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SHORT SCIENTIFIC COMMUNICATION

Repetitive transcranial magnetic stimulation in veterans with debilitating tinnitus: A pilot study

Scott L. Lee, MD, Megan Abraham, BS, Anthony T. Cacace, PhD, and **Steven M. Silver, MD,** Albany, and Schenectady, NY

OBJECTIVE: Available evidence suggests tinnitus arises from excessive spontaneous activity in the left superior temporal gyrus, and repetitive transcranial magnetic stimulation (rTMS) may suppress this activity. Our hypothesis is that rTMS applied to this region would decrease tinnitus complaints in veterans.
STUDY DESIGN: Prospective, nonrandomized trial.
SUBJECTS AND METHODS: Eight patients with tinnitus received 5 consecutive days of rTMS (0.5 Hz, 20 minutes) to the left temporoparietal area. Tinnitus Handicap Inventory (THI) measures before sessions 1 and 3 and after session 5 were used to evaluate efficacy.
RESULTS: Patient 1's THI decreased 40 to 34 to 26, patient 4 reported a subjective improvement, patient 8 withdrew, and the remaining patients reported no improvement. Adverse effects included temporary soreness, restlessness, and photophobia.
CONCLUSION: The parameters for this rTMS study are different from those that reported success with its use. With these current parameters, rTMS did not improve tinnitus in veterans. There were no permanent adverse outcomes.

Tinnitus is the perception of sound in the absence of auditory stimulus. It is estimated to affect 2 to 4 million veterans as a chronic condition.[1] Functional imaging studies in individuals with chronic tinnitus revealed excessive spontaneous activity in the central auditory system.[2] Mounting evidence suggests that low-frequency repetitive transcranial magnetic stimulation (rTMS) temporarily decreases cortical hyperexcitability, thus decreasing tinnitus.[3] The hypothesis of this pilot study is that rTMS applied to the left temporoparietal area over a sequential 5-day period would improve tinnitus in veterans.

METHODS

rTMS is not approved by the United States Food and Drug Administration for any treatment and is limited to research use. Institutional review board approval and informed consent were obtained. Eight adults with moderate to severe tinnitus, Tinnitus Handicap Inventory (THI)[4] scores between 38 and 100, were enrolled. Patient 8 was included despite an initial THI of 18 because his symptomatology more appropriately placed him into a moderate category. Complete history, physical, and audiologic examinations were performed to rule out pharmacologic and/or central nervous system etiologies for tinnitus.

rTMS was delivered with the Magstim 200 (Magstim Company Ltd, Wales, UK) by using a figure-eight coil. A single pulse of TMS was delivered to the primary motor cortex to evoke a contralateral thenar motor response. The lowest intensity of TMS that generated a detectable thenar response defined that patient's motor threshold (MT). Six hundred stimuli at 100% MT were presented at a frequency of 0.5 Hz to the left temporoparietal cortex, regardless of tinnitus laterality, on 5 consecutive days. Foam earplugs were used to attenuate the instrumentation noise. THI measures were obtained before rTMS, immediately preceding the third treatment, and after the last session.

RESULTS

The eight male patients (age range 57-85 years) had bilateral, nonpulsatile tinnitus and a history of noise exposure during military service. THI for patient 1 decreased from 40 to 34 to 26. Patients 2 through 8 had no improvement in their THIs (90, 92, 92; 70, 72, 66; 38, 40, 36; 24, 26, 24; 72, 72, 72; 48, 50, 50; and 18, not applicable, not applicable; respectively). Patient 4 had less tinnitus after treatment 1 that was not reflected by his THI. Patient 3 reported ipsilateral jaw soreness after the first treatment. Patient 8 withdrew after the first session reporting restlessness, imbalance, and photophobia. All side effects resolved spontaneously, and there were no major adverse outcomes.

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DISCUSSION

Functional imaging studies suggest chronic tinnitus to be associated with excessive spontaneous activity in the left temporoparietal cortex, and rTMS may suppress this activity.[2,3] Short-term concerns with rTMS include local discomfort secondary to stimulation of the scalp, and long-term side effects (eg, seizures) are rare.[5] In this study, there were no major adverse effects. Minor side effects included ipsilateral jaw soreness (patient 3) and restlessness (patient 8). Both patients' complaints resolved spontaneously. At the current stimulation parameters, rTMS appears to be safe.

Patient 1 showed improvement in his THI. However, he passed away of an unrelated cause at 5 months, and no long-term follow-up is available. The remaining patients had no improvement in their THIs. These data are in contrast to some of the early success of rTMS reported in the literature. The authors present this series to offer discussion points and contribute to the refinement of rTMS delivery parameters.

In previous rTMS studies, frequencies ranged from 1 to 20 Hz, power varied from 90% to 110% of MT, and duration ranged from 5 to 28 days.[3,5] In this study, the Magstim 200 had a maximal stimulation frequency of about 0.5 Hz. This is lower than the frequencies used by investigators that reported rTMS success. Thus, 0.5 Hz may represent a lower limit of rTMS efficacy. Another difference is that we set power to 100% MT rather than 90% or 110%.[2,3,5] Stimulation should be delivered beyond the overlying soft tissue, so we expect 90% MT to be inadequate; 100% MT should stimulate the cortex, whereas 110% MT may target deeper cortical-thalamic connections. Success with using 110% MT in the literature, combined with the current negative findings of using 100% MT, imply subcortical stimulation may be more efficacious than cortical stimulation. Another possibility is that 600 daily pulses may not be sufficient to affect the proposed hyperexcitability of the auditory cortex. Finally, this veteran population has prolonged tinnitus, which may be less responsive to rTMS.

Accurate delivery of rTMS is important to successfully modulate tinnitus. Perhaps there is a role for right-sided or bilateral stimulation. Neuronavigation-directed rTMS has been reported to be successful,[3] but it may not be cost-effective. Moreover, the precision of TMS does not match the spatial resolution of modern neuroimaging. Therefore, neuronavigation protocols may exceed diagnostically what we are able to deliver therapeutically.

The characterization of tinnitus in this study is limited to the THI. Psychoacoustic measures to quantify pitch, loudness, and the character of tinnitus would provide a more objective supplemental measure of treatment outcomes. This could be incorporated into future studies. Finally, the authors acknowledge that the limited number of study subjects and data points preclude any robust statistical evaluation. The improvement in patient 1 may simply reflect a placebo effect. Ultimately, a larger randomized trial comparing different rTMS settings and duration of treatment would further refine optimal treatment parameters.

CONCLUSION

Although rTMS may offer promise in suppressing tinnitus temporarily in a safe and noninvasive manner, further research is required to refine delivery parameters and measures of efficacy.

AUTHOR INFORMATION

From the Division of Otolaryngology–Head and Neck Surgery, Albany Medical College, Albany, NY (Drs Lee and Silver); Union College, Schenectady, NY (Dr Abraham); Department of Communication Sciences and Disorders, Wayne State University, Detroit, MI (Dr Cacace); and Department of Otolaryngology–Head & Neck Surgery, Stratton VA Medical Center, Albany, NY (Dr Silver).

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Corresponding author: Dr Scott L. Lee, Division of Otolaryngology–Head and Neck Surgery, Albany Medical College, MC-41, 47 New Scotland Ave, Albany, NY 12208.

E-mail address: leesl@mail.amc.edu.

AUTHOR CONTRIBUTIONS

Scott L. Lee, design, data, writer; **Megan Abraham,** data; **Anthony T. Cacace,** design; **Steven M. Silver,** design, data.

FINANCIAL DISCLOSURE

None.

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