ISSN : 2350-0743

www.ijramr.com

*International Journal of Recent Advances in Multidisciplinary Research*

*Vol. 07, Issue 01, pp. 5519-5523, January, 2020*

# RESEARCH ARTICLE

## COMPARISON OF DISTORTION PRODUCT OTOACOUSTIC EMISSIONS (DPOE'S) AND PURE TONE AUDIOMETRY (PTA) DATA RESULTS, IN PATIENTS RECEIVING TRANSCRANIAL MAGNETIC STIMULATION (TMS) AS SOURCE OF NOISE.

***Kamlesh Kumar Dubey**

Melaka-Manipal Medical College, Department of ENT, Bukit Baru, Melaka, Pin-75150

**ARTICLE INFO**

***Article History:***
Received 10th October, 2019
Received in revised form
29th November, 2019
Accepted 05th December, 2019
Published online 30th January, 2020

***Keywords:***
Regeneration Potential,
Tree Volume,
and Biodiversity.

**ABSTRACT**

**Introduction:** Magnetic stimulation is a non-invasive method of stimulating brain and peripheral nervous system using induced currents, when used to stimulate brain it is normally referred to as Transcranial magnetic stimulation (TMS). The last decade has seen a rapid increase in applications of TMS to study cognition, behavior relations and the pathophysiology of various neurologic and psychiatric disorders. Further increase in the widespread use of TMS in medical therapeutic and research applications is expected. This makes the need for clear and updated safety guidelines and recommendations of proper practice and application critical. **Aims & Objectives:** The main aims and objectives of this study is to find out the noise induced auditory changes in patients receiving TMS treatment. Changes were measured with Pure tone audiometry and DPOAE's data obtained compared reliability. **Materials & Methods:** 42 Patients with diagnosis of double drug resistant depression and schizophrenia were included in this study. Baseline PTA and DPOAE's performed and repeated at 1,3,6 month interval. **Result:** Patients developed transient SNHL after TMS noise exposure which improved and come to near normal in one month. One patient had persistent SNHL. Data from PTA and DPOAE's were compared which found to be correlate with clinical finding after TMS noise exposure. **Conclusion:** The present study is one of the few studies done till now to study the changes on distorted product of otoacoustic emissions (DPOAEs), its shows OAEs are better to study the noise induced auditory threshold changes when comparing with pure tone threshold(PTA) results.

## INTRODUCTION

Magnetic stimulation is a non-invasive method of stimulating brain and peripheral nervous system using induced currents, when used to stimulate brain it is normally referred to as Trans cranial magnetic stimulation (TMS) (1). Anthony Barker et.al in 1985 first described the use of a changing (pulsed) magnetic field focused over specific regions of cerebral cortex to induce muscle action potential (2). The device consists of a stimulating coil, which comes in various shapes i.e., round coil (original shape used first time), figure of eight coil (butterfly coil) the most common type of coil in use, H-coil, double cone coli (3). The discharging of capacitor inside makes electric current flow through the stimulation coil, generation a changing magnetic field with characteristic features like generated magnetic field lasting 100-300 milliseconds and its intensity ranging from 1-2.5 Tesla. This magnetic field passes without resistance through the soft tissues of head and skull and inducing a secondary electrical current in the brain, resulting in depolarization of neurons (4).

**The (figure1) showing the basic principle involved:** Epstein et.al 1990(5) indicated that the electrical field does not penetrate deeply into the brain structure (at most 2 cm).

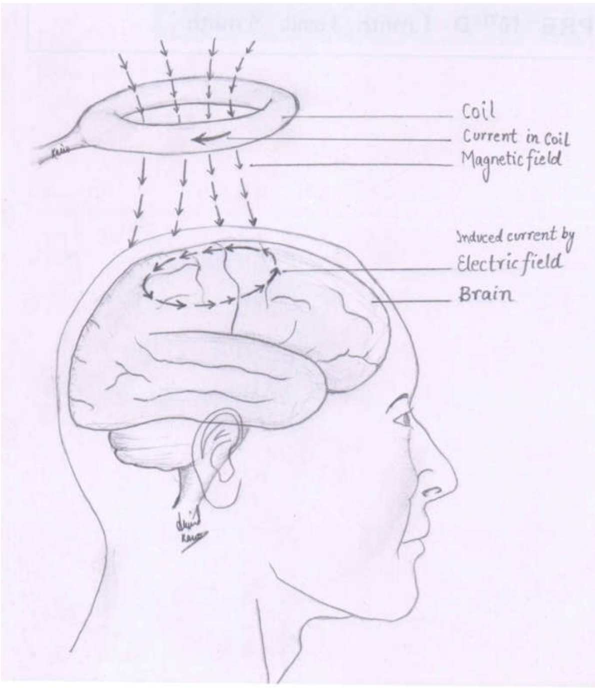
***Corresponding author:* Kamlesh Kumar Dubey,**
Melaka-Manipal Medical College, Department of ENT, Bukit Baru, Melaka, Pin-75150.

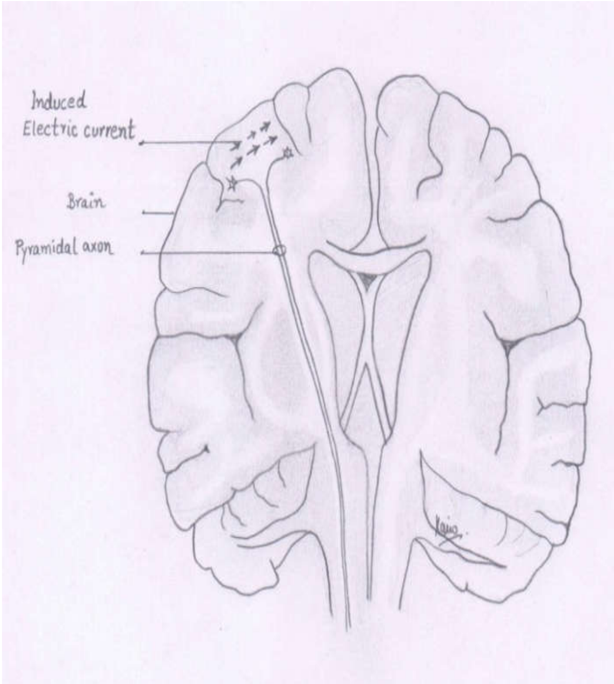
This results mainly in activation of structures just underneath the scalp, such as cerebral cortex or subcortical white matter. Marg and Rudiak 1994(6) indicated that stimulation may reach slightly deeper 18-21mm.The magnetic pulses may be administered individually or in pairs that are a few milliseconds apart (so called paired pulse stimulation), or repeatedly in a sequence, or train, lasting from seconds to minutes also known as repetitive transcranial magnetic stimulation(rTMS). The repetitive transcranial magnetic stimulation is defined by number of pulses or frequency in Hertz (Hz). According to frequency it is divided in to "low frequency" (slow) rTMS with 1 Hz or less and "high frequency) (fast) rTMS with more than 1 Hz (usually between 5 and 25 Hz). The last decade has seen a rapid increase in applications of TMS to study cognition, behavior relations and the pathophysiology of various neurologic and psychiatric disorders (6, 7,). Since 2002 approval in Canada for medication resistant depression and food and drug administration(FDA) in United States approval for use in unipolar depression, it has gained widespread use both in therapeutic as well for research and diagnostic purposes. Therapeutic use has been claimed in literature for psychiatry disorders like depression, acute mania, bipolar disorder, panic, hallucinations obsession and compulsion, schizophrenia, catatonia, posttraumatic stress disorder, neurologic diseases i.e., Parkinson's disease, dystonia, stuttering, spasticity, epilepsy, tinnitus (11,12,13,14,15,16). Further increase in the widespread use of TMS in medical therapeutic and research applications is expected. This makes the need for clear and updated safety guidelines and recommendations of proper practice and application critical (9). The present study was designed and done to evaluate the auditory changes associated with use of TMS, and at the same time if it has any effects on the vestibular system and data from DPOE's and PTA investigations compared to know better prediction of noise induced hearing impairment.

**Aims and objectives:** The main aims and objectives of this study is to find out the noise induced auditory changes in patients receiving TMS treatment. Changes were measured with Pure tone audiometry and DPOAE's data obtained compared reliability.

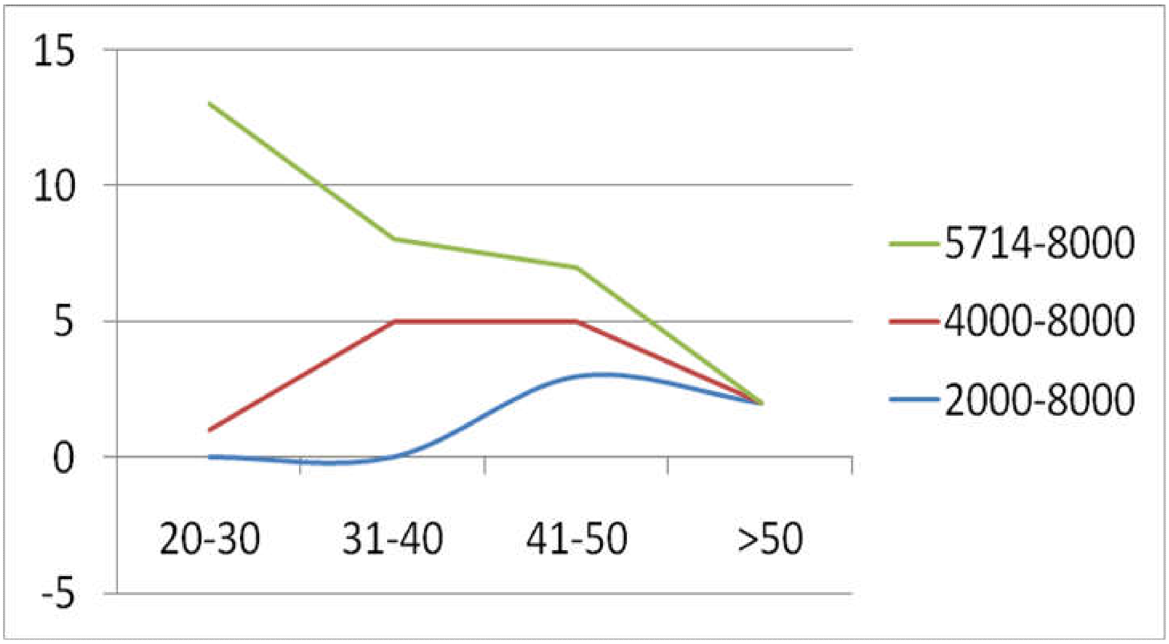
## MATERIAL AND METHODS

The study was conducted in the department of Otorhinolaryngology and Department of Psychiatry in All India Institute of Medical Sciences, New Delhi. After ethical clearance, forty-two patients were included in study. Informed and written consent and thorough ENT examinations were done to rule out any other co morbidities. The transcranial magnetic stimulation was given by Magstim Rapid Magnetic Stimulator Unit, Magstim Corporation, New York, NY (Figure 3). All patients wereadults who were included in study (age ≥18 yrs.).All patients who were willingness for study, with age adjusted normal SNHL, conductive hearing loss of 20dB, with no previous history of dizziness, imbalance were included in study after informed and written consent.

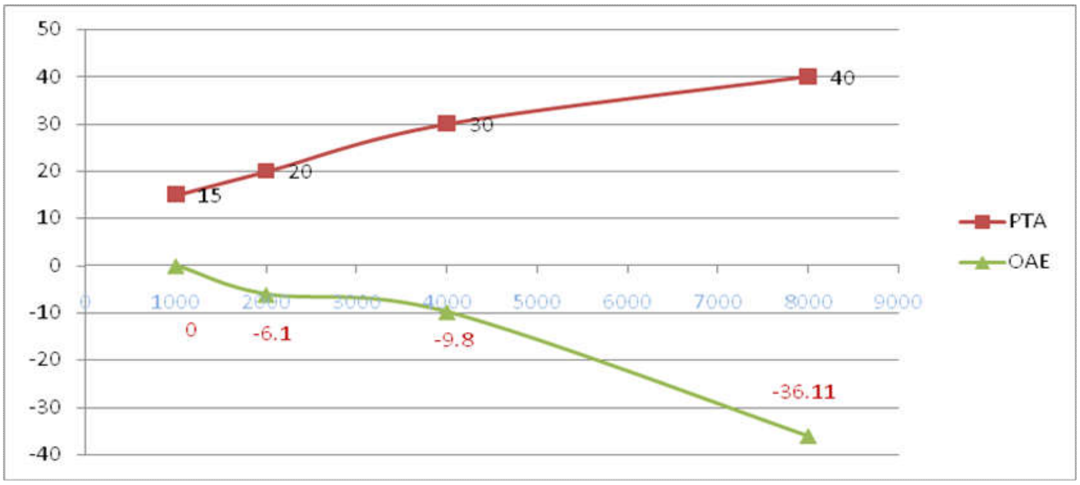



**DPOAEs changes with age:**



## Statistical analysis




**Distorted Product of Otoacoustic Emissions (DPOAEs) frequency changes:**

| Distorted Product Of Otoacoustic Emissions (DPOAE) Frequency Changes On 10th day | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| S. no | Patient | Age | Sex | Pre TMS | 10th day | 1 month | 3 month | 6 month |
| 1 | SO | 30 | M | | 5714-8000 | 1000-8000-N | 1000-8000-N | 1000-8000-N |
| 2 | SU | 25 | M | | 5714-8000 | 1000-8000-N | 1000-8000-N | 1000-8000-N |
| 3 | AM | 36 | M | | 4000-8000 | 1000-8000-N | 1000-8000-N | 1000-8000-N |
| 4 | PB | 37 | M | | 5714-8000 | 1000-8000-N | 1000-8000-N | 1000-8000-N |
| 5 | PT | 28 | M | | 5714-8000 | 1000-8000-N | 1000-8000-N | 1000-8000-N |
| 6 | SA | 27 | M | | 5714-8000 | 1000-8000-N | 1000-8000-N | 1000-8000-N |
| 7 | VP | 43 | M | | 4000-8000 | 1000-8000-N | 1000-8000-N | 1000-8000-N |
| 8 | SS | 62 | M | | 2857-8000 | 4000-8000-D | 4000-8000-D | 5714-8000-N |
| 9 | EA | 44 | M | | 4000-8000 | 1000-8000-N | 1000-8000-N | 1000-8000-N |
| 10 | SS | 27 | F | | 4000-8000 | 1000-8000-N | 1000-8000-N | 1000-8000-N |
| 11 | SK | 32 | M | | 5714-8000 | 1000-8000-N | 1000-8000-N | 1000-8000-N |
| 12 | JSA | 65 | M | | 2000-8000 | 1000-8000-N | 1000-8000-N | 1000-8000-N |
| 13 | DK | 38 | M | | 2857-8000 | 1000-8000-N | 1000-8000-N | 1000-8000-N |
| 14 | SS | 39 | F | | 4000-8000 | 1000-8000-N | 1000-8000-N | 1000-8000-N |
| 15 | GM | 42 | M | | 2857-8000 | 1000-8000-N | 1000-8000-N | 1000-8000-N |
| 16 | TS | 35 | M | | 4000-8000 | 1000-8000-N | 1000-8000-N | 1000-8000-N |
| 17 | SA | 27 | F | | 5714-8000 | 1000-8000-N | 1000-8000-N | 1000-8000-N |
| 18 | JK | 44 | M | | 5714-8000 | 5714-8000 | 1000-8000-N | 1000-8000-N |
| 19 | AG | 33 | M | | 5714-8000 | 1000-8000-N | 1000-8000-N | 1000-8000-N |
| 20 | HK | 49 | M | | 2857-8000 | 1000-5714-N 8000-D | 1000-5714-N 8000-D | 1000-5714-N 8000-D |
| 21 | PK | 27 | M | | 5714-8000 | 1000-8000-N | 1000-8000-N | 1000-8000-N |
| 22 | RG | 43 | M | | 2857-8000 | 1000-8000-N | 1000-8000-N | 1000-8000-N |
| 23 | SC | 49 | F | | 2857-8000 | 1000-5714-N 8000-D | 1000-8000-N | 1000-8000-N |
| 24 | US | 38 | F | | 4000-8000 | 1000-8000-N | 1000-8000-N | 1000-8000-N |
| 25 | VK | 28 | M | | 5714-8000 | 1000-8000-N | 1000-8000-N | 1000-8000-N |
| 26 | SG | 30 | M | | 5714-8000 | 1000-8000-N | 1000-8000-N | 1000-8000-N |
| 27 | PC | 21 | M | | 5714-8000 | 1000-8000-N | 1000-8000-N | 1000-8000-N |
| 28 | AG | 25 | M | | 4000-8000 | 1000-8000-N | 1000-8000-N | 1000-8000-N |
| 29 | SR | 33 | F | | 5714-8000 | 1000-8000-N | 1000-8000-N | 1000-8000-N |
| 30 | SK | 25 | M | | 4000-8000 | 1000-8000-N | 1000-8000-N | 1000-8000-N |
| 31 | UK | 22 | M | | 5714-8000 | 1000-8000-N | 1000-8000-N | 1000-8000-N |
| 32 | VS | 25 | F | | 5714-8000 | 1000-8000-N | 1000-8000-N | 1000-8000-N |
| 33 | RS | 46 | M | | 4000-8000 | 5714-8000-D | 1000-8000-N | 1000-8000-N |
| 34 | GA | 24 | M | | 5714-8000 | 1000-8000-N | 1000-8000-N | 1000-8000-N |
| 35 | CL | 53 | M | | 2857-8000 | 1000-8000-N | 1000-8000-N | 1000-8000-N |

## PTA DATA STATISTICAL ANALYSIS

| Tab 3 | | Right Ear | | | | | Left Ear | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Study interval | Pre TMS | 10th day | 1mth | 3mth | 6mth | Pre MS | 10th day | 1mth | 3 mths | 6 mths |
| Air conduction threshold | Mean | 14.21 | 15.46 | 14.21 | 14.21 | 14.21 | 14.05 | 16.02 | 14.05 | 14.05 | 14.05 |
| | SD | 5.98 | 6.87 | 5.98 | 5.98 | 5.98 | 5.49 | 6.54 | 5.49 | 5.49 | 5.49 |
| | SEM | 0.923 | 1.058 | 0.923 | 0.923 | 0.923 | 0.848 | 1.021 | 0.848 | 0.848 | 0.848 |
| Boneconduction threshold | Mean | 11.29 | 12.34 | 11.29 | 11.29 | 11.29 | 11.49 | 12.35 | 11.49 | 11.49 | 11.49 |
| | SD | 5.45 | 5.92 | 5.45 | 5.45 | 5.45 | 5.65 | 5.69 | 5.65 | 5.65 | 5.65 |
| | SEM | 0.840 | 0.925 | 0.840 | 0.840 | 0.840 | 0.871 | 0.888 | 0.871 | 0.871 | 0.871 |

| | | | | |
|---|---|---|---|---|
| 20dB/20dB | 50dB/45dB | 45dB/45dB | 30dB/25dB | 30dB/25dB |
| 100%/100% | 100%/100% | 100%/100% | 100%/100% | 100%/100% |

All patients who were having history of seizure, stroke, raised ICP, brain injury, on medications lowering seizure threshold, pregnant women & lactating mother and electrical or medical devices implanted patients were excluded from study. All patients underwent 5 audiometry tests (Pure tone audiometry, Speech audiometry, SISI, OAE's, BERA). Patients average pure tone threshold were recorded before starting the transcranial magnetic stimulation. They were evaluated again at 10th day of rTMS, and followed up at 1 months, 3 months, 6 months' interval. Data made into chart (Tab 1) for each ear as air conduction/bone conduction (AC/BC) with average pure tone audiometry (PTA) Threshold at 0.5-4.0 kHz frequency right ear AC/BC. Distorted Product of Otoacoustic Emission's (DPOE'S) was taken the same to compare with PTA data results.

## RESULTS

Out of 42 patients 40 patients had double drug resistant depression and two patients had schizophrenia. Majority of them were young adults (Tab 1). 8(20%) out of 42 patients were females. Noise level of acoustic artifacts produced by stimulating coil recorded with sound level meter at the patient's ear level 110dB sound pressure level and at 1 meter 95 dB sound pressure level. Table 3 shows comparison between average air conduction and bone conduction threshold between results after 10th day of TMS with Pre TMS, 1 month 3 month, 6 month done in right ear. There was no statistically significant difference (p Value: 0.416 and 0.405 respectively)
Similar results were seen on left side as well (p Value: 0.140 & 0.492 respectively).

**Comparison PTA vs DPOAE changes at 10th day of TMS:**

- Comparison of 20-30 age group and >50 years and DPOAE'S changes:
- Fisher's exact test:
- p Value: 0.0110
- Statistically significant

## DISCUSSION

Noise exposure is the most common cause of sensorineural hearing loss (SNHL), which is one of the most common neurological disorders (NIDCD (1995) Research in human communication. Bethesda, MD: National Institute on Deafness and Other Communication Disorders) in modern society.The rapid mechanical deformation of the TMS stimulation coil when it is energized produces intense, broadband acoustic artifact that may exceed 140dB of sound pressure level (SPL) (Counter and Borg. 1992).In the present study as measured by the sound level meter (TES 1350 A) it was 110 dB SPL at patient's ear. This exceeds the recommended safety levels for the auditory system (OSHA). Before using a given coil/stimulator, the operator may consult the manufacturer's Instructions for use or technical specifications to check the specified sound pressure levels. During present study TMS stimulus was given for 10 days at 20 Hz frequency, results showed significant change in auditory threshold after 10 days when recorded by pure tone audiogram. The shift was more on the left the side on which TMS stimulating coils placed, but statistically insignificant. There was change in the average bone conduction threshold and air conduction threshold with pre TMS and after 10th day, result was insignificant i.e. p=0.492 and p=0.141 respectively. Studies by Pascual-Leone *et al.*, 1992; Loo et.al., 2001 reported transient increase in auditory threshold in small percentage of patients. Permanent threshold change has been reported in a single individual who had not used ear protection (Zangen *et al.*, 2005). In the present study 1 patient has auditory threshold change still persisting after 6 months of observation. Patients speech audiometry showed at pre TMS, at 10th day of TMS, 1 month, 3 months and 6 month of observation:

The auditory threshold changes studied with otoacoustic emissions(OAEs) result were in confirmation with pure tone audiometry(PTA) result, absent OAEs in high frequency ranges >4000 Hz, in older patients >50 years' frequency changes involved the lower frequency ranges 2000Hz too. Majority of patients have absence of DPOEAS in high frequency range 5714-8000Hz after 10th day of TMS stimulation, there was recovery after 1month in majority of patients. In a single study on TMS effects on auditory threshold as recorded by otoacoustic emissions changes (Repetitive transcranial magnetic stimulation: hearing safety considerations. Tringali S et, al. Brain stimul. 2012 Jul;5(3):354-63): difference in TEOAE amplitude between pre and post TMS sessions increased significantly with TMS noise for those subject's least protected by ear plugs showing a post TMS slight decrease of TEOAE amplitude for high intensities TMS and hence minor hearing function alteration. However, this correlation was no longer found 1 hour after TMS session.

**Conclusion**

The present study is one of the few studies done till now to study the changes on distorted product of otoacoustic emissions (DPOAEs), its shows OAEs are better to study the noise induced auditory threshold changes when comparing with pure tone threshold(PTA) results.

## REFERENCES

A novel dual-site transcranial magnetic stimulation paradigm to probe fast facilitatory inputs from ipsilateral dorsal premotor cortex to primary motor cortex

An Fmri study of neural interaction in large scale cortico-thalamic visual network. Zhang N, Zhu XH, Zhang Y, Chen W. Neuroimage. 2008 Sep1;42(3): 111.Doi: 10.1016/j.neuroimage.2008.05.060.-12Epub 2008 Jun 12

Anthony T. Barker and Ian Freeston (2007), Scholarpedia, 2(10):2936-1

Barker AT: The history and basic principles of magnetic nerve stimulation. Electroencephalogr Clin Neurophysiol Suppl 1999; 51:3-21

Basic Mechanisms of TMS Yasuo Terao and Yoshikazu Ugawa Journal of Clinical Neurophysiology 2002;19(4):322-343

Cantello R, Rosi S, Varrasi C, Ulivelli M, Civardi C, Bartalini S, *et al.* Slow repetitive TMS for drug resistant epilepsy: clinical and EEG findings of a placebo-controlled trial. Epilepsia 2007; 48:366-74

Counter SA, Borg E. Analysis of the coil generated impulse noise in extracranial magnetic stimulation. Electroencephalogr Clin Neurophysiol 1992; 85:280-8

Counter SA. Neurobiological effects of extensive transcranial magnetic stimulation in an animal model. Electroencephalogr Clin Neurophysiol 1993; 89:341-8

Counter SA. Scand Audiol Suppl 1993; 37:1-32. Electromagnetic stimulation of auditory system: effects and side-effects

Eric M. Wassermann. Electroencephalography and Clinical Neurophysiology 108(1998)1-16. Risk and safety of repetitive transcranial magnetic stimulation: report suggested guidelines from the international workshop on safety of repetitive transcranial magnetic stimulation, June 5-7,1996

Figiel GS, Epstein C, Mcdonald WM, *et al*: The use of rapid rate transcranial magnetic stimulation (rTMS) in refractory depressed patients. J. Neuropsychiatry Clin Neurosci 1998; 10:20-25

Gilbert DL, *et al*. Clin Neurophysiol.2004 Aug;115(8):1730-9. Should transcranial magnetic stimulation research in children be considered minimal risk?

Localizing the site of magnetic brain stimulation in humans. Charles M. Epstein, MD, Daniel G. Schwartzberg, MD, Kent R. Davey, PhD and David B. Sudderth, MD

Loo C, Mitchell P, Sachdev P, *et al*: Double-blind controlled investigation of transcranial magnetic stimulation for resistant major depression. Am J Psychiatry 1999; 156:946-948

Loo CK *et al*. Effects of a 2-4 weeks course of repetitive transcranial magnetic stimulation (rTMS) on neurophysiologic functioning, electroencephalogram and auditory threshold in depressed patients. Biol Psychiat 2001; 49:615-23

Magnetic stimulation of human peripheral nerve and brain: response enhancement by combined magnetoelectrical technique Bickford RG, Guidi M, Fortescue P, Swenson M. Neurosurgery.1987 Jan;20(1):110-6

Mechanisms of action of underlying the effects of repetitive transcranial magnetic stimulation on mood: behavioral and brain imaging studies. Jennifer Barrett Neuropsychopharmacology (2004)29, 1172-1189

Non-invasive stimulation of human motor cortex. Barker A.T, Jalinous R, Freeston I.L. Lancet 1985 May11;1(8437):1106-7-1

O' Reardon J, Solvason B, Janicak P, Sampson S, Isenberg K, Nanhas Z, *et al*. Efficacy and safety of transcranial magnetic stimulation in the acute treatment of major depression: A multi-site randomized controlled trial. Biol Psychiat 2007; 62:1208-16

Pascual *et al*. Safety of rapid rate transcranial magnetic stimulation in normal volunteers. Electroencephalography and Neurophysiology 1993; 89:120-130

Pascual- Leone A, Rubio B, Pallardo F, *et al*: Rapid rate transcranial magnetic stimulation of left dorsolateral prefrontal cortex in drug resistant depression. Lancet 1996; 348:233-237

Pascual-Leone A, Cohen LG, Shortland LI, Dang N, Pikus A, Wasserman EM, Brasil-Neto JP, Valls-Sole J, Hallet M. No evidence of hearing loss in humans due to transcranial magnetic stimulation. Neurology, 1992, 42:647-651

Phosphenes induced by magnetic stimulation over the occipital brain: description and probable site of stimulation Marg E, Rudiak D. Optom Vis Sci. 1994 May;71(5):301-11

Repetitive transcranial magnetic stimulation in treatment of depressive disorder Libor Ustohal, Radovan Prikryl, Hana Prikrylova Kucerova, Eva Ceskova. Act Nerv Super Rediviva 2011;53(1):3-13

Resetting of essential tremor and postural tremor in Parkinson's disease with transcranial magnetic stimulation. Pascual – Leone A, Valls –Sole J, Toro C, Wasserman EM, Hallett M Muscle Nerve. 1994 Jul;17(7):800-7

Ridding MC, Rothwell JC. Is there a future for therapeutic use of transcranial magnetic stimulation? Nat Rev Neurosci 2007; 8:559-67

Rossini P.M, Rossi S. Transcranial magnetic stimulation: diagnostic, therapeutic and research potential. Neurology 2007:68:484-8

Roth Y, Amir A, Levkovitz Y, Zangen A. Three-dimensional distribution of the electric field induced in the brain by transcranial magnetic stimulation using figure of 8 and deep H-coils stimulation of the human motor cortex. J Neurosci Methods 1997; 74:113-122

Rothwell JC: Techniques and mechanisms of action of transcranial magnetic stimulation

Safety, ethical considerations, and application guidelines for the use of transcranial magnetic stimulation in clinical practice and research. Simone Rossi *et al* Clinical Neurophysiology (2009)-9

Starck J, Rimpilainen I, Pyykko I, Esko T, Scand Audiol 1996;25(4):223-6. The noise level in magnetic stimulation

The history and basic principles of magnetic nerve stimulation. Barker A.T, Electroencephalogram Clin. Neurophysiol Suppl. 1999; 51:3-21-3

Transcranial magnetic stimulation and acoustic trauma or hearing loss in children. Collado-Corona MA, Mora-Magana I, Cordero GL, Toral-Martinon R, Shkurovich-Zaslavsky M, Ruiz-Garcia M, Gonzalez-Astiazaran A. Neurol Res. 2001 Jun;23(4):343-6-24

Transcranial magnetic stimulation: A new Investigational and Treatment Tool in Psychiatry Zafaris J J Neuropsychiatry Clin Neurosci 14:4, Fall 2002-14

Triangali S *et al*. Brain Stimul. 2012Jul;5(3):354-63

Wassermann EM, Grafman J, Berry C, Hollangel C, Wild K, Clark K, *et al*. Use and safety of a new repetitive transcranial magnetic stimulator. Electroencephalogr Clin Neurophysiol 1996; 101:412-7

Y. Levokovitz *et al*. Clinical neurophysiology 118 (2007)2730-2744

Zou J, Bretlau P, Pyykko I, Starck J, Toppila E. Act otolaryngol. 2001 Jan;121(2):143-8. Sensorineural hearing loss after vibration: an animal model for evaluating prevention and treatment of inner ear hearing loss.

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