2013 Siemens Expert Series
with James W. Hall III, Ph.D.

Evidence-Based Management of Troublesome Tinnitus:
Practical Guidelines for the Practicing Professional

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Evidence-Based Management of Troublesome Tinnitus:
Practical Guidelines for the Practicing Professional

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Evidence-Based Management of Troublesome Tinnitus:
Practical Guidelines for the Practicing Professional

• Definition of tinnitus?
• Audiologic assessment of tinnitus
• General management strategies
• Specific treatment options
• Summary, questions, & answers
Definition of Tinnitus

- Tinnitus is a phantom auditory perception, i.e., the perception of a sound in the absence of an external sound signal.
- Tinnitus is real, not imagined or “just in your head”.
- Tinnitus is a symptom ... not a disease.
- Bothersome tinnitus is “subjective tinnitus”
- “Somatosounds” require medical assessment and management

Definition of Tinnitus: The type of sound has no diagnostic or prognostic significance

Description of types of tinnitus for 119 patients presenting for consultation

<table>
<thead>
<tr>
<th>Sound Type</th>
<th>Count</th>
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<tbody>
<tr>
<td>ringing</td>
<td>47</td>
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<tr>
<td>crickets</td>
<td>21</td>
</tr>
<tr>
<td>high-pitch tone</td>
<td>17</td>
</tr>
<tr>
<td>hissing</td>
<td>13</td>
</tr>
<tr>
<td>humming</td>
<td>13</td>
</tr>
<tr>
<td>roaring</td>
<td>6</td>
</tr>
<tr>
<td>static noise</td>
<td>5</td>
</tr>
<tr>
<td>buzzing</td>
<td>4</td>
</tr>
<tr>
<td>pulsing</td>
<td>4</td>
</tr>
<tr>
<td>clicking</td>
<td>2</td>
</tr>
<tr>
<td>frying sound</td>
<td>2</td>
</tr>
<tr>
<td>mid-pitch tone</td>
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</tr>
<tr>
<td>screeching</td>
<td>1</td>
</tr>
<tr>
<td>whizzing</td>
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</tr>
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<td>fizzing</td>
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</tr>
<tr>
<td>siren</td>
<td>1</td>
</tr>
<tr>
<td>crackling</td>
<td>1</td>
</tr>
<tr>
<td>running water</td>
<td>1</td>
</tr>
</tbody>
</table>
Definition of Tinnitus: Demographics

- Almost everyone experiences transient spontaneous tinnitus
- About one-third of all adults in U.S.A. experience actual tinnitus at least once
- Tinnitus is experienced regularly by about 40 million Americans (1/5 persons)
- Tinnitus is a serious problem for 13-15% Americans who seek medical attention for their tinnitus.
- Tinnitus is debilitating for an estimated 2 million Americans.

Definition of Tinnitus: Non-Helpful Advice from Physicians

- Poor medical advice and information (summarized from hundreds of patient reports)
  - There’s nothing wrong with you
  - You have normal hearing
  - There’s nothing we can do for you
  - Avoid being around noises
  - “You’ll just have to live with it”
### Definition of Tinnitus:
**Common patient complaints and characteristics**

- Very tired, slowed down, fatigue
- Persistently sad mood
- Patient doesn’t enjoy things the way he/she used to
- Restless or irritable
- Difficulty concentrating
- Sleeping and/or eating less than usual
- Persistent headaches, stomach aches, or chronic pain
- Nervousness
- Excessive crying
- Hopelessness, e.g., life is not worth living
- Absence of pleasures or joys

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**Jack Vernon**  
(1922-2010)  
“American Father of Tinnitus”
Causes and Mechanisms of Tinnitus: 
Anatomy & Physiology (1)

- Origin in cochlea
  - Hair cell damage
  - Imbalance between outer hair cells (OHC) and inner hair cell (IHC) function
  - Peripheral deafferentation
  - Loss of input to tonic inhibitory systems
  - Release of excessive amounts of excitatory neurotransmitter glutamate
  - Over-expression of synaptic receptors type NMDA (N-Methyl D-Aspartate)
- *Eighth cranial nerve*
  - Increased or changed resting potential
  - Changes causes by dysfunction of nerve
  - Influence of middle ear disorder ... increases tinnitus loudness because external everyday sounds do not “mask” tinnitus as much

Tinnitus Anatomy & Physiology: 
Middle Ear, Inner Ear and Auditory Nerve

**ANATOMY OF THE HUMAN EAR**
Causes and Mechanisms of Tinnitus:
Anatomy & Physiology (2)

- Auditory brainstem, thalamus and cortex in the CNS
  - Perception of sound
  - Reorganization of neuronal activity
  - Release of excessive amounts of excitatory neurotransmitter glutamate
  - Over-expression of synaptic receptors type NMDA (N-Methyl D-Aspartate)
- Non-traditional auditory regions
  - Limbic system
  - Autonomic nervous system
- Efferent auditory system in the brain
  - Reduced activity

Current Theories and Publications on the Mechanisms and Management of Tinnitus

  - Somatosensory stimulation via trigeminal and dorsal root ganglia affect physiology in DCN
- Possible Mechanism: imbalance in activity of excitatory (GABA) and inhibitory (glutamate) auditory neurotransmitters in CNS (e.g., brainstem, midbrain, cortex)
Current Theories and Publications on the Mechanisms and Management of Tinnitus (2)

  - Hyperactivity in CN with tinnitus documented in animal models and in humans (imaging studies)
  - Direct electrical stimulation of DNC changes tinnitus loudness
  - Center of integration of different sensory modalities (e.g., pain)
  - Deprivation of input can lead to neural plasticity
  - Neural plasticity can play a role in
    - Balance between excitation and inhibition
    - Hyperactivity
    - Reorganization of CNS and redirection of information to non-classical auditory areas, e.g., limbic system, pain centers
- Possible Mechanism: imbalance in activity of excitatory (GABA) and inhibitory (glutamate) auditory neurotransmitters in CNS (e.g., brainstem, midbrain, cortex)

Pawel Jastreboff
“Neurophysiological Model of Tinnitus”
Tinnitus Anatomy & Physiology

Auditory region of the brain (Heschl's gyrus) in the temporal lobe of auditory cortex ... responsible for the perception of tinnitus

Limbic System
(emotional center of the brain)
Autonomic Nervous System

Controlling the brain’s response to “danger sounds”

Tinnitus ... Current Research and Treatment Options: fMRI Documentation of CNS Representation of Tinnitus

Lockwood AH, Salvi RJ, Coad BA, Towsley ML, Wack DS, Murphy BW.

(Buffalo NY V.A. Medical Center and Univ. of Buffalo)

The functional neuroanatomy of tinnitus: Evidence for limbic system links and neural plasticity

Tinnitus ... Current Research and Treatment Options: fMRI Documentation of CNS Representation of Tinnitus

Brainstem

Cortex

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Tinnitus Assessment and Management: Tinnitus Assessment and Management: Role of the Audiologist

CONSULTATION (1 HOUR)

PATIENT INFORMATION

DIAGNOSTIC AUDIOLOGY

NO FURTHER SERVICES

TINNITUS EVALUATION

HEARING AID (S)

EXTENDED TREATMENTS

Audiological Assessment of Tinnitus

- Diagnostic Hearing Assessment
  - Imittance measurement
    - Do not record acoustic reflexes
    - Approximately 50% of tinnitus patients complain of intolerance to loud sounds
  - Pure tone audiometry
    - Conventional octave frequencies
    - Inter-octaves of 3000 Hz and 6000 Hz
    - High-frequency audiometry (> 8000 Hz) as needed
  - Word recognition scores at a comfortable level
  - Distortion product otoacoustic emissions (DPOAE) for 1 K to 10 K Hz with 6 or 8 frequencies/octave)
Audiological Assessment of Tinnitus: Audiogram versus DPOAE

**Audiogram vs. DPOAE:**
- **Audiogram** shows normal findings at 1K, 2K, 4K, and 8K.
- **DPOAE** shows a decrease in normal findings at 8K, with a sharp drop at 2K.

### Audiological Assessment of Tinnitus

- **Tinnitus Assessment (for each ear):**
  - Threshold for white noise to determine minimal level of background sound a person can hear
  - Match tinnitus pitch:
    - Usually in 2000 to 4000 Hz region
    - High frequency tinnitus pitch (>8000 Hz) is possible
  - Estimate tinnitus “loudness”:
    - Usually less than 10 dB ... often only 1 or 2 dB
    - Loudness is > 15 dB in only about 1% of patients
  - Determine minimum masking level for tinnitus:
    - Intensity level that “covers up” tinnitus
    - Often less than 30 dB even in contralateral ear
  - Measure loudness discomfort levels (LDLs) for tones and speech sounds to identify hyperacusis
Tinnitus Handicap Inventory
(Note: there are at least half dozen other inventories)

- 25 items with scores ranging from 0 to 100
  - Score of 4 for “yes”, 2 for “maybe”, and 0 for “no”
- 12 items on functional subscale, e.g.
  - “Because of your tinnitus do you have trouble falling to sleep at night?”
- 8 items on emotional subscale, e.g.,
  - “Does your tinnitus make you angry?”
- 5 items on catastrophic subscale
  - “Do you feel that you cannot escape your tinnitus?”


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- Counseling is Intervention
  - Obtain thorough medical and audiological history
  - Review all medications
  - Dispense current and accurate information on tinnitus
  - Answer all patient and spouse (significant other) questions about tinnitus
  - Rank tinnitus severity on 0 (no problem) to 10 (my life is ruined) scale
  - Rank patient’s tinnitus, hyperacusis & hearing loss
  - Determine % of time patient is aware of tinnitus
  - Offer practical suggestions for sound enrichment
  - Always treat patient with compassion and empathy

Patient/Family Counseling and Education

“Knowledge is power.”
(Nam et ipsa scientia potestas est.)

Francis Bacon
(1561-1626)

Meditationes Sacrae [1597]
An Ounce of Prevention is Worth a Pound of Cure

Management of Tinnitus: Patient Education

American Academy of Audiology  www.audiology.org
American Tinnitus Association  www.ata.org
Tinnitus is a Symptom of Many Diseases and Disorders:
Medical Management is Top Priority for Select Patients

- Noise-induced cochlear dysfunction
- Presbycusis
- Temporal mandibular joint disorders
- Congenital sensory hearing loss
- Head injury
- Lightning injury
- Meniere’s disease
- Otosclerosis
- Inflammatory disorders, e.g., arthritis
- Metabolic disorders, e.g., hyperlipidemia
- Neurologic disorders, e.g., multiple sclerosis
- *Vestibular schwannoma, e.g., eighth nerve tumor*

Some of the Common Drugs (among over 100 drugs) that may Enhance or (Rarely) Produce Tinnitus
*(for > 3% of patients)*

<table>
<thead>
<tr>
<th>Alka seltzer</th>
<th>Aspirin</th>
<th>Celebrex</th>
<th>Cipro</th>
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</thead>
<tbody>
<tr>
<td>Claritin</td>
<td>Effexor</td>
<td>Floxin</td>
<td>Lariam</td>
</tr>
<tr>
<td>Lipitor</td>
<td>Motrin</td>
<td>Norvasc</td>
<td>Pepcid</td>
</tr>
<tr>
<td>Procardia</td>
<td>Prozac</td>
<td>Pepto-bismol</td>
<td>Phenergan</td>
</tr>
<tr>
<td>Septra</td>
<td>Strepomycine</td>
<td></td>
<td>Tegretol</td>
</tr>
<tr>
<td>Vancanese</td>
<td>Vascor</td>
<td>Viagra</td>
<td>Vioxx</td>
</tr>
<tr>
<td>Xanax</td>
<td>Zithromax</td>
<td>Zoloft</td>
<td>Zyrtec</td>
</tr>
</tbody>
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PROGRESSIVE TINNITUS MANAGEMENT:
VA National Center for Rehabilitative Audiology Research (NCRAR)
James A. Henry and Colleagues

James Henry
www.pluralpublishing.com
Tinnitus: Specific Management Approaches

- In depth counseling by audiologist experienced with tinnitus
- Written accurate information for patient and significant others
- Melatonin in the evening before going to bed
- Sound enrichment
  - Environmental sound device (< $25), e.g., Bed, Bath & Beyond
  - [www.soundtherapy.com](http://www.soundtherapy.com)
  - Sound pillow
- Amplification if at all indicated (natural sound therapy)
  - Hearing aid (open fit hearing aids are especially useful)
  - Combination hearing aid/sound generator
- Cochlear implants (as indicated)

Melatonin in the Management of Tinnitus


Melatonin is a neurohormone that is secreted by the pineal gland and known to impact the sleep-wake cycle. Melatonin is regarded to be a safe and natural sleep aid. Since many people with tinnitus suffer sleep disturbance, melatonin has been studied as a therapeutic agent for tinnitus. A review of the literature suggests that melatonin has a beneficial effect on tinnitus, especially for patients with sleep disturbance, but it does not seem to modify the strength or frequency of the tinnitus.
**Melatonin and Sulodexide* in the Management of Tinnitus**

*used for the prophylaxis and treatment of thromboembolic diseases*

De Stefano et al. (2009). Treatment of central and sensorineural tinnitus with orally administered Melatonin and Sulodexide: personal experience from a randomized controlled study. *Acta Otorhinolaryngol Ital*, 29, 86-91

After randomisation, 34 patients were treated with Melatonin and Sulodexide, another 34 were treated with Melatonin alone, while the remaining 34 (control group) were managed without treatment in order to evaluate spontaneous variations in the quality of tinnitus. Patients were assessed prospectively with the Tinnitus Handicap Inventory … both pre- and post-treatment. Better results … were found in the group who received Melatonin and Sulodexide compared to those receiving Melatonin alone. No improvement was observed in the control group. In conclusion, Melatonin in combination with Sulodexide is, in our opinion, a viable treatment option for patients suffering from central or sensorineural tinnitus.

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**Sound Enrichment in the Management of Tinnitus**

<table>
<thead>
<tr>
<th>Environment Sound Machine</th>
<th>Sound Pillow</th>
</tr>
</thead>
<tbody>
<tr>
<td>~ $25</td>
<td>~ $30</td>
</tr>
</tbody>
</table>

![Environment Sound Machine](image1.jpg)

![Sound Pillow](image2.jpg)
Benefit of Counseling in Tinnitus:
THI scores before versus > 6 months after counseling
(Hall & Haynes, 2001)

<table>
<thead>
<tr>
<th>Total Score</th>
<th>Functional Items</th>
<th>Emotional Items</th>
<th>Catastrophic Items</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
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<tr>
<td>20</td>
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</table>

Custom Sound Therapy/Hearing Aid Devices as Part of a Tinnitus Management Program
Custom Sound Therapy/Hearing Aid Devices as Part of a Tinnitus Management Program

- Open fit hearing aids
- Sound generation devices
- Combination hearing aid sound generation devices, e.g., Tinnitus control feature for:
  - Siemens Pure Carat 701, 501, and 301 hearing instruments
  - Siemens Life 701, 501, 301, and 101 hearing instruments
- Used with programs for
  - Microphone input (amplification)
  - Noise (sound generation for tinnitus therapy)
    - White noise (equal intensity at each frequency)
    - Pink noise (equal intensity within each octave)
    - Speech noise (NBN in speech frequency region)
    - High tone noise
  - Mixed (tinnitus therapy plus hearing aid)

Tinnitus Retraining Therapy (TRT): The Neurophysiologic Model

“The model stresses (a) the importance of the basic principles of the functioning of the nervous system, such as the capacity to be habituated to signals that are emotionally neutral and do not carry important information, and (b) the fundamental feature of the nervous system – its plasticity.”

Jastreboff, Gray & Gold, 1996
Tinnitus Retraining Therapy (TRT): Recent Evidence of Positive Outcome

  - decrease in THI from 49 to 28 after 6 months
  - Improvement by Jastreboff category
    - 1. Tinnitus (n = 6), 100% improved
    - 2. Tinnitus with hearing loss (n = 16); 62% improved
    - 3. Hyperacusis (with or without Tinnitus) (n = 16), 88.5% improved
    - 4. Hyperacusis (with or without Tinnitus, exacerbated by noise) (n = 8), 75% improved.
  - TRT is effective
  - Tinnitus masking more effective than TRT at 3 months
  - TRT more effective than tinnitus masking at 18 months

Sound Enrichment/Treatment
(Pawel Jastreboff)

- Tinnitus
- Quiet Ambient Sound
- Masking Sound
- Sound Enrichment
Neuromonics Tinnitus Treatment: Five Step Treatment

- Step 1: Comprehensive Personalized Assessment
- Step 2: Processor Configuration
- Step 3: Pre-Conditioning Stage
- Step 4: Active Treatment Stage
- Step 5: Maintenance Stage

Intervention and Management of Tinnitus: Residual Inhibition


- Feldman (1971) first reported brief reduction in tinnitus after the use of a masker for tinnitus relief, i.e., residual inhibition (RI)
- RI most effective when masker is in the frequency region of the hearing loss (and tinnitus)
- Mechanism of residual inhibition may be related to loss of efferent activity within CANS in persons with tinnitus, one mechanism of tinnitus
- Some patients with tinnitus experience sustained relieve from tinnitus after brief periods of masking (Danesh, 2007)
  - Perhaps measurement of responsiveness to RI should be determined in the clinical evaluation of tinnitus
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Summary

- Tinnitus is a symptom, not a disease.
- Audiologic and medical diagnosis is essential.
- With general and short term management options, most patients (> 80%) return to the quality of life they enjoyed before the perception of bothersome tinnitus.
- Effective extended tinnitus management options are available, e.g., TRT or Neuromonics.
- All patients with bothersome tinnitus should have hope.

Discussion and Questions