

## Managing Chronic Tinnitus As Phantom Auditory Pain

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### ABSTRACT:

Patients experiencing severe chronic tinnitus have many characteristics in common with chronic pain patients. This study explored these similarities in order to formulate treatment strategies that are likely to be effective for patients experiencing phantom auditory pain. Answers to questionnaires filled out by 160 patients who visited our Tinnitus Clinic were analyzed. Patients rated the severity and loudness of their tinnitus; completed the State-Trait Anxiety Inventory (STAI) and an abbreviated version of the Beck Depression Inventory (aBDI). Patients received counseling, audiometric testing, and matched the loudness of their tinnitus to sounds played through headphones. Tinnitus severity was highly correlated with patients degree of sleep disturbance, STAI and aBDI scores. The reported (on a 1-to-10 scale) -- but not the matched -- loudness of tinnitus was correlated with tinnitus severity, sleep disturbance, STAI, and aBDI scores. Treatment recommendations are discussed in reference to these results.

### INTRODUCTION:

Tinnitus is the sensation of sound without external stimulation. Jastreboff<sup>1</sup> referred to tinnitus as phantom auditory perception. Outside of the auditory system, the most infamous example of phantom perception is reported by some patients who have lost a finger, hand, arm, toe, foot or leg. These patients continue to perceive the presence of -- and sometimes pain from -- appendages that have been amputated. Missing appendages that continue to generate sensations are known as phantom limbs; painful sensations attributed to them are referred to as phantom limb pains.

Similarities between the perception of chronic tinnitus and the perception of chronic pain were listed by Tonndorf<sup>2</sup>: both tinnitus and pain are subjective sensations; both are continuous events that may change in quality and/or character over time; both have the potential to be masked/reduced by appropriate sensory stimulation or medications; both the auditory and somatosensory systems possess a well-developed network of efferent fibers that appear to exercise some control over afferent activity; de-afferentation (that is, a disruption in the balance between afferent and efferent activity) might explain both perceptions; both perceptions are under the control of the central nervous system; efforts to treat both sensations peripherally have met with limited success.

To this list of similarities Moller<sup>3</sup> added: chronic pain and some forms of tinnitus are characterized by hypersensitivity to sensory stimulation; the anatomic locations of the neural structure(s) generating the sensations of chronic pain or tinnitus are different from the locations of the structures to which these symptoms are referred (the ears for tinnitus or the peripheral location of injury for pain); the strong psychological component that often accompanies chronic pain or tinnitus supports the hypothesis that brain areas (limbic/sympathetic) other than those responsible for sensory perception are involved; pain and tinnitus are both heterogenous, multimodal disorders that can have different causes and pathophysiologies; consequently, multimodal approaches should be used to treat these disorders.

Muhlneckel et al<sup>4</sup> used magnetoencephalography to compare the organization of auditory cortex in 10 chronic tinnitus patients with that of 15 non-tinnitus control subjects. Results of their study demonstrated that the organization of auditory cortex in tinnitus patients was significantly different from the control subjects, especially in brain areas corresponding to perceived tinnitus frequencies. Muhlneckel et al<sup>4</sup> concluded that similarities between these data and the previous demonstrations that phantom limb pain is highly correlated with cortical reorganization suggest that tinnitus may be an auditory phantom phenomenon.

Jeanmonod et al<sup>5</sup> hypothesized that positive neurological symptoms (including neurogenic pain and tinnitus) might be attributable to abnormal neuronal activity in the thalamus (specifically, low threshold calcium spike bursts that are related to thalamic cell hyperpolarization). A subsequent magnetoencephalographic study by Llinas et al<sup>6</sup> demonstrated that neurogenic pain and tinnitus are both characterized by thalamocortical dysrhythmia resulting from inhibitory asymmetry between high- and low-frequency thalamocortical modules at the cortical level. These findings support the assertions of Jastreboff<sup>1</sup>, Tonndorf<sup>2</sup>, Moller<sup>3</sup> and others who contend that abnormal asymmetries of neuronal activity are responsible for tinnitus generation.

It is clear that the perception of chronic tinnitus has many physiological characteristics in common with the perception of chronic pain. In his behavioral nosology, Briner<sup>7</sup> used the phrase phantom auditory pain to describe severe chronic tinnitus. The present study will explore similarities in psychological characteristics, reactions, and coincidental disturbances exhibited by patients who experience chronic tinnitus or pain. The goal is to contribute to the development of treatment strategies that are likely to be effective for patients experiencing phantom auditory pain.

**METHODS:**

Detailed questionnaires were mailed to patients prior to their initial appointment at the Oregon Health Sciences University Tinnitus Clinic. These questionnaires requested information about patients medical, hearing, and tinnitus histories. Appendix 1 contains twelve questions that constitute the Tinnitus Severity Index<sup>8</sup> which is an efficient indicator of the negative impacts of tinnitus upon patients. The State-Trait Anxiety Inventory (STAI)<sup>9</sup> and an abbreviated version of the Beck Depression Inventory (aBDI)<sup>10</sup> were also included.

Data relating to patient demographics, audiometric thresholds, matched and reported (according to the 1-to-10 scale in Appendix 1) tinnitus loudness, tinnitus severity, sleep difficulties, aBDI and STAI scores were analyzed.

TABLE 1. Grand averages of pure tone air conduction thresholds of patients (dB HL)

	(Hz) 250	500	1000	2000	3000	4000	6000	8000
RIGHT EAR	18.3±20.6	16.9±21.1	19.7±21.9	22.9±24.1	33.1±25.8	39.7±27.2	43.6±27.2	46.2±28.5
LEFT EAR	16.6±15.2	14.7±14.9	17.7±17.3	22.2±19.7	34.9±22.8	40.3±25.3	44.6±25.4	45.9±27.7

## RESULTS:

Data from the last 160 patients (112 males, 48 females; mean age 50.912.8 years; age range 17-87 years) who visited our clinic were analyzed. Table 1 contains the grand averaged pure tone air conduction thresholds for these patients. This pattern of high-frequency sensorineural hearing loss is typical for our patient population.

Table 2 contains mean STAI, aBDI, tinnitus severity scores, matched and reported tinnitus loudness values for three groups of patients based on their response to question 12: Does your tinnitus interfere with sleep? Note that mean values for all of these measures tend to increase with greater sleep interference. Statistically significant differences exist between the No and Often sleep interference groups on all measures except the matched loudness of tinnitus. Statistically significant differences exist between the Sometimes and Often sleep interference groups on all measures except the matched and reported loudness of tinnitus. Statistically significant differences exist between the No and Sometimes sleep interference groups on two measures: severity and reported loudness of tinnitus.

TABLE 2. Mean responses of patients grouped by frequency of sleep interference

	<b>GROUP 1 NO n=39</b>	<b>GROUP 2 SOMETIMES n=73</b>	<b>GROUP 3 OFTEN n=48</b>
<b>TINNITUS SEVERITY SCORE</b>	32.1±4.7	40.1±6.0	45.9±7.6
<b>COMPARISONS BETWEEN GROUPS</b>	<b>1 and 2</b>	<b>1 and 3</b>	<b>2 and 3</b>
<b>p≤</b>	.0005	.0005	.0005
<b>MATCHED LOUDNESS OF TINNITUS (dB SL)</b>	4.0±2.8	7.5±8.9	13.2±12.4
<b>COMPARISONS BETWEEN GROUPS</b>	<b>1 and 2</b>	<b>1 and 3</b>	<b>2 and 3</b>
<b>p≤</b>	.619	.068	.185
<b>REPORTED LOUDNESS OF TINNITUS</b>	5.8±1.3	7.4±1.6	8.0±1.4
<b>COMPARISONS BETWEEN GROUPS</b>	<b>1 and 2</b>	<b>1 and 3</b>	<b>2 and 3</b>
<b>p≤</b>	.0005	.0005	.146
<b>STATE ANXIETY SCORE</b>	31.0±11.7	37.3±13.1	48.2±15.4
<b>COMPARISONS BETWEEN GROUPS</b>	<b>1 and 2</b>	<b>1 and 3</b>	<b>2 and 3</b>
<b>p≤</b>	.144	.0005	.002
<b>TRAIT ANXIETY SCORE</b>	33.3±9.6	38.4±10.9	47.8±12.6
<b>COMPARISONS BETWEEN GROUPS</b>	<b>1 and 2</b>	<b>1 and 3</b>	<b>2 and 3</b>
<b>p≤</b>	.166	.0005	.002
<b>BECK DEPRESSION SCORE</b>	2.5±2.1	5.5±5.5	9.6±6.7
<b>COMPARISONS BETWEEN GROUPS</b>	<b>1 and 2</b>	<b>1 and 3</b>	<b>2 and 3</b>
<b>p≤</b>	.070	.0005	.004

Table 3 contains mean STAI, aBDI, tinnitus severity scores, matched and reported tinnitus loudness values for all of the patients in the study. Because there were no significant differences between male and female patients in any of these measures, correlation analyses were performed on mean values derived from the group as a whole. Fifty patients (31%; 30 males, 20 females) reported that they had current depression. Fifty nine patients (37%; 35 males, 24 females)

reported a history of depression. Scores on the aBDI ranged from 0 to 28 (maximum possible score = 39). Thirty four patients (21%) scored 8 or higher on the aBDI which, according to Dobie & Sullivan<sup>10</sup>, can indicate that a patient is experiencing major depression.

TABLE 3. Means and Standard Deviations

	MALES n=112	FEMALES n=48
MATCHED LOUDNESS OF TINNITUS (dB SL)	5.91 ± 6.87	11.97 ± 10.37
REPORTED LOUDNESS OF TINNITUS	6.94 ± 1.67	7.08 ± 1.64
STATE ANXIETY SCORE	36.73 ± 14.84	39.71 ± 15.11
TRAIT ANXIETY SCORE	36.90 ± 12.46	41.19 ± 12.33
BECK DEPRESSION INVENTORY	4.98 ± 5.40	5.73 ± 5.79
TINNITUS SEVERITY SCORE	37.60 ± 9.30	38.86 ± 9.50

Table 4 contains Pearson Correlation coefficients and 2-tailed p values that resulted from statistical analyses of these measures. Note that tinnitus severity is highly correlated with STAI and aBDI scores. The reported -- but not the matched -- loudness of tinnitus is correlated with tinnitus severity, STAI, and aBDI. Both anxiety indices were highly correlated with each other and also with the aBDI.

TABLE 4. Pearson Correlation Coefficients

	ANXIETY STATE	ANXIETY TRAIT	BECK DEPRESSION INVENTORY	MATCHED LOUDNESS	REPORTED LOUDNESS
TINNITUS SEVERITY	.573***	.567***	.559***	.085	.523***
STATE ANXIETY		.851***	.800***	.062	.273**
TRAIT ANXIETY			.837***	.051	.255*
BECK DEPRESSION INVENTORY				.145	.291**

\*\*\*p<.0001

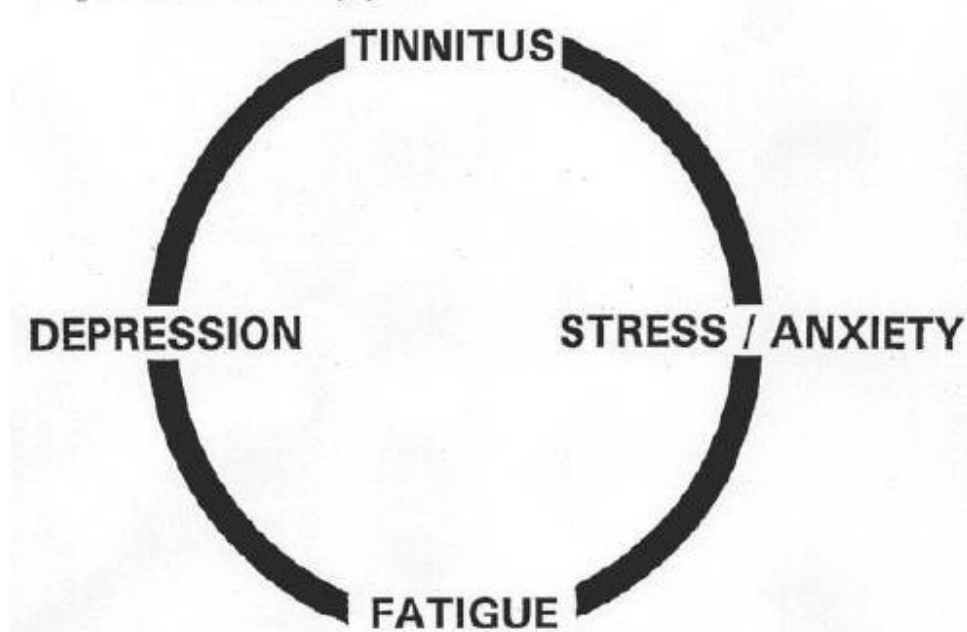
\*\*p<.001

\*p<.005

## DISCUSSION:

Results from this and other studies demonstrated that the severity of chronic tinnitus is often correlated with insomnia<sup>11</sup>, anxiety<sup>12</sup>, and depression.<sup>13</sup> As illustrated in Figure 1, these symptoms can form a vicious circle and exacerbate each other. Insomnia, anxiety, and depression are also common co-symptoms for patients with chronic pain. In fact, the word pain can be substituted for the word tinnitus in Figure 1 and the relationships among these symptoms will remain the same.

Figure 1. A Vicious Circle of Symptoms



What other characteristics do pain patients have in common with tinnitus patients? Numerous studies contributed to the following list: hypochondriasis; obsessive-compulsive tendencies; high degrees of self-focus/attention; perceived lack of control over symptoms/life events; catastrophic thinking; focusing/dwelling on symptoms; maladaptive coping strategies; reluctance to admit to problems other than immediate physical symptoms; the patients perceived severity of their

condition is not necessarily related to objective measures of stimulus intensity; severity of symptoms can be related to patients' perceptions of attitudes or reactions of others to their condition. Of course, every patient does not necessarily possess any or all of these characteristics. However, these traits are more likely to occur in pain or tinnitus patients who perceive their symptoms to be severe or debilitating.

Did the onset of chronic tinnitus cause these behaviors or co-symptoms to occur? Dobie & Sullivan<sup>10</sup> reported that approximately 50% of their tinnitus patients with depression had at least one bout of major depression before the onset of their tinnitus. Rizzardo et al<sup>14</sup> reported that 50% of their patients exhibited psychological symptoms before the onset of tinnitus; 71% of these patients experienced greater than normal levels of depression, anxiety, hypochondriasis, and/or neuroticism after tinnitus began.

Rizzardo et al<sup>14</sup> stated that there appears to be a link between psychological distress and tinnitus in a potential somatopsychological and psychosomatic vicious circle (a psychological predisposition to react emotionally to events, tinnitus as a source of distress that reinforces the symptom, accentuating hypochondriac fears). Dobie & Sullivan<sup>10</sup> agree that some people are more predisposed to depression than others and that tinnitus is one of many internal and external triggers that can precipitate major depression in susceptible individuals. Perhaps the most logical conclusion was stated by Halford & Anderson<sup>12</sup>: It is considered that the causal relationship between these psychological variables and tinnitus severity is likely to be bi-directional.

How can this information be used to help patients with severe chronic tinnitus? Because tinnitus patients share many similarities with chronic pain patients, otolaryngology clinicians can use some of the same techniques and strategies in tinnitus treatment that are employed in pain management. These include the following<sup>15</sup>:

1. Treatment of depression using medications and/or psychotherapy. Sullivan et al<sup>16</sup> demonstrated that successful treatment of depression can reduce the severity of tinnitus for patients experiencing both maladies. Some antidepressant medications will also improve sleep patterns and reduce anxiety. Identification of tinnitus patients who are also experiencing depression can be accomplished by using the complete Beck Depression Inventory<sup>17</sup> or other appropriate instruments (such as the aBDI<sup>10</sup>).



2. Treatment of insomnia using medications, relaxation therapy, and/or acoustic therapy (this includes pleasant sounds generated in the bedroom by tabletop devices, tapes, CDs, pillow speakers, fans, or small fountains).

3. Treatment of anxiety using medications, relaxation therapy, psychotherapy, biofeedback, hypnosis, massage, or any other appropriate stress management techniques.

4. Any neuroses, psychoses, or other maladaptive behaviors need to be assessed and addressed during a series of psychotherapy/counseling sessions. Many experts agree with House<sup>18</sup> who wrote that most tinnitus patients can often be helped by psychological intervention. If the physician, nurse, or audiologist does not feel that they have the time or training to provide the counseling personally, the clinician should refer the patient to an appropriate mental health professional.

Acoustic therapy is one way to give patients some control over -- and relief from -- their tinnitus. This can include the devices mentioned above as well as in-the-ear sound generators, hearing aids, or combination instruments (hearing aids + sound generators).

Because patients with severe tinnitus often have negative affectivity (characterized by tendencies to be distressed, worried, anxious, and self-critical), their counseling should be as positive and productive as possible. Jakes et al<sup>19</sup> admonished clinicians: instead of advising patients that they must learn to live with it with no advice as to how this is to be achieved, one could rather advise them that distress about tinnitus is not determined by having tinnitus, and that an intrusive, subjectively loud tinnitus will not necessarily produce a strong effect on the patient's social, domestic, or economic functioning. After appropriate tests have ruled out acoustic neuroma or other retrocochlear etiologies for a patient's tinnitus, clinicians should reassure the patient that tinnitus is usually related to hearing loss<sup>20</sup> and that it is a harmless perception of sound generated by the auditory system. Tinnitus will not necessarily become worse with time and it does not portend additional hearing loss nor the manifestation or exacerbation of any other medical condition.

Because each tinnitus patient has a unique medical, psychological and social history, therapeutic interventions should be individualized. In fact, the most successful treatment programs employ multimodal strategies that are designed to address the specific needs of each patient. Hawthorne et al<sup>21</sup> concluded that

psychiatric intervention significantly reduced the emotional distress in a population of tinnitus patients. This was achieved by not only dealing with the somatic disease but also by psychiatric management of the coincidental mental distress. This was very time-consuming. Many of the patients had complex difficulties; although they all had tinnitus and most had mood disturbance, no history was typical. The problems were protean and the psychotherapeutic interventions had to be tailored for each person.

How effective are individualized, multimodal treatment programs at reducing the severity of chronic tinnitus? We conducted a long-term follow-up study of 174 patients (130 males, 44 females; mean age 55.9 years) who were evaluated and treated in our clinic between 1994-1997. 22 One to four years after their initial clinic appointment (mean = 2.3 years), these patients reported no significant change in self-rated loudness of tinnitus. However, there was statistically significant improvement in nine of the twelve measures of tinnitus severity (including feeling irritable or nervous; feeling tired or stressed; difficulty relaxing; difficulty concentrating; interference with their required activities; interference with their overall enjoyment of life; interference with sleep; the amount of effort to ignore tinnitus; and the amount of discomfort usually experienced when tinnitus is present) for the entire patient population. A subset of 40 patients who purchased and used in-the-ear devices (hearing aids, maskers, or combination instruments) reported significant improvement in all twelve measures of tinnitus severity.

If a clinician has assessed and treated every reasonable medical cause for a patient's tinnitus, and the patient reports little improvement in tinnitus severity, the clinician should do one of two things: 1) spend the time necessary to effectively treat the patient according to procedures described here and elsewhere<sup>23</sup>; or 2) refer the patient to a comprehensive treatment center with experienced personnel who are willing and able to spend a substantial amount of time with each patient. For a certain number of patients with phantom auditory pain, only a specialized treatment program of this type can help them to improve their condition. Telling patients that since nothing can be done for tinnitus they just have to learn to live with it is both erroneous and counterproductive.

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APPENDIX 1: Tinnitus Severity Questions

DIRECTIONS: For the questions below, please **CIRCLE** the number that best describes you

	Never	Rarely	Sometimes	Usually	Always
<b>Does your tinnitus</b>					
1. Make you feel irritable or nervous . . . . .	1	2	3	4	5
2. Make you feel tired or stressed . . . . .	1	2	3	4	5
3. Make it difficult for you to relax . . . . .	1	2	3	4	5
4. Make it uncomfortable to be in a quiet room . . . .	1	2	3	4	5
5. Make it difficult to concentrate . . . . .	1	2	3	4	5
6. Make it harder to interact pleasantly with others .	1	2	3	4	5
7. Interfere with your <u>required</u> activities (Work, home, care, or other responsibilities) . . . .	1	2	3	4	5
8. Interfere with your social activities or other things you do in your leisure time . . . .	1	2	3	4	5
9. Interfere with your overall enjoyment of life . . .	1	2	3	4	5

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10. Does your tinnitus interfere with sleep?

- No . . . . . 1
- Yes, sometimes . . . . . 2
- Yes, often . . . . . 3

11. How much of an effort is it for you to **ignore** tinnitus when it is present?

- Can easily ignore it . . . . . 1
- Can ignore it with some effort . . 2
- It takes considerable effort . . . 3
- Can never ignore it . . . . . 4

12. How much **discomfort** do you usually experience when your tinnitus is present?

- No discomfort . . . . . 1
- Mild discomfort . . . . . 2
- Moderate discomfort . . . . . 3
- A great deal of discomfort . . . 4

On the scale below, please **CIRCLE** the number that best describes the loudness of your **usual** tinnitus

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1	2	3	4	5	6	7	8	9	10
Very quiet				Intermediate					Very loud