Winter 12-31-2020

Pathogenesis and Onset of Tinnitus and Use of Holistic and Traditional Audiological Approaches for Management

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Audiological Approaches for Management

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Approved: December 2020

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Abstract 1

Introduction: Tinnitus is the subjective sensation of noise perceived at the peripheral or central level. Occasionally, tinnitus perception may be severe enough to present debilitating effects on daily activities. The occurrence of tinnitus can be related to occupational or non-occupational hazardous noise exposure. Case Presentation: A 60-year-old male presented with bilateral tinnitus with an initial onset at age 21. The progression of his tinnitus has caused disruptions in sleeping patterns and concentration. His history included extensive occupational and non-occupational noise exposure. Discussion: Hearing conservation is an important aspect of facilitating tinnitus management for individuals who have noise-related tinnitus. Hearing aids, sound therapy, counseling, and follow-up are a few discretionary tinnitus rehabilitation tools. Conclusion: Successful tinnitus management calls for audiologists to provide education, support, and personalized intervention for patients.

Case Presentation 1: Tinnitus Onset from a Suspected Relationship with Longstanding Noise Exposure

Introduction

Tinnitus is defined as the subjective perception of noise when no external sound source is present (Henry & Manning, 2019; Martz & Henry, 2016). A patient's case history can be essential in determining the etiology of their tinnitus. A history of noise and auditory distress can often result in the onset of tinnitus (Musiek et al., 2012); however, tinnitus often does not require treatment and does not have a significant impact on 80% of affected individuals (Henry & Manning, 2019). Nevertheless, in a minority of the population, tinnitus may eventually become debilitating, affecting essential functions of daily life such as the ability to focus and sleep (Katz et al., 2014; Musiek et al., 2012). A common application utilized for the evaluation of tinnitus is the Tinnitus Handicap Inventory (THI). The THI focuses on the impact of tinnitus on the social, emotional, and functional aspects of patient's lives. Seldomly, individuals who experience tinnitus do not have an otologic or physiologic history consistent with the symptom.

Case Presentation

For this case, a 60-year-old male was seen for a tinnitus evaluation. He presented with constant bilateral tinnitus with an initial onset age of 21 years old. Reportedly, his tinnitus gradually progressed in severity and eventually disrupted daily activities, including sleep, concentration, and socialization. The patient had a long history of recreational and occupational noise exposure and reported sensitivity to high-pitched tones while only able to tolerate them in small doses. His tinnitus also contributed to difficulty with communication. On a ten-point scale, tinnitus was rated as nine for severity and annoyance. No other otologic concerns were identified, although the patient did report a history of hypertension.

Our protocol for tinnitus evaluation and management included the THI, which was administered during the intake process and at all subsequent appointments. The initial THI data (Figure 1.1) revealed a score of 56, indicative of a *moderate* tinnitus handicap. A subsequent THI (Figure 1.2), administered two months later, revealed a score of 48, also consistent with *moderate* tinnitus handicap. The Patient Health Inventory (PHQ-9) was administered to assess his mental health status, however no mental health problems were identified. A previous audiological assessment (Figure 1.3) revealed normal, sloping to severe, bilateral, sensorineural hearing loss.

Data for the tinnitus evaluation may be found in Table 1.1. His tinnitus resembled an 8000 Hz tone in the right ear and 4000 Hz tone in the left ear, perceived at 7 dB and 4 dB above thresholds at those frequencies, respectively. Minimal masking levels (MMLs) are a measurement of the lowest level of white noise necessary to mask tinnitus perception. There are two points of masking in MML: (1) ipsilaterally, in which a stimulus is introduced to the tinnitus perceived ear and (2) contralaterally, wherein a stimulus is introduced to mask the tinnitus perception in the contralateral ear. The ipsilateral MML was 20 dB of effective masking (EM) for the right and left ears. Residual inhibition is a measure of the return of tinnitus perception following effective masking presentation of 60 seconds. In this case, the patient immediately perceived his tinnitus after the masking stimulus was discontinued.

Uncomfortable loudness levels (UCLs) are administered as part of a tinnitus evaluation protocol to identify the presence of hyperacusis or pitch-specific sound sensitivity. The patient's UCLs were found to be within a normal range, so no hyperacusis was considered evident.

Management

The patient was counseled on the theories of the suspected physiologic nature of his tinnitus; in that, his tinnitus was likely related to damage of his auditory system sustained from substantial noise exposure. He was encouraged to decrease noise exposure by using

hearing protection, while sound therapy was recommended to habituate to his tinnitus perception.

The goal of habituation is to allow patients to minimize the disruption of bothersome tinnitus. The use of hearing devices can help alleviate tinnitus severity by providing sound input to the central auditory system. Hearing aids with continuous tinnitus masking noise were demonstrated and fitted. As a result, the patient reported immediate tinnitus relief. He agreed to pursue our tinnitus management recommendations and plans for follow-up in order to track his habituation, including use of self-assessment tools. He was then given information and tools for the use of sound therapy and methods to achieve habituation.

Discussion

Researchers estimate that approximately 15% of adults are affected by tinnitus (Henry & Manning, 2019). When no underlying and reversible medical factor is suspected, a consult to a physician may prove to be useless. Audiologists can deliver timely relief to individuals who suffer from bothersome and debilitating tinnitus by providing highly specialized evaluations and treatments. In addition, hearing loss prevention practices can help to protect individuals with noise-related tinnitus, especially by preventing the exacerbation of symptoms (Musiek et al., 2012). It is important to use tools like the THI, in tinnitus management, to quantify tinnitus severity and areas impacted by the condition. The THI is primarily comprised of psychosocial questions, which reflect associated emotional difficulties. Importantly, patients with bothersome or debilitating tinnitus should complete a THI at every appointment to monitor their perception of tinnitus. To provide immediate relief from tinnitus, the prescription of hearing aids can be significantly beneficial. Finally, if assistive listening devices are used for tinnitus management, it is crucial to incorporate habituation counseling and employ regular follow-up to assess the effectiveness of your treatment.

Conclusion

Tinnitus commonly occurs as a result of noise exposure and the life-long taxation of the auditory system. Audiologists are called to play the role of a hearing conservationist for their patients when overseeing management of suspected noise-induced tinnitus. Self-assessment questionnaires should be used to measure the impacts of tinnitus, thus allowing clinicians to track patient habituation. Hearing aids are effective in reducing the perception of tinnitus and can offer a long- term therapeutic strategy. Hence, tinnitus management is far more than just a prescription of amplification. To that end, counseling is an important component of tinnitus rehabilitation because habituation begins when patients understand how to mentally and emotionally manage their condition.

Abstract 2

Introduction: Tinnitus has been associated with the incidence of head trauma. Although tinnitus may subside when the trauma resolves, it may continue to persist as well. Case Presentation: A 65-year old female presented with unilateral tinnitus after sustaining a concussion. Discussion: Trauma-induced tinnitus may be more debilitating than other tinnitus etiologies. There are several management approaches available for the treatment of tinnitus, but outcome measures are important tools that may be used to classify and track progression, especially during treatment. Conclusion: Audiologists are very equipped to effectively evaluate and manage individuals who suffer from tinnitus.

Case Presentation 2: Effects of Tinnitus in Post-Concussion Syndrome

Introduction

Tinnitus has been associated with the incidence of auditory trauma and traumatic brain injuries (Henry & Manning, 2019; Martz & Henry 2016; Kreuzer et al, 2008; Reddy et al, 2018). Trauma-induced tinnitus is more likely to cause disruption and impairment than non-trauma induced tinnitus (Kreuzer et al., 2008). Even after resolution of causative injury, tinnitus may continue to persist (Currie et al, 2017; Vander Werf & Rieger, 2019). So, for patients who experience persistent tinnitus as a result of head trauma, the consultation of an audiologist is vital to optimize their rehabilitation.

Case Presentation

A 65-year old female was seen in our clinic for a tinnitus evaluation. She presented with a right-sided unilateral tinnitus, reporting a head injury on the right which caused significant pain, headache, and laceration with minor bleeding at the point of impact. Although she maintained consciousness, the patient was reportedly disoriented and groggy, and this was followed by persistent headaches, sustained disorientation, tinnitus, and blurred vision, primarily affecting her right-side. The patient consulted medical professionals and was directed to an emergency room. While there, a CT scan, or computed tomography, was administered with no evidence of acute intracranial hemorrhaging. She was subsequently diagnosed with post-concussion syndrome (PCS) and advised to follow-up with her primary care provider who confirmed the diagnosis. Notably, a diagnosis of PCS can occur when a concussion is improperly managed and, ultimately, may take a year or longer to resolve.

The patient reported that her blurred vision was improving, however the tinnitus was not. She reported the presence of non-bothersome intermittent tinnitus before her head injury that became significantly worse after the concussion, resulting in spontaneous episodes of severe tinnitus resulting in a migraine and blurred vision that affected her right-side. Her

television and telephone sound applications were used to manage tinnitus and aid with sleep.

The patient completed the Tinnitus Handicap Inventory (THI) (see Figure 2.1) as part of the clinical-intake process. The intake THI score was 14, indicative of a *slight* tinnitus handicap. At the beginning of her next appointment the THI was re-administered, resulting in a score of 10 (Figure 2.2). These findings were comparable, even though slight improvement in tinnitus handicap was reported by the patient. A diagnostic audiological evaluation was administered (Figure 2.3) showing an asymmetric, sloping, and notched hearing loss, worse for her right ear. Word recognition performance was *excellent* in both ears however a difference in performance was noted between ears, with the right ear poorer (Table 2.1). Testing revealed that the patient's tinnitus resembled a 4000 Hz tone at a sensation level of 3 dB HL above the threshold at that frequency. Data from the tinnitus evaluation can be seen in Table 2.2.

Management

The patient indicated that she perceived no difficulties with hearing, however acknowledged that communication partners disagreed with her. She had no interest in using assistive listening devices for tinnitus management, so a direct counseling approach was pursued. The patient was given a thorough consultation about her tinnitus, including the pathological basis of its onset and persistence. Common triggers and exacerbating factors were discussed, and we recommended the use of relaxation and meditative techniques to reduce stress. She was then provided information about sound therapy tools that would allow her to customize sound profiles and was counseled on healthy sleep hygiene habits. For example, the patient was encouraged to discontinue using her television as a sleep aid and encouraged to replace it with a sound therapy apparatus. Furthermore, she was directed to limit strenuous activities and to rest on days when the tinnitus was severe. A recommendation was made for the patient to return to the clinic to monitor her tinnitus.

Discussion

While the exclusive characteristics of injury-induced tinnitus remain elusive, it tends to be more intense and bothersome than non-injurious tinnitus etiologies (Kreuzer et al., 2012; Zagloski and Strek, 2014; Vernon and Press, 1994). Tinnitus resulting in traumatic injuries can result in higher levels of mental burden, making habituation more difficult to obtain (Kreuzer et al., 2012) and is perceived more loudly and spontaneously in those with head injury etiologies (Zagloski and Strek, 2014). As such, it is crucial to track the onset of trauma-induced tinnitus and whether the symptoms change over time. Tinnitus and mental health self- assessments should be used regularly throughout the rehabilitation process. Audiologists are trained to provide direct counseling to tinnitus patients and may be instrumental in obtaining positive outcomes for patients. For those who experience extreme mental distress from their tinnitus, it is important for clinicians to use a multi-disciplinary approach that includes a mental-health professional.

Conclusion

It is important to routinely access handicap and mental impacts for trauma-induced tinnitus patients. Head injuries are a prevalent etiology of debilitating tinnitus, which can be disruptive and cause significant impairment. Self-assessments are important tools for audiologists to measure treatment effectiveness. Ongoing assessments may assist clinicians with the effective management of tinnitus cases. At this time, there are several validated tinnitus self-assessments that audiologists may use, and these tools can be especially helpful for quantifying improvement with patients who have debilitating tinnitus.

Tables/Figures (Case 1)

Figure 1.1

Tinnitus Handicap Inventory (adapted)			
1. Because of your tinnitus, is it difficult for you to concentrate?	Yes	No	Sometimes
2. Does the loudness of your tinnitus make it difficult for you to hear people?	Yes	No	Sometimes
3. Does your tinnitus make you angry?	Yes	No	Sometimes
4. Does your tinnitus make you confused?	Yes	No	Sometimes
5. Because of your tinnitus are you desperate?	Yes	No	Sometimes
6. Do you complain a great deal about your tinnitus?	Yes	No	Sometimes
7. Because of your tinnitus, do you have trouble falling to sleep at night?	Yes	No	Sometimes
8. Do you feel as though you cannot escape your tinnitus?	Yes	No	Sometimes
9. Does your tinnitus interfere with your ability to enjoy your social activities (such as going out to dinner, to the movies)?	Yes	No	Sometimes
10. Because of your tinnitus, do you feel frustrated?	Yes	No	Sometimes
11. Because of your tinnitus, do you feel that you have a terrible disease?	Yes	No	Sometimes
12. Does your tinnitus make it difficult for you to enjoy life?	Yes	No	Sometimes
13. Does your tinnitus interfere with your job or household responsibilities?	Yes	No	Sometimes
14. Because of your tinnitus, do you find that you are often irritable?	Yes	No	Sometimes
15. Because of your tinnitus, is it difficult for you to read?	Yes	No	Sometimes
16. Does your tinnitus make you upset?	Yes	No	Sometimes
17. Do you feel that your tinnitus problem has placed stress on your relationships with members of your family and friends?	Yes	No	Sometimes
18. Do you find it difficult to focus your attention away from your tinnitus and on other things?	Yes	No	Sometimes
19. Do you feel that you have no control over your tinnitus?	Yes	No	Sometimes
20. Because of your tinnitus, do you often feel tired?	Yes	No	Sometimes
21. Because of your tinnitus, do you feel depressed?	Yes	No	Sometimes
22. Does your tinnitus make you feel anxious?	Yes	No	Sometimes
23. Do you feel that you can no longer cope with your tinnitus?	Yes	No	Sometimes
24. Does your tinnitus get worse when you are under stress?	Yes	No	Sometimes
25. Does your tinnitus make you feel insecure?	Yes	No	Sometimes
Answer count subtotal	**8**	**5**	**12**
Points Total	**56**		

Figure 1.1, Tinnitus Handicap Inventory questionnaire. A score of 56 is indicative of a *moderate* tinnitus handicap. Points are calculated with the following formula: ("Yes" x 4) + ("Sometimes" x 2).

Figure 1.2

Tinnitus Handicap Inventory (adapted)			
1. Because of your tinnitus, is it difficult for you to concentrate?	Yes	No	Sometimes
2. Does the loudness of your tinnitus make it difficult for you to hear people?	Yes	No	Sometimes
3. Does your tinnitus make you angry?	Yes	No	Sometimes
4. Does your tinnitus make you confused?	Yes	No	Sometimes
5. Because of your tinnitus are you desperate?	Yes	No	Sometimes
6. Do you complain a great deal about your tinnitus?	Yes	No	Sometimes
7. Because of your tinnitus, do you have trouble falling to sleep at night?	Yes	No	Sometimes
8. Do you feel as though you cannot escape your tinnitus?	Yes	No	Sometimes
9. Does your tinnitus interfere with your ability to enjoy your social activities (such as going out to dinner, to the movies)?	Yes	No	Sometimes
10. Because of your tinnitus, do you feel frustrated?	Yes	No	Sometimes
11. Because of your tinnitus, do you feel that you have a terrible disease?	Yes	No	Sometimes
12. Does your tinnitus make it difficult for you to enjoy life?	Yes	No	Sometimes
13. Does your tinnitus interfere with your job or household responsibilities?	Yes	No	Sometimes
14. Because of your tinnitus, do you find that you are often irritable?	Yes	No	Sometimes
15. Because of your tinnitus, is it difficult for you to read?	Yes	No	Sometimes
16. Does your tinnitus make you upset?	Yes	No	Sometimes
17. Do you feel that your tinnitus problem has placed stress on your relationships with members of your family and friends?	Yes	No	Sometimes
18. Do you find it difficult to focus your attention away from your tinnitus and on other things?	Yes	No	Sometimes
19. Do you feel that you have no control over your tinnitus?	Yes	No	Sometimes
20. Because of your tinnitus, do you often feel tired?	Yes	No	Sometimes
21. Because of your tinnitus, do you feel depressed?	Yes	No	Sometimes
22. Does your tinnitus make you feel anxious?	Yes	No	Sometimes
23. Do you feel that you can no longer cope with your tinnitus?	Yes	No	Sometimes
24. Does your tinnitus get worse when you are under stress?	Yes	No	Sometimes
25. Does your tinnitus make you feel insecure?	Yes	No	Sometimes
Answer count subtotal	**9**	**8**	**8**
Points Total	**52**		

Figure 1.2, Tinnitus Handicap Inventory questionnaire. The score is 52, which is consistent a moderate tinnitus handicap.

Figure 1.3

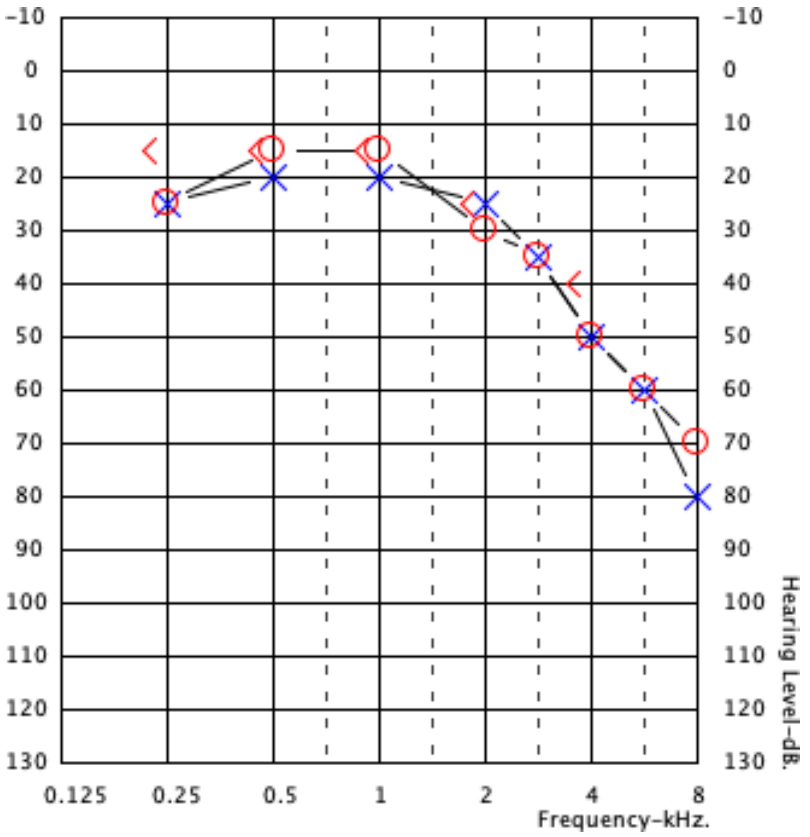

Figure 1.3, Audiogram from a previous visit.

Table 1.1

Tinnitus Evaluation	**Right**		**Left**	
White noise thresholds	2 dB EM		1 dB EM	
Tinnitus Pitch Match	8000 Hz		4000 Hz	
Loudness Match	7 dB SL		4 dB SL	
Minimum Masking Level	R: 20 dB EM	L: 35 dB EM	L: 20 dB EM	R: 75 dB EM
Residual Inhibition	0 seconds		0 seconds	

Discomfort Levels	**750 Hz**	**1500 Hz**	**3000 Hz**
Right	105 dB HL	100 dB HL	110 dB HL
Left	110 dB HL	110 dB HL	105 dB HL

Table 1.1, Tinnitus Evaluation. For residual inhibition, the tinnitus returned immediately after the masking stimulus was terminated. EM= effective masking, SL= sensation level

Table/Figure (Case 2)

Figure 2.1

Tinnitus Handicap Inventory (adapted)			
1. Because of your tinnitus, is it difficult for you to concentrate?	Yes	No	Sometimes
2. Does the loudness of your tinnitus make it difficult for you to hear people?	Yes	No	Sometimes
3. Does your tinnitus make you angry?	Yes	No	Sometimes
4. Does your tinnitus make you confused?	Yes	No	Sometimes
5. Because of your tinnitus are you desperate?	Yes	No	Sometimes
6. Do you complain a great deal about your tinnitus?	Yes	No	Sometimes
7. Because of your tinnitus, do you have trouble falling to sleep at night?	Yes	No	Sometimes
8. Do you feel as though you cannot escape your tinnitus?	Yes	No	Sometimes
9. Does your tinnitus interfere with your ability to enjoy your social activities (such as going out to dinner, to the movies)?	Yes	No	Sometimes
10. Because of your tinnitus, do you feel frustrated?	Yes	No	Sometimes
11. Because of your tinnitus, do you feel that you have a terrible disease?	Yes	No	Sometimes
12. Does your tinnitus make it difficult for you to enjoy life?	Yes	No	Sometimes
13. Does your tinnitus interfere with your job or household responsibilities?	Yes	No	Sometimes
14. Because of your tinnitus, do you find that you are often irritable?	Yes	No	Sometimes
15. Because of your tinnitus, is it difficult for you to read?	Yes	No	Sometimes
16. Does your tinnitus make you upset?	Yes	No	Sometimes
17. Do you feel that your tinnitus problem has placed stress on your relationships with members of your family and friends?	Yes	No	Sometimes
18. Do you find it difficult to focus your attention away from your tinnitus and on other things?	Yes	No	Sometimes
19. Do you feel that you have no control over your tinnitus?	Yes	No	Sometimes
20. Because of your tinnitus, do you often feel tired?	Yes	No	Sometimes
21. Because of your tinnitus, do you feel depressed?	Yes	No	Sometimes
22. Does your tinnitus make you feel anxious?	Yes	No	Sometimes
23. Do you feel that you can no longer cope with your tinnitus?	Yes	No	Sometimes
24. Does your tinnitus get worse when you are under stress?	Yes	No	Sometimes
25. Does your tinnitus make you feel insecure?	Yes	No	Sometimes
Answer count subtotal	0	18	7
Points Total	14		

Figure 2.1, Tinnitus Handicap Inventory questionnaire. The initial score was 14, indicative of a *slight* tinnitus handicap. Points are calculated by the following formula: ("Yes" x 4) + ("Sometimes" x 2)

Figure 2.2

Tinnitus Handicap Inventory (adapted)			
1. Because of your tinnitus, is it difficult for you to concentrate?	Yes	No	Sometimes
2. Does the loudness of your tinnitus make it difficult for you to hear people?	Yes	No	Sometimes
3. Does your tinnitus make you angry?	Yes	No	Sometimes
4. Does your tinnitus make you confused?	Yes	No	Sometimes
5. Because of your tinnitus are you desperate?	Yes	No	Sometimes
6. Do you complain a great deal about your tinnitus?	Yes	No	Sometimes
7. Because of your tinnitus, do you have trouble falling to sleep at night?	Yes	No	Sometimes
8. Do you feel as though you cannot escape your tinnitus?	Yes	No	Sometimes
9. Does your tinnitus interfere with your ability to enjoy your social activities (such as going out to dinner, to the movies)?	Yes	No	Sometimes
10. Because of your tinnitus, do you feel frustrated?	Yes	No	Sometimes
11. Because of your tinnitus, do you feel that you have a terrible disease?	Yes	No	Sometimes
12. Does your tinnitus make it difficult for you to enjoy life?	Yes	No	Sometimes
13. Does your tinnitus interfere with your job or household responsibilities?	Yes	No	Sometimes
14. Because of your tinnitus, do you find that you are often irritable?	Yes	No	Sometimes
15. Because of your tinnitus, is it difficult for you to read?	Yes	No	Sometimes
16. Does your tinnitus make you upset?	Yes	No	Sometimes
17. Do you feel that your tinnitus problem has placed stress on your relationships with members of your family and friends?	Yes	No	Sometimes
18. Do you find it difficult to focus your attention away from your tinnitus and on other things?	Yes	No	Sometimes
19. Do you feel that you have no control over your tinnitus?	Yes	No	Sometimes
20. Because of your tinnitus, do you often feel tired?	Yes	No	Sometimes
21. Because of your tinnitus, do you feel depressed?	Yes	No	Sometimes
22. Does your tinnitus make you feel anxious?	Yes	No	Sometimes
23. Do you feel that you can no longer cope with your tinnitus?	Yes	No	Sometimes
24. Does your tinnitus get worse when you are under stress?	Yes	No	Sometimes
25. Does your tinnitus make you feel insecure?	Yes	No	Sometimes
Answer count subtotal	0	20	5
Points Total	10		

Figure 2.2, Subsequent THI, prior to the tinnitus evaluation. The score was 10, with the tinnitus handicap in the slight category.

Figure 2.3

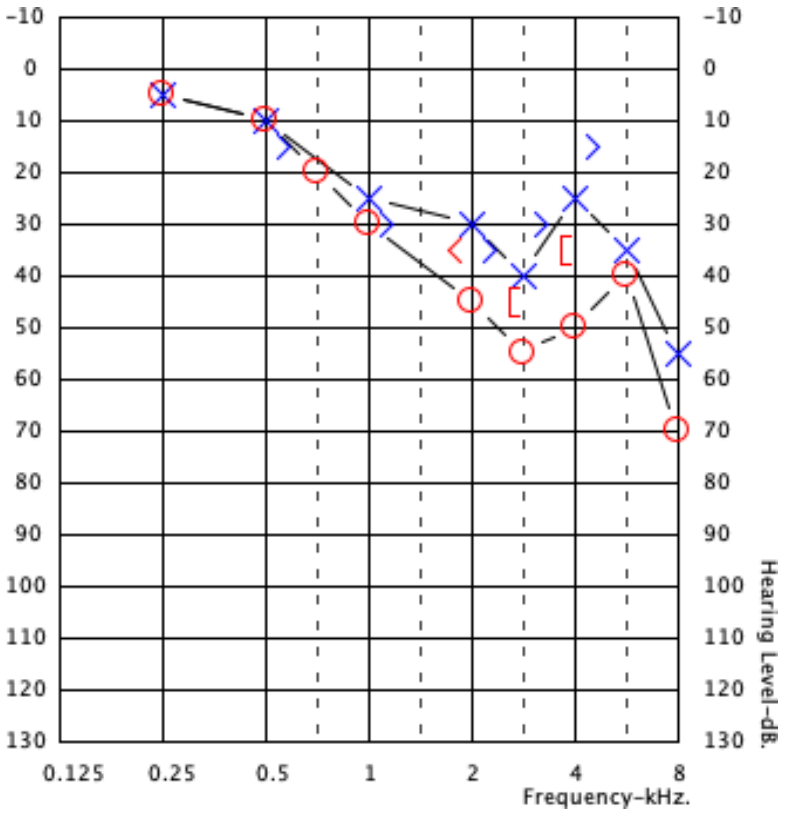

Figure 2.3, Audiogram. Asymmetric, notched hearing loss with normal hearing sloping to mild sensorineural (SNHL), sloping to moderate in the left ear and normal hearing sloping to moderate to moderately-severe SNHL in the right ear.

Table 2.1

Ear	SRT	WRS % correct	WRS level	WRS Masking
Right	35 dB HL	90	75 dB HL	55 dB HL
Leftt	25	100	65	

Table 2.1. Speech audiometry results. Asymmetry in word recognition ability was present, with right performing poorer.

Table 2.2

Tinnitus Evaluations	**Right**	**Left**
White noise thresholds	12 dB EM	11 dB EM
Tinnitus Pitch Match	4000 Hz	-
Loudness Match	3 dB SL	-
Minimum Masking Level	17 dB EM	-
Residual Inhibition	unable to completely suppress	-

Uncomfortable Levels	**750 Hz**	**1500 Hz**	**3000 Hz**
Right	105 dB HL	105 dB HL	110 dB HL
Left	110 dB HL	105 dB HL	110 dB HL

Table 2.2, Tinnitus Evaluation. Tinnitus closely resembles a 4000 Hz tone at a sensation level of 3 dB SL. MML is 17 EM ipsilaterally and 20 EM contralaterally. Complete suppression of tinnitus was not obtained during residual inhibition.

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