OMT for Tinnitus: Evidence Based Applications

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Objectives

- Recognize somatosensory tinnitus
- Propose management
- Perform OMT for somatosensory tinnitus
Roadmap

• Cases
• Auditory Pathways
• Introduction to tinnitus
• Research
• Treatment
Case 1

- 73 year old male with tinnitus that feels like it is emanating from his neck
- Has sensorineural hearing loss
- Tinnitus is worse on the right
- Worsened by biceps/triceps exercises. Turning head to the right makes the right ear worse
- Tinnitus volume - High
- Hard to concentrate at work
- 3:00 AM wife found him outside hitting head into cinder block wall
- After OMT x 4 tinnitus down to 0.5 -1.
Case 2

• 52 year old male in high speed MVC resulting in blunt trauma to the left side of the head
• Constant tinnitus – high intensity
• Sensorineural hearing loss
• Does not modulate
• Did not respond to OMT
• Why does one patient respond and not the other?

• Let’s find out.
AUDITORY PATHWAYS
Auditory Pathway

• Tonotopically organized – higher frequency toward the outer spiral of the cochlea and therefore the outer part of the cochlear nerve (division of CN VIII)

• Spiral ganglion just outside the cochlea to cochlear nerve

• Dorsal and Ventral cochlear nuclei
  – Wrapped around lateral aspect of the inferior cerebellar peduncle at the pontomedullary junction

Auditory Pathway

• Ascend **bilaterally** to the inferior colliculi
  – Mainly via lateral lemniscus
  – Multiple deccussations of fibers

• On to the medial geniculate nuclei of the thalamus and then to the primary auditory cortex at the Superior Temporal Gyrus (Heschl’s/ Brodmann 41)

• But there is more detail...
Auditory Pathway

• Dorsal cochlear nucleus ipsilateral to spiral ganglion
  – Fibers pass dorsal to the inferior cerebellar peduncle cross the pontine tegmentum and ascend to the contralateral lateral lemniscus in the pons
  – Continues on to the inferior colliculus at the midbrain where auditory information is shared between the two colliculi and onto the medial geniculate nucleus

• What about the ventral cochlear nucleus?
Auditory Pathway

• Many but not all fibers of the ventral cochlear nucleus pass ventral to the inferior cerebellar peduncle to synapse **bilaterally** at the superior olivary nuclear complex in the rostral medulla and caudal pons
  – Localization?
• Fibers cross and form the trapezoid body
  – White matter
• Fibers ascend from the superior olivary nuclear complex bilaterally via the lateral lemniscus to the inferior colliculi of the dorsal midbrain seated under the thalamus

Auditory Pathway

• Decussation at the inferior colliculi
  – Fibers pass dorsal and ventral to the cerebral aqueduct
  – Fibers ascend from the brachium of the inferior colliculi to the medial geniculate nuclei
    • Brachium travels lateral to the superior colliculus to the posterior thalamus

• Medial geniculate nucleus
  – Posterior inferior thalamus above the cerebral peduncle
  – Primary auditory cortex via auditory radiations

• Superior Temporal Gyrus/Heschl’s Gyrus behind the Sylvian fissure/lateral sulcus
Basic Auditory Modulation

- Efferent feedback from the brainstem to the cochlea to modulate sensitivity of the hair cells in response to sound intensity
- Reflexes from ventral cochlear nuclei to facial and trigeminal motor nuclei to contract stapedius and tensor tympani respectively
  - The importance of CN V will become more apparent later, keep it in mind

Other Auditory Pathways

- Cochlear nuclei to the reticular formation to the thalamus to limbic system & hypothalamus & cortical structures

- Straightforward right, so why tinnitus then...
Tinnitus

• Perception of sound where none exists
• Tinnitus can be caused by dysfunction **anywhere in the auditory system**
• Affects 16% of Americans
• Treatment resistant (or is it?)
• Acoustic – buzzing, hissing, ringing
  – Unlike hallucinations (voices, instruments)
• Unilateral, bilateral, deep from within
• Intermittent, pulsatile, constant
• Subtle to loud
• Pitch matches the frequency of hearing loss
Tinnitus

• Objective
  – Audible by the examiner
  – Inner body source of generator
    • Tensor tympani/palatal myoclonus
    • Blood flow alteration
  – Neurology & ENT referral!

• Subjective (more common & our focus here)
  – Patient hears
Tinnitus: to whom do you belong?

• Long thought to be a disease of the cochlea only
  – Damage to hair cells
  – Dead regions of cochlea seen on pathology
  – Managed by ENT

• Perhaps it is a neurological disease
  – Tinnitus persists after auditory nerve section
  – Treatments targeting the cochlea are of variable efficacy
  – Auditory association cortex shows activity in tinnitus
Subjective Tinnitus

• Sensorineural hearing loss
• Somatosensory
  – TMJ
  – Whiplash
  – Cervical spine disorders
• Vascular insufficiency
• Bone disease
• Infection
• Metabolic Derangements
• CNS pathology
• Autoimmune Disease
• Medications
Epidemiology

• Male
• Age
• Hearing impairment
• Noise exposure
Associated Symptoms

• Irritable
• Anxious
• Frustrated
• Depression
• Insomnia
• Hyperacusis
• Difficulty hearing (distinct from hearing loss)
• Poor concentration

Pathophysiology

• Usually there is cochlear damage (hair cell) → abnormal neural activity in the central auditory pathway → perception of tinnitus
• Can also happen if the auditory nerve is injured
• Not everyone with hearing loss gets tinnitus
• Patients with tinnitus may have a normal audiogram
  – These patients usually have cochlear dead regions though
  – Is Tinnitus akin to phantom limb?
Neural Mechanisms

• Multifactoral – auditory deprivation causes changes to neural plasticity which alters neural activity and triggers compensation for absent input; abnormal somatosensory afferent input from the neck and face affect the central auditory pathways

• Cortex- reduced inhibition in the deafferented area, edge regions which receive input extend into the deafferented area
  – Is this compensation for sound loss or the generator of tinnitus – unknown

• Magnetoencephalography and EEG show gamma band activity in the auditory cortex in patients with normal function and in those with tinnitus
  – Is this a problem of failure to inhibit?

Neural Mechanisms

- Tinnitus changes are not restricted to the auditory cortices
- Anterior insula, anterior cingulate, thalamus, amygdala, hippocampus
  - Abnormal amygdala – cingular cortex seen in patients with chronic pain syndromes and somatiform disorders
- Maybe nucleus accumbens and subgenual cingulate cortex
- Tinnitus changes the brain over time and covers a number of neural networks – it becomes locked in
  - Maybe

Neurotinnitus?

• Dorsal cochlear nucleus (DCN) exhibits dysfunctional excitability in tinnitus
  – Treat this excitability and treat the tinnitus?
  – Giving NMDA receptor antagonist reduced abnormal plasticity in the DCN in an animal model
    • Much more to come
    • Memantine/Namenda is an NMDA antagonist
  – Keep the DCN in mind for later

SOMATOSENSORY TINNITUS
Somatosensory Tinnitus

• Tinnitus modulated by movement of the head/neck
  – Pitch and volume changes

• Specific maneuvers
  – Cervical spine flexion, extension, side bending, rotation
  – Pressure to the forehead, occiput, vertex, mandible, temple, and other sites with resistance
  – Clench teeth, open mouth, protrude jaw, slide jaw side to side

Somatosensory Tinnitus

• Risk of tinnitus is 8.37 times higher in patients with temporomandibular disorders

• 79.67% of patients with history of TMJ or cervical spine disorders have tinnitus modulation with specific musculoskeletal maneuvers
  – Tested maneuvers increased loudness in 94%
  – 75% have unilateral tinnitus

Somatosensory Tinnitus

• Is there interaction between the musculoskeletal system and auditory system to explain this?

• Animal model shows the dorsal cochlear nucleus receives projections from the auditory nerve, trigeminal nerve, and the dorsal column ganglia.

Back to Auditory Pathways

• Dorsal Cochlear Nucleus
  – Receive somatosensory input
    • Does this inhibit sound?
  – Hyperexcitability in tinnitus

  – We don’t know what this means but the integration of somatic afferents with auditory afferents begs the question...
Somatosensory Tinnitus

• If there is a musculoskeletal connection, could this type of tinnitus be amenable to osteopathic manipulation?
RESEARCH
Research

• Alexander J et al. Response of Tinnitus to Osteopathic Manipulation. OMED October 2015.
Study 1: Who responds to OMT

- Retrospective of 20 patients at a tertiary center
  - 11 responded
    - 80% had worsening tinnitus with musculoskeletal activity
      - Head turning, cervical flexion, cervical side bending, chewing
      - 100% have somatic dysfunction of the head and neck
      - Average reduction in perceived tinnitus volume 76.9%
      - All have sensorineural hearing loss superimposed
      - Responded after 3.25 treatments; treated average of 5.89 times
  - 9 non-responders
    - None have change in tinnitus with musculoskeletal activity
    - 33% have somatic dysfunction
    - Etiology: auditory trauma, blunt cochlear trauma, sensorineural hearing loss
Study 2: effect of manipulation on somatosensory tinnitus

- 122 Dutch participants with cervicogenic somatosensory tinnitus
  - Had to have cervical dysfunction by history and examination
  - Divided into groups receiving manipulation and manipulation + counseling
- Specific manipulation protocol
- Primary outcome: reduction in Visual Analog Scale (VAS) for Tinnitus
- 38.5% female
- Average duration with tinnitus 7.3 years
- Average treatments ~10
- No adverse effects
- Study showed significant reduction in VAS score
  - 5.9 for manipulation only group (+/- 17.7; p 0.01)
  - 12.3 for manipulation + counseling (+/- 20.3; p 0.00)
Study 3: effect of physical therapy on somatosensory tinnitus

- Delayed-start randomized control trial
- Standardized cervical physical therapy for patients with somatosensory tinnitus
- 38 Belgian patients from tertiary tinnitus clinic
  - Group 1: 6 weeks of treatment, 6 weeks of follow-up
  - Group 2: 6 week delay, 6 weeks treatment, 6 weeks follow-up
- Tinnitus Functional Index (TFI)
  - Measures tinnitus impact in 8 areas
- TFI 48 (severe tinnitus) at baseline
- TFI decreased to 44 (SD 22 p0.04) immediately after treatment
- TFI increased to 47 (SD 22) 6 weeks after treatment
QUESTIONS? CRITICISM? COMMENTS?
TREATMENT
Treatment Time

- Pterygoids – 10 minutes total
- Diaphragms – 20 minutes total
- Auditory Pathways – 40 minutes +
  – This one takes time and patience
- Clean up & questions- 20 minutes
Treatment

• Our focus today
  – Pterygoids – do this if nothing else!
  – Tentorium cerebelli
  – Auitory pathways

• You can do detailed anatomy review on your own of the pterygoids, mandible, temporal bone, diaphragms, etc...

• Also remember this is a component of a larger treatment model. Integrate this into the person, do not impose it on them.

• You may need to treat a number of other things first!
Treatment

• Medial Pterygoid
  – CN V via mandibular branch which also innervates tensor tympani
  – Deep and superficial head
    • Origin: lateral pterygoid plate and palatine bone
    • Insertion: ramus and angle of mandible
  – Orientation
    • Downward, lateral, posterior
  – Action
    • Mandible elevation, excursion, and protrusion
Treatment

• Lateral Pterygoid
  – Innervation: lateral pterygoid nerve from CN V
  – Origin: Superior head from greater wing of sphenoid; Inferior head on the lateral pterygoid plate
  – Insertion: condyloid process of mandible and TMJ
  – Action: Opens mandible, protrusion
  – Orientation: Superior head inferomedial
    • Inferior head superomedial
Muscles Involved in Mastication (Deep)
Lateral View

- Articular disc of temporomandibular joint
- Articular disc
- Lateral pterygoid muscle
- Sphenomandibular ligament
- Medial pterygoid muscle
- Masseter muscle
- Buccinator muscle
- Temporalis muscle
- Platysma muscle
- Suprahyoid and infrahyoid muscles
- Mandible (mandibular rami)
Treatment

• Pterygoids
  – Inhibition using your pinkie
    • Patients can do this at home with their index finger
      – and masseter massage
  – Follow muscle fibers
  – Monitor PRM
    • Treat the system
  – Place your other hand under the cervical spine and cradle
    the neck. Monitor C2 and use fluid technique to treat the
    pterygoids and upper cervical muscles – usually splenius
    cervicis
  – Integrate CN V if needed (it’s right behind your pinkie)
  – Lab
Treatment

• Treat the diaphragms
  – Tentorium cerebelli, (Sibson’s fascia), respiratory diaphragm, pelvic diaphragm
  – You may find venous sinus technique more helpful in treating the tent
  – Let’s talk about the tent a little
  – *Lab (time dependent)*
Treatment

• Tentorium cerebelli
  – Attached to the falx cerebri in the midline
    • Straight sinus
    • Superior position makes it seem tented
  – Anterior portion attaches to the anterior clinoid process
    • Forms lateral cavernous sinus
    • Deep tentorial notch is U shaped
  – Anterolateral attachment to superior petrous, extends laterally to the posterior clinoid process
    • Superior petrosal sinus
  – Posterolateral margin separates to 2 layers of dura & attach at the transverse sulci of the occipital bone. Anteriorly it attaches to the posterior-inferior angles of the parietal bone
  – Posterior attachment to internal occipital protuberance
    • Transverse sinus
Treatment

• Sibson’s Fascia/suprapleural membrane
  – Attaches to the inner border of the first rib and transverse process of C7

• You know the respiratory and pelvic diaphragms
Tinnitus treatment

THE AUDITORY PATHWAYS
Tinnitus Treatment

• Treat the auditory pathways from the cochlea to the auditory cortices
  – Be mindful of bilateral pathways
  – *Lab*

*Netter. CIBA Vol 1.*
Lateral Lemniscus from Cochlear Nuclei
Rostral Pons Lateral Lemniscus extremely lateral
Midbrain Inferior Colliculus and Lateral Lemniscus
Inferior Colliculus to MGN in red
Inferior colluuli and Thalamus

- Genu of corpus callosum
- Nasal Septum
- Splenium of Corpus callosum
- Superior Colliculus
- Inferior Colliculus
- Pons
- Medulla
Red = Heschl’s Gyrus
Treat Bilaterally

- Cochlea
- Auditory nerve
- Cochlear nuclei
  - Start ventral and look at the superior olivary complex then come down and look at the dorsal cochlear nucleus then treat as one unit
- Inferior colliculi
  - Mind the decussaiton
- Heschl’s Gyrus
- Auditory Association Cortex
Tinnitus Treatment: other thoughts

• Find where temporal motion is being restricted
  – Does patient have gliosis, fascial restriction?
• Treat petrous portion of the temporal bone
• Fascial unwind of the ear and external auditory canal
• Treat the CSF/ventricles
Tinnitus Treatment: other thoughts

• Digastric
• SCM – Occipitomastoid release and/or direct inhibition
• Align the jaw
• Liberate the atlas
• Treat the pelvis
• Look at the fascia
• Treat the arm if levator scapula is involved