving multisensory integration, orienting or arousal. The authors concluded that the complexity of the response to TMS warrants cautious interpretation of its physiological and behavioral consequences, and a deeper understanding of the mechanistic underpinnings of TMS will be critical for advancing it as a scientific and therapeutic tool.

In 2023 UpToDate reported on the acute treatment of migraine in adults with sTMS and found that the efficacy of sTMS was demonstrated in a sham-controlled trial of 201 adults with episodic migraine with aura. The analysis was based upon 164 patients who treated at least one attack of migraine during the aura phase. Pain freedom at two hours post-treatment was significantly greater with the TMS device compared with sham stimulation (39 versus 22 percent, absolute risk reduction 17 percent, 95% CI 3-31

percent). Furthermore, significance for a sustained pain-free response was maintained at both 24 and 48 hours. There were no serious adverse events related to use of the device.

Also, in 2023, UpToDate reported on the preventive treatment of episodic migraine in adults and found limited observational evidence suggests that single-pulse transcranial magnetic stimulation (sTMS) may be effective for migraine prevention. An open-label, prospective study of subjects with episodic and chronic migraine, with and without aura, assessed preventive (four pulses twice daily) and acute (three pulses repeated up to three times for each migraine attack) sTMS treatment over a 12-week period. During weeks 9 through 12, the mean reduction of headache days was greater with TMS compared with an estimated placebo response derived from historical data (-2.75 versus -0.63 days). Adverse events were infrequent, but included lightheadedness, tingling, and tinnitus. In a meta-analysis of sham-controlled trials, repetitive TMS over the dorsolateral prefrontal cortex was associated with reduced functional disability and medication use but no improvement in pain intensity or headache days. sTMS received FDA approval for the acute and prophylactic treatment of migraine in 2017.

A single-pulse TMS device received approval in the United States by the US Food and Drug Administration (FDA) for the acute treatment and prevention of migraine in adolescents (age ≥12 years) and adults. The portable TMS device may prove to be useful as a second-line intervention for those who have migraine that does not respond to first-line therapy with triptans or other agents discussed above or who are unable to take these agents because of contraindications or intolerance. However, TMS should not be used to treat migraine for patients who have epilepsy, since there is theoretical concern that TMS could trigger seizures.

The FDA issued a premarket 510(k) approval for the eNeura SAVI Dual™ device for the treatment of migraine headaches on May 16, 2023 (K230358).

Applicable Coding

CPT Codes

64999 Unlisted procedure, nervous system

HCPCS Codes

No applicable codes

References:

1. Ailani, J., et al. (2021). "The American Headache Society Consensus Statement: Update on integrating new migraine treatments into clinical practice." Headache 61(7): 1021-1039.
2. Barker, A. T. and K. Shields (2017). "Transcranial Magnetic Stimulation: Basic Principles and Clinical Applications in Migraine." Headache 57(3): 517-524.
3. Bhola, R., et al. (2015). "Single-pulse transcranial magnetic stimulation (sTMS) for the acute treatment of migraine: evaluation of outcome data for the UK post market pilot program." J Headache Pain 16: 535.
4. Calabro, R. S., et al. (2022). "Applications of transcranial magnetic stimulation in migraine: evidence from a scoping review." J Integr Neurosci 21(4): 110.
5. Dodick, D. W., et al. (2010). "Transcranial magnetic stimulation for migraine: a safety review." Headache 50(7): 1153-1163.
6. Evers S. Non-Invasive Neurostimulation Methods for Acute and Preventive Migraine Treatment-A Narrative Review. J Clin Med. 2021 Jul 27;10(15):3302. doi: 10.3390/jcm10153302. PMID: 34362086; PMCID: PMC8347785.
7. Food and Drug Administration (FDA). “SAVI Dual™ Migraine Therapy”. Premarket 510(k) K230358. May 16, 2023. Accessed: October 10, 2023. Available at: https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfpcd/classification.cfm?id=3976
8. Hansen, J. M. and A. Charles (2019). "Differences in treatment response between migraine with aura and migraine without aura: lessons from clinical practice and RCTs." J Headache Pain 20(1): 96.

9. Irwin, S. L., et al. (2018). "Transcranial Magnetic Stimulation for Migraine Prevention in Adolescents: A Pilot Open-Label Study." Headache 58(5): 724-731.
10. Lan, L., et al. (2017). "The efficacy of transcranial magnetic stimulation on migraine: a meta-analysis of randomized controlled trails." J Headache Pain 18(1): 86.
11. Leung, A., et al. (2020). "Transcranial Magnetic Stimulation for Pain, Headache, and Comorbid Depression: INS-NANS Expert Consensus Panel Review and Recommendation." Neuromodulation 23(3): 267-290.
12. Lipton, R. B., et al. (2010). "Single-pulse transcranial magnetic stimulation for acute treatment of migraine with aura: a randomised, double-blind, parallel-group, sham-controlled trial." Lancet Neurol 9(4): 373-380.
13. Lloyd, J. O., et al. (2020). "Cortical Mechanisms of Single-Pulse Transcranial Magnetic Stimulation in Migraine." Neurotherapeutics 17(4): 1973-1987.
14. Lloyd, J. O., et al. (2022). "Single-Pulse Transcranial Magnetic Stimulation for the preventive treatment of difficult-to-treat migraine: a 12-month prospective analysis." J Headache Pain 23(1): 63.
15. Reuter, U., et al. (2019). "Non-invasive neuromodulation for migraine and cluster headache: a systematic review of clinical trials." J Neurol Neurosurg Psychiatry 90(7): 796-804.
16. Saltychev, Mikhail, and Juhani Juhola. "Effectiveness of high-frequency repetitive transcranial magnetic stimulation in migraine: a systematic review and meta-analysis." American Journal of Physical Medicine & Rehabilitation 101.11 (2022): 1001-1006
17. Shen M, Li C, Wei X, Zhang L, Li Y, Wu H, Zhang X, Dong Z, Gao S, Ma Y, Ma Y. Transcranial Magnetic Stimulation as a Therapy for Migraine: An Overview of Systematic Reviews. J Pain Res. 2023 Sep 13;16:3133-3144. doi: 10.2147/JPR.S416993. PMID: 37724171; PMCID: PMC10505396.
18. Siebner, H. R., et al. (2022). "Transcranial magnetic stimulation of the brain: What is stimulated? - A consensus and critical position paper." Clin Neurophysiol 140: 59-97.
19. Stilling, J. M., et al. (2019). "Transcranial Magnetic and Direct Current Stimulation (TMS/tDCS) for the Treatment of Headache: A Systematic Review." Headache 59(3): 339-357.
20. UpToDate® "Acute Treatment of Migraine in Adults". Literature current through: September 2023. Topic last updated: August 10, 2023. Topic 3347. Version 98.0. Accessed: October 12, 2023. Available at: https://www.uptodate.com/contents/acute-treatment-of-migraine-in-adults?search=single%20pulsed%20transcranial%20magnetice%20stimulation&source=search_result&selectedTitle=9~150&usage_type=default&display_rank=9#H1082803594
21. UpToDate® "Preventive Treatment of Episodic Migraine in Adults". Literature current through September 2023. Topic last updated: September 25, 2023. Accessed: October 12, 2023. Available at: https://www.uptodate.com/contents/preventive-treatment-of-episodic-migraine-in-adults?search=single%20pulsed%20transcranial%20magnetice%20stimulation&source=search_result&selectedTitle=16~150&usage_type=default&display_rank=16#H344989030
22. Zhong, Jiugen, et al. "Efficacy of repetitive transcranial magnetic stimulation on chronic migraine: A meta-analysis." Frontiers in Neurology 13 (2022): 1050090.