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**AFOEM Annual Training Meeting**

# **Hearing assessment in the workplace**

## **Hearing aids in the workplace**

### **A brief overview of acoustic shock**

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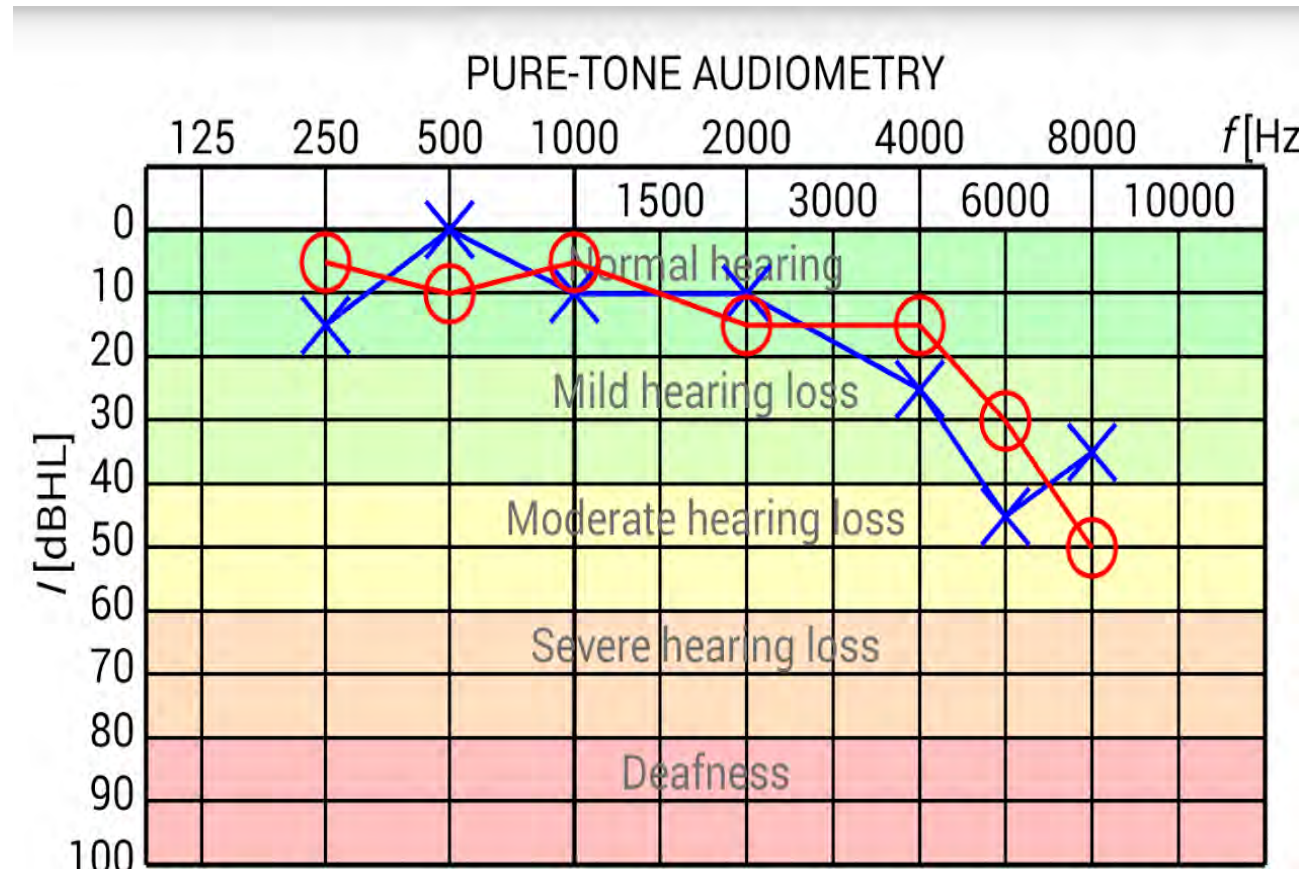
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# Pure tone audiometry

- 5 dB up, 10 dB down technique, single frequency pure tones to find hearing threshold levels (HTLs) in dB HL
- 2 out of 3 correct responses is accepted
- Air conduction (AC) HTLs via headphones/insert earphones measured for 250, 500 Hz, 1 (1.5), 2, (3), 4, (6), 8 KHz
- Bone conduction (BC) HTLs measured for 500 Hz, 1, 2, 4 KHz via bone conductor
- Results entered onto an audiogram

# Audiogram: severity of hearing loss



# Interaural attenuation: crossover

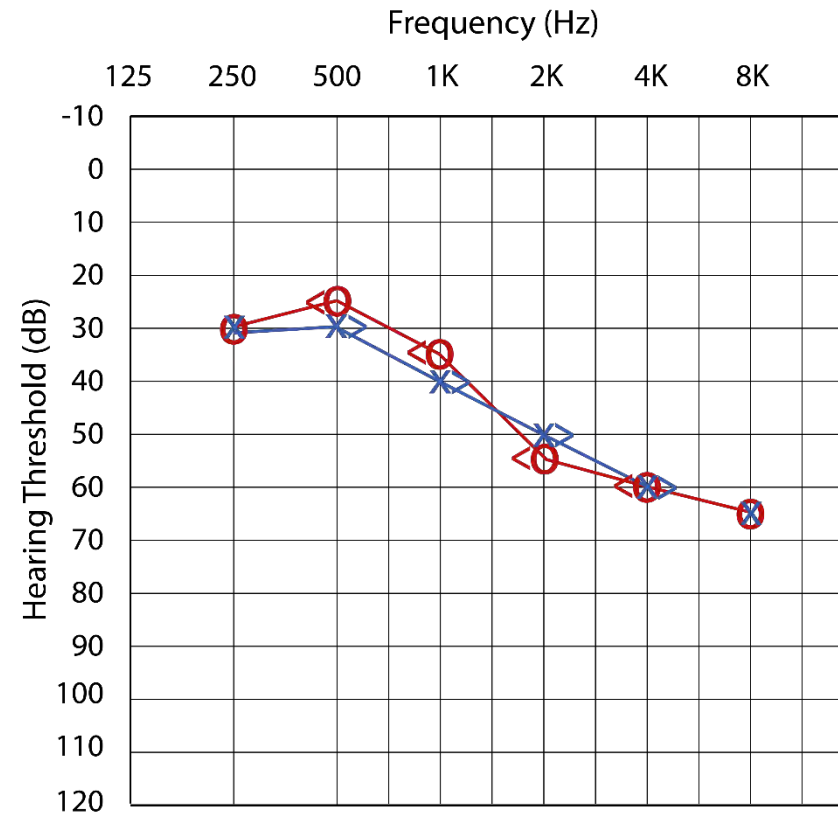
Masking of the non-test ear is needed if there is a risk of crossover to the test ear affecting the patient's responses.

Crossover from the non-test ear can occur:

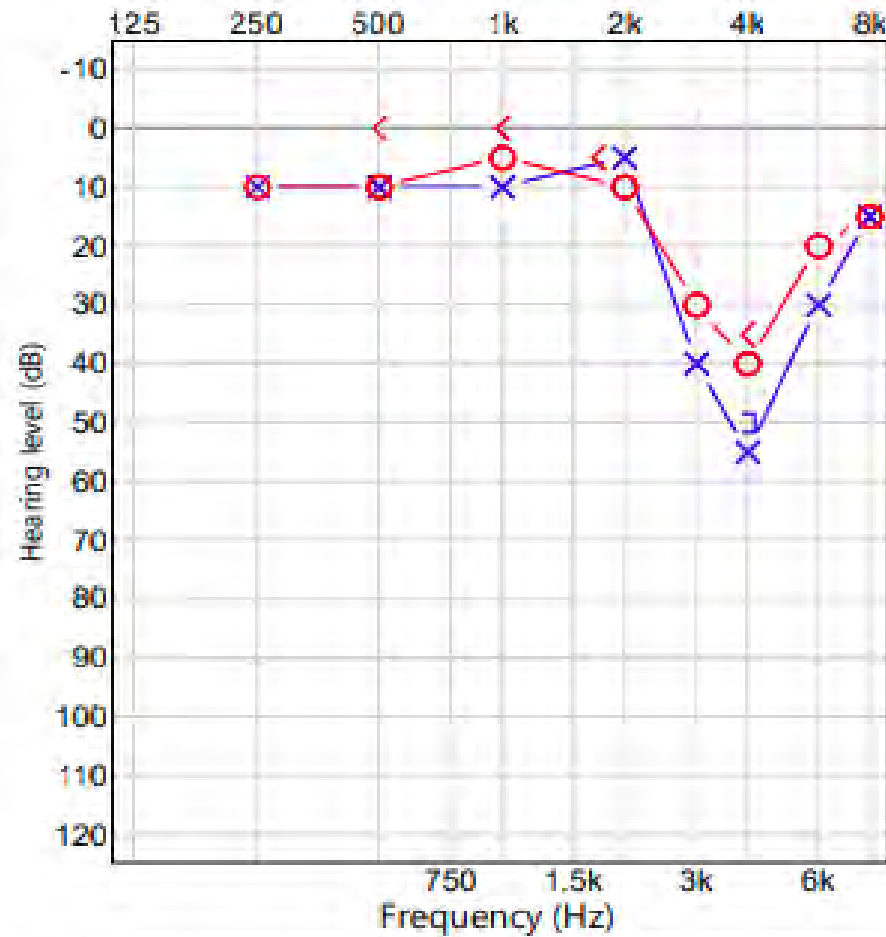
- AC testing: if there is a difference in HTLs between ears
  - via headphones of  $\geq 40$  dB
  - via insert earphones  $\geq 60$ dB
- BC testing: even at 0 dB. An asymmetry of  $\geq 15$ dB in air conduction HTLs should have masked bone conduction HTLs performed on each ear.

Masking: narrow band noise in the non-test ear for pure tone testing, broad band speech noise for speech discrimination testing. A protocol to guide masking levels is carried out to avoid cross back to the test ear.

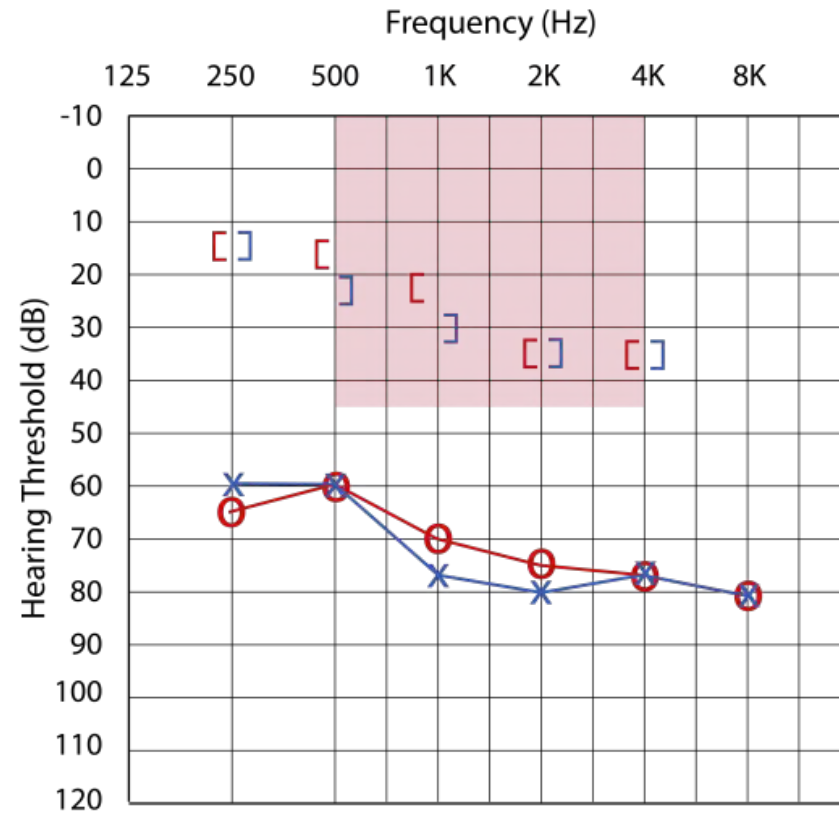
# Audiogram: sensorineural hearing loss



# Audiogram: noise damage



# Audiogram: conductive hearing loss



# Tympanometry

Tympanometry (impedance testing) measures compliance (tympanic membrane mobility), used to diagnose middle ear function.

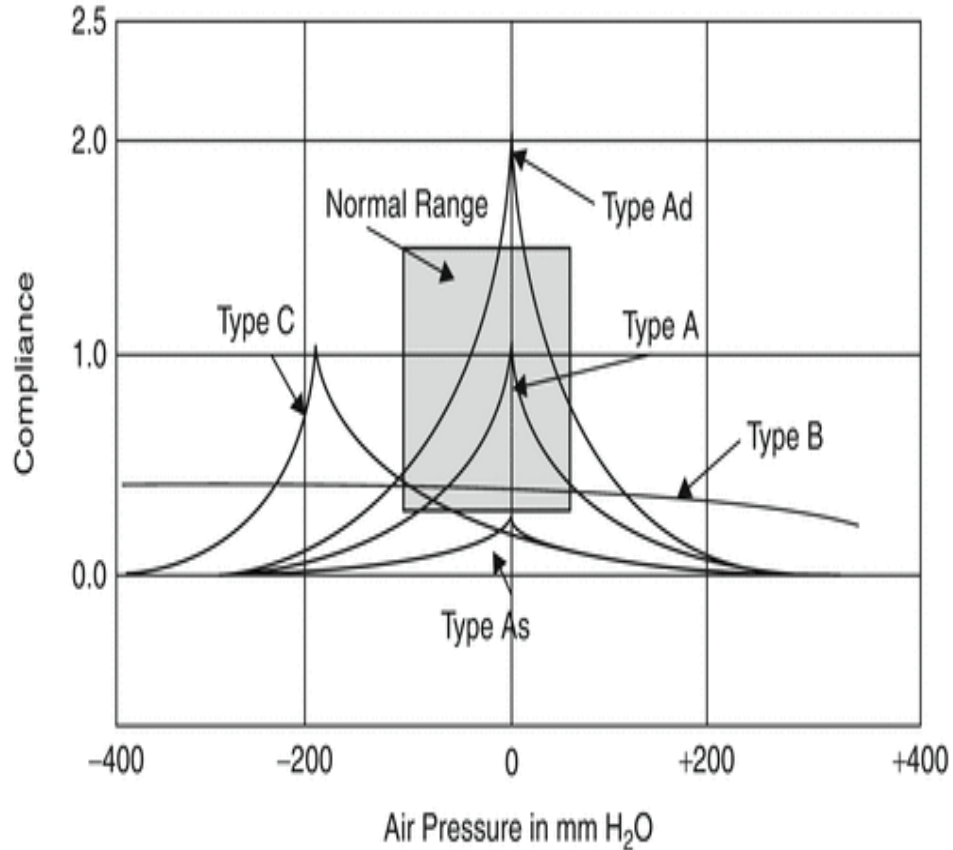
A range of pressure, from positive to negative, plus a constant tone is delivered via a probe into the ear canal.

Tympanometry assesses how much of the probe tone is absorbed into the middle and inner ear, and how much is reflected back from the tympanic membrane.

Acoustic reflex testing can also be carried out via the probe used for tympanometry. It is no longer performed as a standard test due to the high intensity levels required.



# Tympanogram



“Type A”: peak compliance occurs at or near atmospheric pressure, indicates normal middle ear pressure.

- “Type A”: Normal shape = normal middle ear function.
- “Type Ad”: A deep curve with a tall peak = an abnormally compliant middle ear system: a flaccid tympanic membrane/healed perforation or ossicular chain dislocation.
- “Type As”: A shallow curve = a stiff system: a thickened tympanic membrane or ossicular fixation with otosclerosis.

A “Type B” curve, no sharp peak and little or no variation in impedance over a wide sweep range: consistent with middle ear effusion. If combined with a high ear canal volume: consistent with a tympanic membrane perforation or patent grommet tube.

A “Type C” curve, peak compliance  $\geq$  - 150 mm H<sub>2</sub>O = negative middle ear pressure consistent with Eustachian tube dysfunction.

# Speech discrimination testing

- Speech in quiet.
- Phonemically balanced monosyllabic word lists (PBM).
  - 25 word lists, plus 5 practice items, free field at 70 dB with the speaker 1 meter in front.
  - A pass score is 70% correct. Hearing aids can be worn.
- Phonemically balanced monosyllabic word lists in noise (PBN)
  - 50 word lists, + 10 signal:noise ratio, free field at 70 dB with the speaker 1 meter in front.
  - A pass score is 50% correct. Hearing aids can be worn.

# Hearing tests in the workplace

- Pre-employment
- Risk of noise damage in the workplace: eg armed forces, musicians (risk to self and to fellow musicians), sound engineers, hospitality industry workers, gym instructors.

In Victoria, if there is a need to provide hearing protection within the workplace, the employer is legally required to monitor employees' hearing.

- Where the safety of others (co-workers, the public) is at risk if the worker has a hearing loss eg:
  - CASA (pilots, air traffic controllers)
  - Police force
  - 000 call centre operators
  - Commercial drivers
  - Rail safety workers. Risk categorisation: safety critical or non-safety critical worker? Risk assessment – is the worker required to hear speech in noise?

To pass, HTLs of 40dB or less in better ear averaged over 0.5, 1, 2, 3 KHz may be required or there may be requirements at each frequency.

If fail, speech in noise testing generally required.

- Workplace induced tinnitus, acoustic shock

# Hearing aids: limitations

- Hearing aids provide amplification to compensate for the loss of volume resulting from a hearing loss.
- Inner ear damage from a sensorineural hearing loss ALSO causes distortion, which hearing aids are not able to 'cure':
  - Recruitment
  - Loss of speech clarity
  - Reduced speech in noise discrimination ability
  - Loss of ability to localise sound
- High levels of concentration are needed to follow a conversation – even while wearing hearing aids, leading to fatigue. Concentration is further affected by fatigue, stress, being unwell etc.

Additional difficulties: following rapid/unclear speech, a strong accent, or a speaker not being face to face, poor room acoustics, background noise.

- Successful hearing aid use requires:
  - commitment
  - realistic expectations
  - professional and family understanding and support:
    - throughout the process of adaptation to hearing aid use
    - while learning to “hear” again
    - tuning away unimportant sounds
    - hearing aid maintenance

# Acoustic shock

An involuntary fright/psychological trauma response to a sudden, loud, unexpected sound, leading to a characteristic cluster of involuntary, highly specific neurophysiological symptoms as well as symptoms consistent with trauma and fright.

Acoustic shock is different to cochlear damage from noise (acoustic trauma) causing a noise induced hearing loss.

Initial symptoms of acoustic shock can include:

- Severe startle reaction with a head/neck jerk
- Stabbing pain in the ear
- Dull ache in the ear, can radiate to cheek, neck, arm
- Tinnitus, hyperacusis
- Sensation of fullness/blockage in the ear
- Sensations of burning, numbness, tingling in and around the ear
- Mild vertigo, nausea
- Muffled, distorted hearing (usually subjective with no measurable change in hearing)
- Shock response: shaking, crying, disorientation, headache, fatigue

# Milhinch and Doyle (2001)

Milhinch and Doyle (2001): the first large scale study of acoustic shock in call centre employees.

Total 103 people: 91 females (89%) and 12 males (11%), exposed to 123 acoustic incidents between 1994-1999.

Symptoms reported:

- Pain 95%: in ear 85%; neck/jaw 11%; facial pain 7%
- Tinnitus 50%
- Loss of balance 48%
- Hyperacusis 32% - the most distressing and durable symptom
- Headaches 32%
- Facial numbness 9%; tingling 3%
- Burning feeling in the ear or face 5%
- Feeling of pressure/fullness in the ear 11%
- Echo/hollow feeling in the ear 18.4%
- Hearing loss 18.4%

In some, all symptoms resolved within a few hours or days, in others symptoms persisted indefinitely.

10% experienced a range of long term emotional reactions: anxiety, depression, hypervigilance, anger.

## **Hyperacusis =**

an abnormal sensitivity or intolerance of everyday sounds, which other people can tolerate

+ a heightened sense of volume (central gain) to those sounds

+ physical discomfort from those sounds

If hyperacusis develops, acoustic shock symptoms can:

- escalate
- become increasingly severe
- become persistent, with symptoms exacerbated by loud/intolerable sound exposure
- become permanently disabling (acoustic shock disorder)
- result in trigeminal nerve inflammation, potentially leading to chronic sound-aggravated pain and symptoms similar to temporomandibular disorder (TMD)

# How does hyperacusis develop?

Sounds evaluated in the subconscious as threatening:

- judged as important
- highlighted
- appear to be boosted in volume
- transmitted to the more conscious parts of the brain
- become increasingly prominent

**Hyperacusis = threat response from everyday loud/impact/sudden sounds when they are subconsciously processed, leading to sound-induced physical discomfort**

- PTSD – like response to sounds similar to the triggering acoustic incident
- anxiety that aural symptoms will be aggravated: tinnitus, hearing loss, pain
- in the belief that ears/hearing are vulnerable; being damaged by intolerable sound exposure (nocebo effect)
- fear of: discomfort/pain, distress from intolerable sounds



# Acoustic incidents triggering acoustic shock

The acoustic incident is always an ***unexpected*** or ***unpredictable*** sound, triggering a strong startle and threat response.

Additionally, acoustic incidents leading to acoustic shock disorder are often:

- loud
- sudden or have an impact quality
- threatening
- in close proximity to the ear(s)
- unavoidable: occurring in a situation where the person is unable to move away from the sound
- outside the person's control

Call centre staff - vulnerable to acoustic shock, research has focused on this cohort.

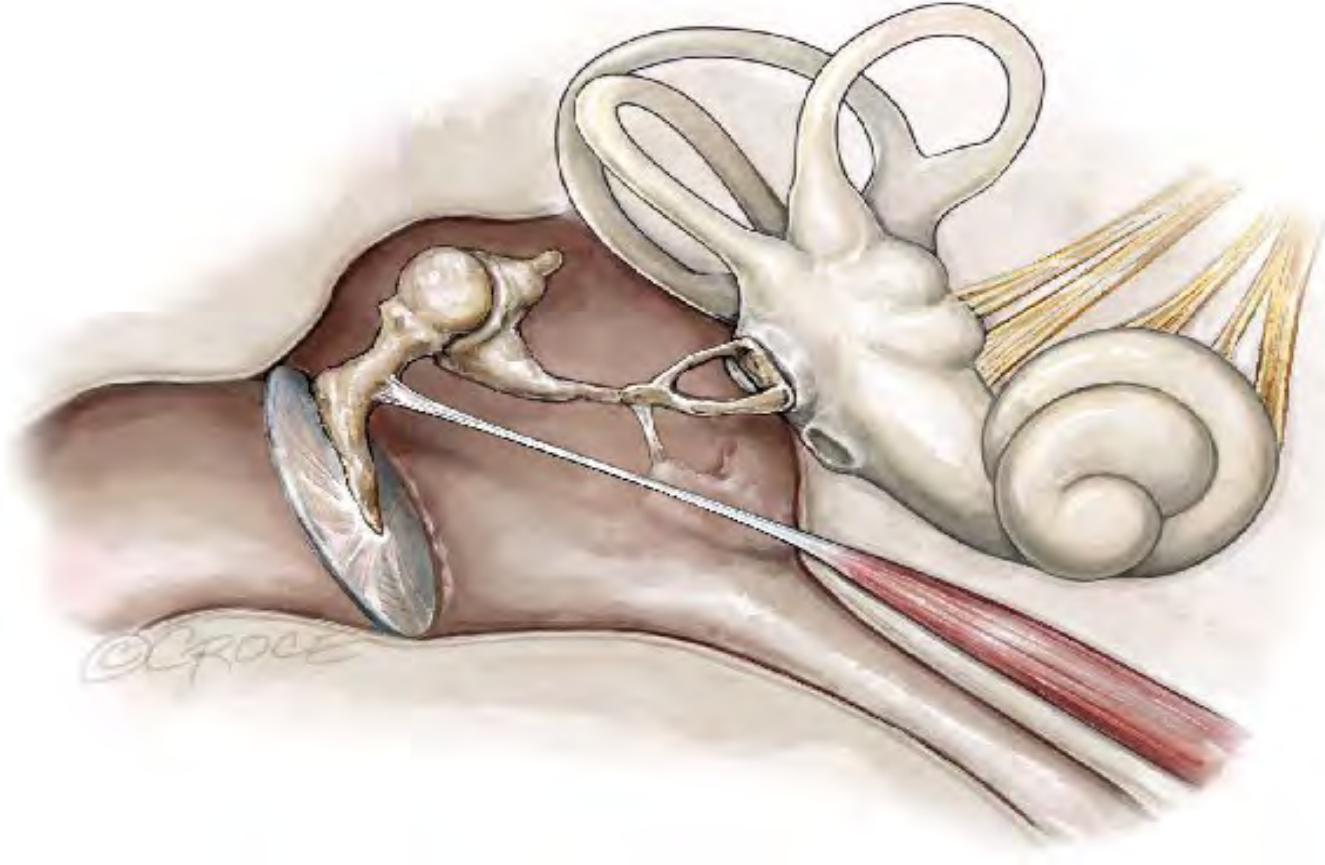
**BUT.....**

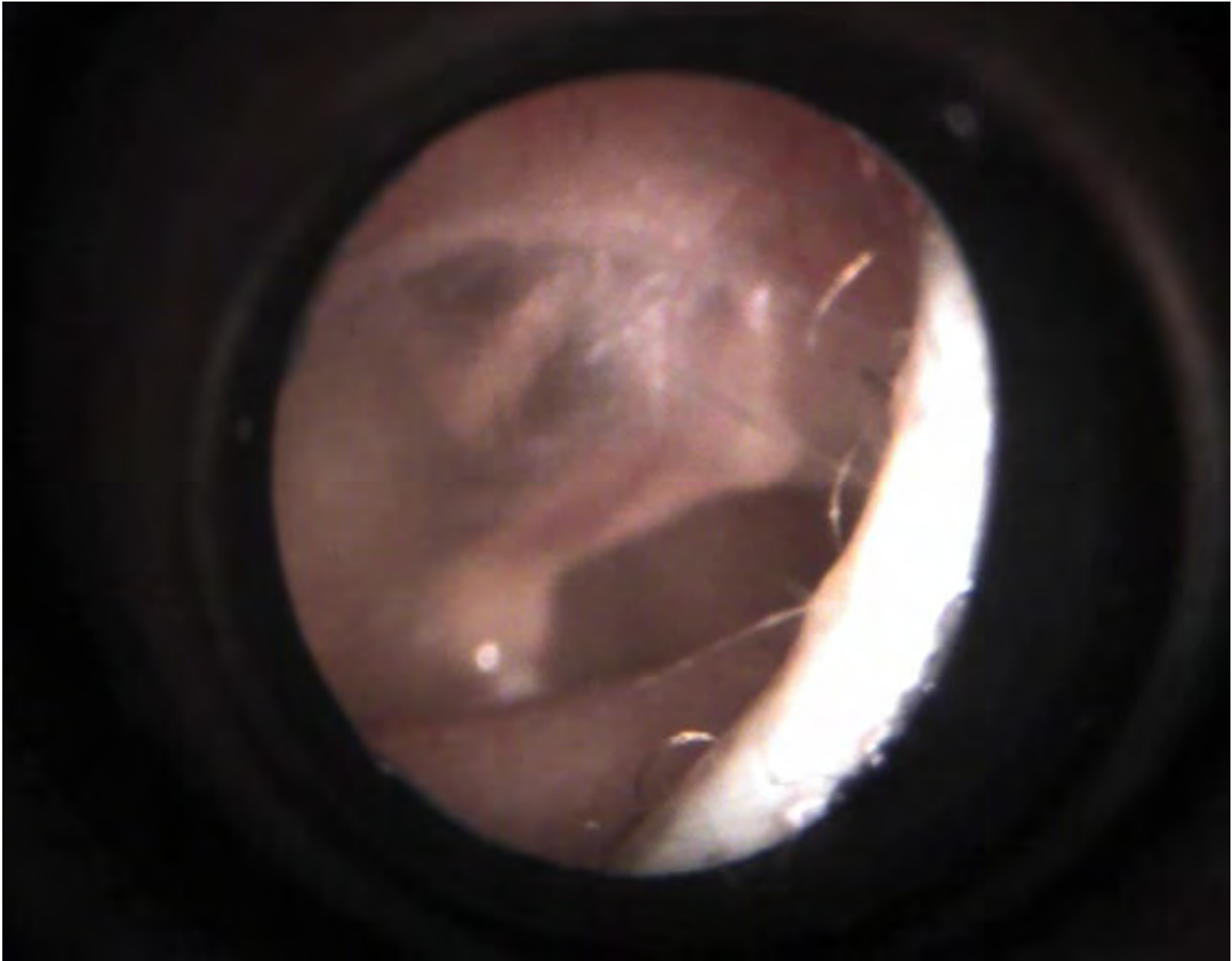
Acoustic incidents can occur anywhere – not just in the workplace.

**The primary cause of acoustic shock:** Excessive middle ear muscle contractions from exposure to the acoustic incident (Patuzzi, Milhinch and Doyle, 2000, Patuzzi, 2002).

**Persistent symptoms of acoustic shock disorder:** consistent with tonic tensor tympani syndrome (TTTS), Klockhoff (1961, 1971, 1978, 1979).

TTTS = frequent or continual spasm of the tensor tympani muscle in the middle ear.





# TTTS: physiological consequences

- **Tinnitus**, often with a clicking<sup>1,2</sup>, rhythmic quality; LF rumbling, buzzing sound<sup>3</sup>
- **tympanic membrane flutter**<sup>4</sup>
- alterations in ventilation of the middle ear cavity: **aural blockage/fullness**, a frequent **aural “popping”** sensation, **mild vertigo**.<sup>5,6</sup> TM retraction: **dull earache**.
- **fluctuating low frequency hearing loss** (mixed conductive and sensorineural) leading to symptoms of **“muffled”** and/or **“distorted”** hearing:
  - minor alterations in middle ear impedance<sup>7</sup> causing a conductive hearing loss<sup>8</sup>
  - a LF mixed hearing loss has been identified in VEM patients<sup>3</sup>
  - in some cases of acoustic shock a mild low frequency sensorineural hearing loss develops<sup>9,10</sup>.Possible mechanisms for the sensorineural component:
  - changes in inner ear perilymphatic pressure from intense TT contraction<sup>8,11</sup>
  - loss of osteo-tympanal contribution to BC thresholds<sup>3</sup>
  - change in the cochlear impedance load<sup>3</sup>
- inflammation of the trigeminal nerve innervating the tensor tympani muscle: **PAIN, numbness and burning sensations in and around the ear, along the cheek, neck and jaw joint (TMJ)**<sup>12-14</sup>

1. Pollack et al, 2014  
2. Ellenstein et al, 2013  
3. Wickens et al, 2017  
4. Westcott et al, 2013  
5. Aristeguieta et al, 2010  
6. Douglas et al, 2010  
7. Riga et al, 2010

8. Bance et al, 2013  
9. Westcott, 2006  
10. Milhinch, 2001  
11. Rock, 1995  
12. Ramirez et al, 2008  
13. Westcott, 2010  
14. Norena et al, 2018

# Tonic Tensor Tympani Syndrome (TTTS) in Tinnitus and Hyperacusis Patients: A Multi-Clinic Prevalence Study

M Westcott et al.

Noise and Health Journal, Mar-Apr 2013, Volume 15, Issue 63 pp117-128

- Data collected on all consecutive T and H patients seen over a survey period in 2010 in 8 tinnitus/hyperacusis clinics (Australia/NZ, Brazil, Spain). Total 345 patients (52% male, 48% female).
- whether the T, H had been triggered by an acoustic incident
- presence of symptoms consistent with TTTS in one or both ears
- whether these symptoms developed from, or were exacerbated by, exposure to loud/intolerable sounds

## Results:

- 60.0% (207/345) of total sample had at least one symptom consistent with TTTS
- 47.5% (164/345)  $\geq 2$  symptoms

# Multi-clinic TTTS symptom prevalence study: Acoustic Shock results

24.1% of total sample identified an acoustic incident trigger for their T/H onset

Of those, 81.9% reported  $\geq 1$  symptoms consistent with TTTS, compared to 53.1% of patients without an acoustic incident trigger ( $p < 0.001$ )

19.7% of total patients fitted a diagnosis of acoustic shock

Acoustic shock reported in all countries: Australia/NZ 26.3%; Spain 13.2%; Brazil 12.4%

83.8% of acoustic shock patients had H, 41.2% of non-AS group had H ( $p < 0.001$ )

97% of patients with a unilateral acoustic incident trigger for their acoustic shock had  $\geq 1$  symptoms consistent with TTTS to a greater degree on the affected side ( $p < 0.001$ )

# Acoustic shock disorder: major impact

The most severe cases of hyperacusis seen in my clinic are patients with acoustic shock disorder.

Acoustic shock disorder symptoms are involuntary, subjective, easily misunderstood or not believed. An inadequate understanding of these symptoms often exacerbates anxiety and distress.

Major impact on quality of life:

- persistent TTS symptoms, exacerbated by everyday sounds, causing suffering due to aural discomfort/pain and other symptoms
- tinnitus enhancement
- auditory hypervigilance: constant environmental monitoring
- increased startle
- bewilderment, anger, anxiety, depression, adjustment disorder, PTSD
- severe lifestyle constraints
- difficulty explaining this abnormal reaction to sound to others, including health professionals



# Onward Referrals

## Acoustic shock disorder patients with constant pain: treat as trigeminal neuralgia/TMD

### **Pain Specialist:**

- diagnosis
- nerve pain medication: Endep, Lyrica (Pregabalin, anticonvulsant)
- stellate ganglion block

### **Musculo-skeletal physiotherapist:**

- Identification and location of myofascial trigger points
- neck, jaw relaxation exercises

### **TMJ specialist:**

- diagnosis, treatment of secondary TMJ/TMD

## Acoustic shock disorder patients:

### **ENT Specialist:**

- Vertigo/balance disturbances – to exclude fistula
- Severe TTS symptoms – to exclude aural pathology
- To support diagnosis of acoustic shock disorder (necessary for 3<sup>rd</sup> party funding)

### **Psychologist/psychiatrist:**

- anxiety, depression, PTSD, critical incident stress, adjustment disorder treatment
- PTSD patients can have acoustic shock disorder/hyperacusis
- Pain management

# Conclusion

TTTS, Acoustic shock need to be:

- acknowledged as legitimate conditions
- diagnosed and demystified to patients
- effectively treated

The potential severity and persistence of hyperacusis, TTTS, Acoustic shock disorder symptoms has significant clinical, occupational and medico-legal implications:

- With the global growth of call centres, health professionals are increasingly likely to encounter acoustic shock disorder.
- Acoustic incidents can be expected to occur in military/police workplaces. Tinnitus, hearing loss and PTSD are the top 3 injuries in American war veterans.