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# **The Association Between Tinnitus and Mental Illnesses**

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Additional information is available at the end of the chapter

<http://dx.doi.org/10.5772/52755>

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## **1. Introduction**

Tinnitus is defined as a perception of sound which is unrelated to an external acoustic source (Kompis et al., 2004). Some sufferers usually describe the noise as “ringing” but others describe it with various hyperboles such as grinding, whistling, humming, roaring, chirping, howling, buzzing or clicking. It is a symptom of unknown patho-physiology with few therapeutic measures (Tan et al., 1999). Even as there are many available potential treatment modalities, there has never been a single intervention which has been identified to consistently eliminate this symptom. It has become a source of increasing health concern affecting all strata of the public manifesting with comorbid psychological stresses which necessitate psychiatric treatment (Halford & Anderson, 1991; Schaaf et al., 2003).

It impinges on the quality of life of affected individuals to varying degrees occurring as a minor irritation to some and in extreme cases result in the intentional or ambivalent self destructive act of suicide (Simpson & Davies, 1999). Tinnitus sufferers often give reports of associated co-morbidities. They may complain of impairment in lifestyle, emotional difficulties, sleep deprivation, hindrance with work and social life and a general decrease in health status (Folmer & Griest, 2000; Folmer et al., 1999; Tyler & Baker, 1983). Patients with tinnitus have been known to have an increased risk for depression, anxiety and insomnia although the causative relationships are rare (Folmer & Griest, 2000; Crocetti et al., 2009; Schleuning, 1991).

## **2. History of tinnitus**

Famous people who had suffered tinnitus are often mentioned in its history. These include Joan of Arc (1412-31), Ludwig van Beethoven (1770-1827), Bedrich Smetana, a great music

composer of his time who described his tinnitus as a “high E”. Others were Charles Darwin (1809-82) who recorded the amplitude and frequency of his tinnitus daily. Michelangelo and his fellow Italian rival Leonardo da Vinci were other famous people who suffered tinnitus.

The work on tinnitus was of modest scope in the past, not until the development of modern electroacoustic equipments. In the past, the description of tinnitus was highly dependent on cultural factors. For example in ancient oriental mysticism, tinnitus was regarded as sensitivity to the divine. Old Egyptians believed that tinnitus occurred from a bewitched ear and instilled oils or herbs into the external auditory canal as a form of treatment. This practice continued through the middle Ages. In the 400 century BC, Hippocrates and Aristotle introduced the masking of tinnitus suggesting the probability of a greater sound driving out the lesser sound of tinnitus.

In the Babylonian Talmud, tinnitus was referred to as the “curse of Titus”. It was described as a buzzing sound in the brain which responded to sound therapy and habituation. In recent times, sound therapy is commonly used in treating tinnitus. It was first administered in high levels to mask tinnitus (Feldmann, 1971; Vernon, 1977) and subsequently replaced by low-dose white band noise generators (Jastreboff & Hazel, 1993).

As far back as during the Roman times, tinnitus was regarded as being associated with depression and seizure disorders. These three disorders were thought to have a common pathophysiology. However, these days the pathways are explained in a completely different way (Holgers et al., 2005).

Due to the heterogeneity of tinnitus patients from the stand point of symptoms and etiological factors, understanding of tinnitus requires a multivariate approach that were not available in the past until the advent of modern methods for assessment and treatment. The overall goal is to develop better methods for treatment and prevention.

### 3. Epidemiology

Tinnitus is a widespread distressing symptom affecting 30-40% of the adult population with 0.5-2.5% of affected individuals experiencing significant distress from it, interfering with their quality of life (Krog et al., 2010; Nondahl et al., 2011; Shargorodsky et al., 2010a; Sindhusaki et al., 2003). An estimated 16 (50 million) percent of Americans experience tinnitus with about 16 million of these seeking medical help and 2 million unable to lead normal enjoyable lives because of distressing tinnitus (American Tinnitus Association, 2012). The prevalence reported from Nigeria is 15.1% (Adoga et al., 2008). It is estimated that at least one third of the population experience tinnitus once in their lifetime and about 1-5% experience serious psychosocial complications (Martinez et al., 2010). The overall prevalence of depression and anxiety in a population based study in Nigeria reveals 17.4% and 22.8% respectively (Adoga et al., 2008). Twenty percent of individuals are said to endure the distress they experience (Robinson et al., 2003). The prevalence is higher in men (Hoffman & Reed, 2004). Tinnitus frequency is lower in women but its charac-

teristics are more complex in men who are reported to present at a younger age and have a greater hearing loss. Adults and children experience tinnitus but its development is said to increase with age and with exposure to loud sounds (Hoffman & Reed, 2004) especially in young adults (Bulbul et al., 2009) presumed to be from exposure to high volume music from portable or mini devices (Shargorodsky et al., 2010b). However the rate in children has been reported to be as high as 13%.

#### 4. Pathophysiology and risk factors

It is important to note that tinnitus is a symptom and not a disease therefore reflecting one or more underlying abnormalities. These abnormalities range from impaction of wax in the external auditory canal to acoustic tumours which will require medical or surgical attention.

A number of risk factors have been associated with tinnitus and they include increasing age, hearing loss and exposure to loud noise (Axelsson & Ringdahl, 1989; Nondahl et al., 2002). Exposure to noise is the largest attributed aetiological factor in tinnitus (American Tinnitus Association, 2011). People can develop hearing loss and tinnitus when exposed to loud military, industrial and recreational noise. Military personnel are commonly exposed to high levels of sound. Tinnitus is the most common military service related disability amongst veterans of the United States of America returning from Iraq and Afghanistan (American Tinnitus Association, 2012). These events can be classed under Post Traumatic Stress Disorders (PTSD) in which tinnitus in these individuals may serve as a constant reminder of a traumatic event such as exposure to a blast.

Environmental sound is of importance for the awareness of tinnitus with 94 percent of individuals experiencing transient tinnitus in completely silent surroundings (Heller & Bergman, 1953). Tinnitus has been suggested to be an early symptom of hearing loss particularly noise induced hearing loss (Griest & Bishop, 1998) but then there are studies to dispute this statement (Rubak et al., 2008). However, tinnitus is not always secondary to hearing loss. There are individuals with normal hearing who experience tinnitus.

Tinnitus shares similar risk factors with hearing loss. In addition to those mentioned above, these risk factors are exposure to toxins and otologic diseases such as cerumen auris, ear infections, acoustic neuromas, Meniere's disease. Others are dizziness, head injury, poor socioeconomic and general health status of individuals and ototoxic drugs e.g. aspirin, quinine, aminoglycosides and cancer chemotherapeutics especially cisplatin. The effects of these drugs may be temporary or permanent. The relationship between tinnitus and these risk factors are however unclear but there may be a bidirectional relationship between them (Guitton, 2006).

The patho-physiology of tinnitus is unknown; however, central nervous system mechanisms are believed to play a role in its patho-physiology (Saunders, 2007). Therefore, risk factors related to homeostatic neural plasticity may be of importance. Neural plasticity is an ongoing dynamic process and it describes the ability of the brain to adapt its nerve cell, synapses

or even the whole brain and its organisation to modified biological requirements. There are two types of neural plasticity;

1. *Cortical plasticity* describes the activity dependent changes in size, connectivity or the activation patterns in the cortical networks of the brain.
2. *Synaptic plasticity* describes the activity dependent changes in the strength of transmission of impulses across the synapse which can affect both the morphology and physiology of the synapse. From the standpoint of molecular biology, this type of neural plasticity is said to be important for the development and persistence of tinnitus. Stimulation of afferent nerve fibres causes long term changes in synaptic transmission, a process called long-term potentiation or long-term depression. An imbalance between these two processes which results from damage to the hair cells and vestibulocochlear nerve leads to changes in gene expression and involves changes in neurotransmission, in the expression of receptors, ion channels, regulatory enzymes and direct changes on the synapses. These events increase the level of cellular activity leading to hyperactivity in the dorsal cochlear nucleus, inferior colliculus and in the auditory cortex causing changes in cortical plasticity leading to tinnitus (Mazureck et al., 2010).

It has also been suggested that tinnitus results from an abnormally synchronised action potential pattern of the spontaneous activity within the central auditory pathways due to inner ear damage (Lenarz et al., 1993). This hypothesis however neither explains why some patients with sensorineural deafness due to damage to hair cells perceive tinnitus while others do not, nor does it explain the suffering experienced from tinnitus. Not all individuals who have tinnitus complain of comorbid debilitating conditions.

Whether tinnitus results from the amplification of contrasts between neighboured frequencies with differences in the input has been a subject of debate for many years. Findings from animal models however clearly suggest that it is the homeostatic mechanisms which are responsible for tinnitus generation. This is an important step forward in the understanding of tinnitus especially since the molecular mechanisms that are involved have been identified (Mazureck et al., 2010; Knipper et al., 2012). This generally believed mechanism of the generation of tinnitus also conforms to the clinical observation that in most cases the tinnitus frequency is in the same frequency area like the hearing loss. For example a patient with noise induced hearing loss around 4 kHz also perceives the tinnitus at 4 kHz. However tinnitus is not a disease of the auditory system alone.

It is postulated that the difficulty to ignore tinnitus, the annoyance patients experience from tinnitus, the anxiety that tinnitus becomes worse, the experience of irritability and concentration difficulties are related to functional changes in non-auditory brain systems (Jastreboff, 1990). Neuro-imaging studies such as electroencephalography (EEG), functional magnetic resonance imaging (fMRI) and positron emission tomography (PET) in tinnitus patients have helped to identify the structures in the central nervous system believed to be responsible for the patho-physiology of tinnitus (De Ridder et al., 2011; Scheckmann et al., 2011; Van de Heyning et al., 2008) demonstrating in the auditory cortex of patients suffering from tinnitus a reduction of alpha wave activity and an increase in the

delta and gamma wave activities. Therefore, altered activity in the central auditory pathways is not sufficient for the perception of tinnitus. This explains that many patients with hearing loss (and consequent increased activity in the central auditory pathways) do not perceive tinnitus. It is only when the auditory activity is connected to activity in the “attentional network” that the tinnitus is consciously perceived (De Ridder et al., 2011).

The complex nature of changes associated with tinnitus in the central nervous system may very well explain its treatment difficulty.

## 5. Classification and aetiology

The noise of tinnitus can present in different forms but it is classified into two major types and these are;

1. *Objective tinnitus*- also described as pulsatile is a type of tinnitus that is perceptible to the patient and other people. It is rare, affecting 3percent of patients. It is mostly caused by myoclonic contractions of the tensor tympani muscle or blood vessels, eustachian tube dysfunction and tumours of the middle ear. Its presence signifies a serious underlying disease such as hypertension, vascular aneurysms, otitis media, brain tumours and glomusjugulare tumours. Diagnosis and appropriate treatment of these conditions makes the tinnitus to cease.
2. *Subjective tinnitus*- also described as idiopathic is a type of tinnitus that is perceptible only to the patient. It is the most common type and causes the most nuisances to patients. The causes of subjective tinnitus are prolonged exposure to loud sounds, ototoxicity, otosclerosis, head injuries, meningitis and brain tumours. It is the type mostly associated with psychosocial comorbidities.

As a result of the rarity of objective tinnitus, it is argued that all tinnitus is subjective and should be classified based on origin either as somatic or neurophysiologic. By this classification, somatic tinnitus (somatosounds) is described as tinnitus that has an underlying medical condition which creates internal acoustic mechanical sounds i.e. this type is of a vascular, muscular, respiratory and temporomandibular joint origin (Henry et al., 2010). The sounds produced in this type of tinnitus is commonly described as pulsatile and can be heard when an examiner uses a stethoscope or a microphone. The treatment therefore for this type of tinnitus is finding the underlying cause and treating it. Neurophysiologic (subjective idiopathic) tinnitus is the commonest type, non-pulsatile, mostly bilateral and difficult to evaluate. Matching the loudness and pitch of this type of tinnitus to external sounds with known acoustical parameters is helpful in the management of patients.

The causes of tinnitus are shown in Table 1.



TYPE OF TINNITUS	CAUSES
<b>Subjective tinnitus</b>	
Otologic	Noise-induced hearing loss, presbycusis, otosclerosis, otitis, impacted cerumen sudden deafness, Meniere's disease, and other causes of hearing loss
Neurologic	Head injury, whiplash injury, multiple sclerosis, vestibular schwannoma (acoustic neuromas) or other cerebellopontine-angle tumours
Infectious	Otitis media and sequelae of Lyme disease, meningitis, syphilis, and other infectious or inflammatory processes that affect hearing
Drug-related	Common side effect of many drugs, such as salicylates, nonsteroidal anti-inflammatory drugs, aminoglycosides antibiotics. Loop diuretics and cancer chemotherapeutics (e.g. , cisplatin and vincristine)
Others	Temporomandibular-joint dysfunction and other dental disorders
<b>Objective tinnitus</b>	
Pulsatile	Carotid stenosis, arteriovenous malformations, other vascular anomalies, vascular tumours (e.g., the glomusjugulare), valvular heart disease (usually aortic stenosis), states of high cardiac output (anaemia and drug-induced high output) , and other conditions causing turbulent blood flow
Muscular or anatomical	Palatal myoclonus, spasm (of stapedius or tensor tympani muscle, patulousEustachian tube
Spontaneous	Spontaneous otoacoustic emissions

**Table 1.** Causes of subjective and objective tinnitus (Adapted with the permission of Matthews RJ).

6. Comorbidities and severity

Several studies have demonstrated the close association between tinnitus and comorbid psychological disorders (Adoga et al, 2008; Harter et al., 2004; Reynolds et al., 2004; Londero et al., 2006) showing that tinnitus causes distresses leading to deterioration in psychological well being and hampering the daily life enjoyment of affected individuals. There could also be a reversal in this relationship with increase in tinnitus severity during periods of poor psychological well being (Rauschecker et al., 2010). Therefore this association can be said to be dual. A population study has reported that emotional exhaustion is a strong predictor of tinnitus severity which indicates the degree to which an affected individual is worried, bothered or angry about the tinnitus (Hebert et al., 2012) with the severity of tinnitus depending on these comorbid psychological disorders.

Some researchers group tinnitus severity into the following; help-seekers, non-help-seekers; complainers and non-complainers (Attias et al., 1995; Hallberg et al., 1993). Others classify tinnitus severity into three subgroups based on the predictive factors for incapacitating tinnitus and these are: audiological tinnitus, somatic tinnitus and depression and anxiety related tinnitus with the latter group being the largest subgroup (Holgers et al., 2000).

The neurophysiologic model explains the severity of tinnitus to be a conditioned response focusing on the network of neural activity in the auditory system, the sympathetic and parasympathetic autonomic nervous systems and the limbic system (Jastreboff & Hazel, 1993).

Some of the psychological disorders associated with tinnitus are anxiety, depressive disorders, hysteria, insomnia, anger, fear and despair. Researchers have found associations between tinnitus and anxiety disorders (Shargorodsky et al., 2010) and depression (Krog et al., 2010). However, patients with tinnitus and depression may not meet the clinical criteria for the diagnosis of major depressive disorder (Shargorodsky et al., 2010). Patients with tinnitus and comorbid anxiety and depressive disorder often present with exaggerated symptoms or non-tolerance of tinnitus. The clinical manifestations which may be seen in these patients are highlighted in Table 2 and 3.

Type of symptom	Manifestations
Increased arousal	Restlessness, increased startle response, disturbance with sleep
Mood	Fearfulness, apprehension, worries, irritability
Thoughts	Unrealistic appraisal of danger, belief in inability to cope, fear of impending death or a sinister background illness for the tinnitus
Behaviour	Constriction of purposeful activities, avoidance
Overactivity of autonomic nervous system	Tachycardia, hot and cold flushes, dry mouth, diarrhoea, urinary frequency, sweating
Somatization	Sense of retrosternal constriction, hyperventilation, faintness, muscular tension, fatigue, pain, tremor

Table 2. Manifestations of anxiety disorder

Type of symptom	Manifestations
Loss of interest	Inescapable sadness, loss of capacity for enjoyment or interest in previously pleasurable activities
Loss of energy	Staying indoors and avoidance of social interactions, inactivity with degeneration in physique, strength and physical well being
Biologic symptoms	Change in appetite and weight, disturbance of sleep and loss of libido
Disorders of thought content	Feeling of guilt, worthlessness, hopelessness
Psychomotor agitation	Incoherent conversation, expansive gesturing, pacing and hair twirling
Psychomotor retardation	Slow speech, coordination and impaired articulation
Others	delusions, depersonalization, derealization, obsessive-compulsive phenomena

Table 3. Manifestations of depressive disorders



Researchers have also found out a strong association between hearing loss (which is a strong predictor of tinnitus) and mental illnesses (Hebert et al., 2012; Dalton et al., 2003). Hearing loss reduces an individual's ability to communicate with people and this can worsen a mental health disorder like anxiety and depression. Tinnitus severity ratings also strongly correlate with levels of psychological distress indicating that tinnitus may worsen mental illnesses (Fagelson, 2007; Henry et al., 2007; Mrena et al., 2002). Anxiety and depression often increase in patients with tinnitus suggesting that tinnitus and these mental illnesses may affect similar neuronal mechanisms in the central nervous system which affect attention, emotions and perception (Fagelson, 2007; Henry et al., 2007).

## 7. Clinical assessment

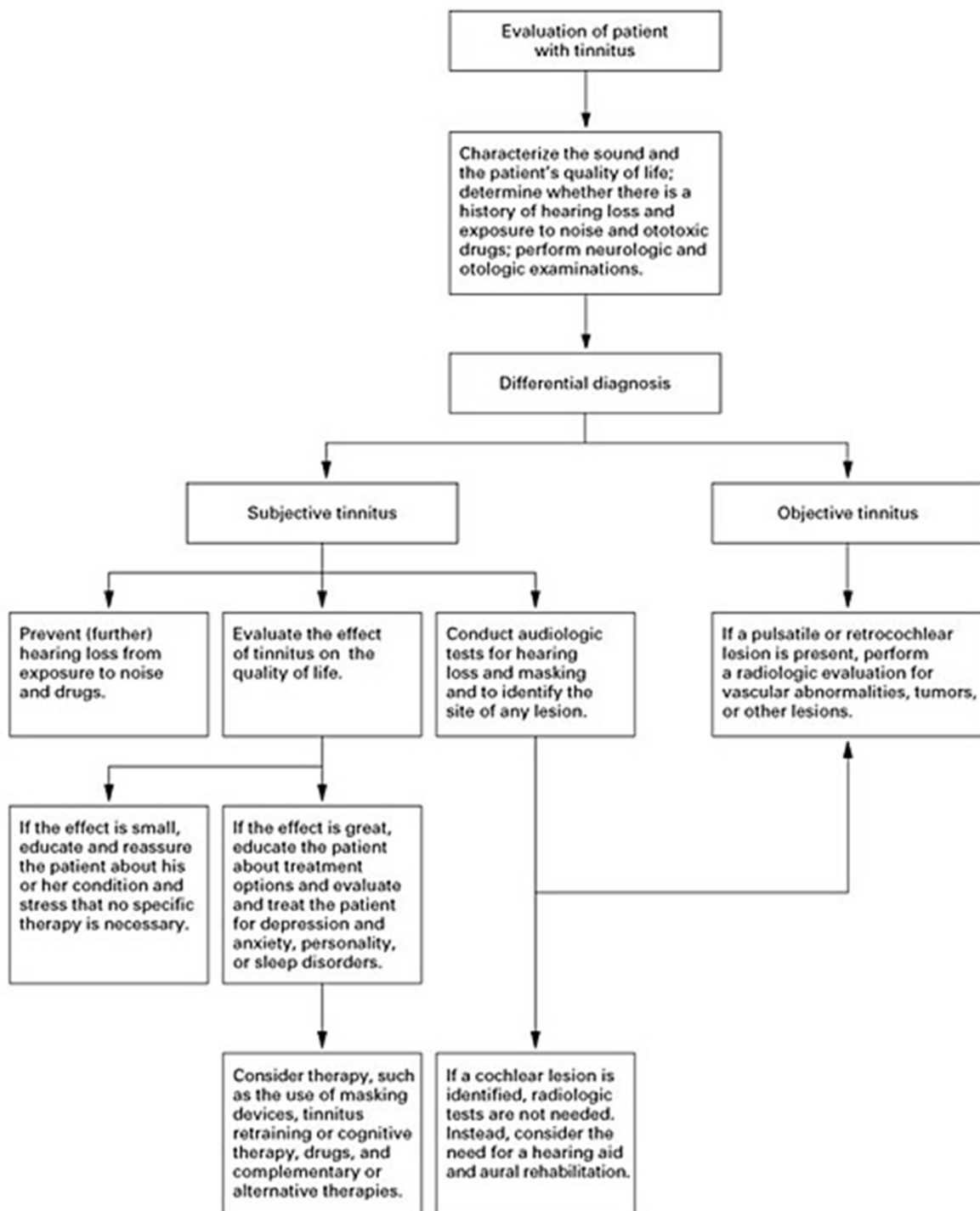
One of the most criticized points in the clinical studies of tinnitus is the lack of consensus about the methods available for assessment of patients (Figueiredo et al., 2010). The aim of clinical assessment is to determine the underlying etiological factor that had led to tinnitus. As a result of the large number of differential diagnoses of tinnitus this assessment is difficult. However, the diagnosis is largely dependent on a thorough clinical history, physical examination and indicated laboratory investigations. All of these require attention to detail in picking the exact risk and etiological factors responsible for the symptoms and the absence or presence of comorbid psychological distresses for the effective treatment of patients. Many patients with associated psychological distresses will require various psychological evaluation techniques to assist in their management.

The time taken to listen to patients in obtaining a history is not a wasted venture although many details may be obscured by the number of factors that have taken place since the onset of the tinnitus. Since tinnitus is mostly subjective in type, a systematic approach to the history and physical examination should be geared towards differentiating subjective from objective tinnitus (Figure 1), identifying those conditions that are treatable, protect the patient's hearing and treat comorbid psychological distresses. Questions to patients should largely attempt to determine the presence, development, time course and the severity of any hearing loss as most cases of tinnitus are associated with hearing loss.

It is vital to get a description of the type of sound the patient hears and this can be ascertained by asking if the sound is constant or episodic; unilateral or bilateral; sudden or gradual in onset; the circumstances of onset; the duration of the tinnitus; the pitch and loudness of the sound- audiological protocols can be used to match the loudness and pitch of tinnitus experienced by patients to external sounds with known acoustical parameters (Holgers, 2003). Subjective tinnitus can be measured using numeric rating scales which provide a high measurement resolution and are easy to score (Stouffer & Tyler, 1990; Meikle et al., 2008).

Other questions to be asked are the presence of vertigo, otalgia, otorrhea or temporomandibular joint disorder; exposure to loud sounds, history of head injuries, otologic surgeries or the ingestion of ototoxic drugs. It is also important to elicit the presence of psychiatric illnesses by assessing the mental status- ask how the tinnitus affects the patient's daily life and

the ability to function. These related distresses are measured using various psychometrically validated questionnaires (Robinson et al., 2003). Questionnaires can be used for diagnosis, treatment and for follow up of patients to measure the level of progress.



**Figure 1.** Algorithm for evaluation of tinnitus patients (Adapted with the permission of Matthews RJ).

Physical examination of patients should focus on the ears and the entire head and neck region.

The ears should be examined for cerumen impaction, otitis media with effusion or the presence of suppuration in the external auditory canal indicating otologic infection. Otomicroscopy may reveal a bluish tint on the tympanic membrane indicating an uncovered jugular vein, a bluish red mass in the tympanum which blanches on positive pressure with pneumatic otoscopy indicating the presence of a glomusjugulare tumour or a red hue suggesting otosclerosis. Auscultation of the periauricular region to listen for tinnitus is also helpful. The stethoscope can also be used to listen to the carotid vessels in the neck for bruits and venous hums, the cranium to check for arteriovenous malformations as well as listening to the heart.

Understanding that tinnitus is as much a medical condition as it is psychological gives room for a thorough psychological assessment of patients with a view to instituting appropriate treatment, the aim of which is to reduce the impact of tinnitus on the quality of life of patients. Psychological assessment is achieved via interviews of patients, use of questionnaires, tinnitus severity ratings etc. Dairies may have to be employed to document the characteristics of the tinnitus experienced.

In psychological assessment of patients, perceptual, emotional, attentional and behavioural parameters are considered. In doing this the following are sought; the characteristics of the tinnitus i.e. loudness, localization and the pitch, onset, duration, intensity, aggravating and relieving factors of the tinnitus. The visual analogue scale can be used for this analysis indicating a position along a continuous line between two endpoints (Figueiredo et al., 2009). Tinnitus questionnaires contain a series of questions from which patients select a response from the given choices which is usually recorded as a graded scale. In this way the severity of the tinnitus is graded. However, some questionnaires were not designed to measure the effectiveness also called responsiveness of tinnitus interventions (Kamalski et al., 2010). This effectiveness emphasizes effect sizes, content validity and response scaling which enables the detection of changes in condition of the patients during treatment (Kazdin, 2003; Lipsey, 1990). The Tinnitus Functional Index (TFI) is a new self-report type of questionnaire developed to scale the severity and negative impact of tinnitus and used for measuring changes during treatment (Meikle et al., 2012).

Cognitive evaluation of these patients is also vital finding out if they feel anger, sadness, helpless or have suicidal tendencies as a result of the tinnitus. Evaluate for psychological or mental comorbid disorders such as anxiety depression and sleep disorders which may have an impact on the general life quality of the patient. Assessing tinnitus also involves finding out what the patient perceives of his/her condition. Some considerations have to be given to the peculiar characteristics of an affected individual and not just the features of the tinnitus related psychological distress because individuals vary in the manner they can cope to these tinnitus related distresses. This will categorise individuals who simply experience tinnitus from those who have incapacitating psychological or mental disorders from tinnitus and therefore require psychological treatment (Sweetow, 1986).

Following history and physical examination of patients, some investigations are vital in helping to arrive at a diagnosis;

A complete audiogram with speech discrimination score and tympanometry is mandatory for all patients with tinnitus. An audiogram is done even though the patient does not make a complaint of hearing loss. The audiologist in this process can complete the subjective tinnitus matching evaluation to have a better understanding of the patient's condition. The pitch and loudness matching should be assessed remembering that 90 percent of tinnitus patients match their tinnitus at 20dB or less and 84 percent match theirs at 9dB or less. Other important audiological evaluations are the minimum tinnitus masking level and residual inhibition. The minimum masking level measures the degree to which tinnitus can be masked by external acoustic sources. This test employs a band of noise extending from 2000Hz to 12000Hz as the masking sound which is applied to the affected ear using earphones. The masking sound is gradually increased until it is detected by the patient. The pitch of the sound is increased until the patient no longer hears the tinnitus. In most people the minimum masking level is 8dB or less. Residual inhibition records the time the tinnitus is reduced or eliminated following a masking period. This is achieved by masking the tinnitus at a minimum level plus 10dB for 60 seconds and the length of time it takes the tinnitus to improve is determined.

Poor speech test performance indicates pathology in the central nervous system (Brechtelsbauer, 1990). Tympanometry identifies a previously undetected middle ear effusion, tympanic membrane stiffness from a patulous eustachian tube or stapedial and palatal muscle myoclonus (Meyerhoff & Cooper, 1991).

If suggested by the presence of a medical comorbidity, a full blood count, thyroid function tests, autoimmune tests e.g. rheumatoid factor, lipid profile may be done.

A computed tomography (CT) scan of the temporal bone can delineate a sigmoid sinus or a bony defect over the jugular bulb. Magnetic resonance imaging (MRI) with or without magnetic resonance angiography can pick up a glomusjugulare tumour, an arteriovenous and other vascular malformations.

## 8. Treatment

The development of therapeutic measures for tinnitus has been made difficult as a result of the complex relationship between tinnitus and its comorbid mental illnesses. However, a range of treatment modalities are available with varying degrees of statistical reliability. These comorbidities may modulate the experience of tinnitus and treatment of these conditions will alleviate patients' conditions. It is argued that psychological treatment should be employed before the consideration of drugs of which there is no single agent or groups of agents specifically recommended for this treatment.

There are no clear cut clinical standards or practice guidelines for the management of tinnitus, however, an evidence based review and tinnitus triage guide (Henry et al., 2010) has

been developed to help family physicians who may be the first contact point for these patients (Table 4).

If patient	Refer to	Status/Considerations
Has neural deficits such as facial weakness, head trauma, or other urgent medical condition	Otolaryngology or ED	Emergency
Has unexplained sudden hearing loss	Audiology and otolaryngology	Emergency; must see audiologist prior to otolaryngologist on same day
Expresses suicidal ideation or manifests obvious mental illness	Mental health or ED	May be emergency; report suicide ideation; provide escort, if necessary
Has any of the following: <ul style="list-style-type: none"><li>• symptoms suggestive of somatic origin of tinnitus (eg, tinnitus that pulses with heartbeat)</li><li>• persistent otalgia or otorrhea</li><li>• vestibular symptoms (eg, dizziness/vertigo)</li></ul>	Otolaryngology and audiology	Urgent; schedule otolaryngology exam as soon as possible
Has symptoms that suggest a neurophysiologic origin of tinnitus without: <ul style="list-style-type: none"><li>• ear pain, drainage, or malodor</li><li>• vestibular symptoms</li><li>• sudden hearing loss</li><li>• facial weakness or paralysis</li></ul>	Audiology and otolaryngology	Nonurgent; schedule audiology exam before patient sees otolaryngologist

**Table 4.** Tinnitus Triage Guide (Henry et al., 2010)

Treatment depends on the cause and in a host of patients; the cause is inner ear damage. In these patients, reassurance of the benign nature of their condition usually suffices.

The treatment for tinnitus is classified into medical, otopsychiatric, sound modulation and surgical.

**Medical treatment-** Is further subdivided into pharmacological treatment, electrical stimulation, psychological counselling and homeopathic therapy.

*Pharmacological treatment:* There is no single pharmacological agent approved for the treatment of tinnitus. Most medications available are used in the modulation of tinnitus related comorbidities especially psychological conditions hence the use of anxiolytics, antidepressants, vasodilators and even intravenous anaesthetic agents like lidocaine have been used (Noble, 2008; Johnson et al., 1993; Agrawal & Pothier, 2009; Kalcioglu et al., 2005). Newer medications are being investigated with promising results which attempt to modulate the central auditory pathways and reducing tinnitus. Examples are Pramipexole and Acamprosate (Sziklai et al., 2011; Azevedo & Figueiredo, 2005; Sharma et al., 2012).



Drugs presently in use are tricyclic antidepressants (Amitriptyline 50 to 100mg daily at bedtime; Nortriptyline 50mg given at bedtime). Beneficial effects are noticed in about three to four weeks of treatment. Selective serotonin reuptake inhibitors have also been used such as Sertraline (50mg daily) and Paroxetine (10mg at bedtime). Alprazolam has been found to improve the visual analogue scales in patients who did not have anxiety or depression (Jalali et al., 2009). Others are Gabapentin, prostaglandin E1 and botulinum toxin A.

*Electrical stimulation:* The mechanism by which this works is still largely unknown but stimulation of the auditory system has been found to relieve tinnitus. There are many types of electrical stimulation which have been attempted, cutaneous, transcranial, promontory etc. Reports suggest relieve of tinnitus in 80 percent of patients but the effects are only transient.

*Psychological counselling:* Many patients consider tinnitus to be a very severe condition, afraid that it will worsen with deafness setting in over time. Therefore, patients need to be thought about tinnitus especially the relationship between selective attention on tinnitus and its cognitive emotional and behavioural effects. Educating the patients that they are able to cope with their tinnitus usually suffices.

*Homeopathic therapy:* The use of alternative medical therapies for tinnitus has been on the increase over the years. This is because for some patients modern medical therapies may not provide relief from this symptom. Though there seem to be a strong suggestion of a placebo effect with some of these therapies indicating that the belief of the patient and the provider of the therapy are strong factors in treatment success. The therapies used include ginkgo biloba extracts, niacin, acupuncture and hyperbaric oxygen. Others which are largely available to individuals especially as information on the internet are diet modification e.g. avoidance of caffeine, nicotine, refined sugar, chocolate, saturated and unsaturated fats e.t.c. and a combination of vitamins and supplements.

The extract of the ginkgo biloba tree is an antioxidant which increases blood flow to the brain and small blood vessels, inhibits platelet activating factor, alter neuron metabolism and prevent free radicals from damaging cell membranes. Bleeding time should be checked if treatment is to last longer than 4 weeks since it inhibits platelet aggregation.

About half the patients on niacin express successful treatment reporting that it reduces the severity and intensity of the tinnitus. Niacin provides smooth muscle relaxation especially of tiny blood vessels hence increasing blood flow to the inner ear. Skin flushes are the drawback of its use.

Acupuncture as treatment for tinnitus originated in Asia with the belief that the discomfort from tinnitus is reduced when needles are applied to the hand and face on the affected side (Park et al., 2000). However, there are doubts in this form of therapy as controlled studies indicate a strong component of faith by the patients in the physician or the treatment.

Hyperbaric oxygen which is used for the treatment of certain medical conditions such as carbon monoxide poisoning, necrotising fasciitis, gas gangrene etc has been reported to relieve tinnitus associated with sensorineural hearing loss by increasing the blood hence oxygen supply to the inner ear (Bennett et al., 2005).



**Otopsychiatric treatment-** Psychological comorbidities are often times neglected with the physician giving medications for tinnitus alone and when improvement is not noticeable by the patients they tend to go doctor shopping and the eventual result will be disappointment and frustration. Seeking the help of a psychologist and psychotherapist early is quite vital. The other spectrum is the referral of these patients to the psychologist and/ or psychotherapist without full medical and audiological assessment. Therefore, the close collaboration of the physician, audiologist, psychologist and psychotherapist is important in the effective management of these patients.

The ultimate objective of otopsychiatric treatment is to help patients direct their attention away from the tinnitus and putting negative cognitive processes under control.

*Cognitive behavioural therapy:* Psychological assessment/treatment should be an integral part of the tinnitus management protocol and not just based on the presence of a mental illness. Referral to the psychologist and psychotherapist which has to be carefully planned is essential to assessing associated comorbid mental disorders because tinnitus patients may be psychologically vulnerable (Langguth et al., 2001). This type of therapy will help improve patients' quality of life by restructuring thought patterns and habituating these patterns when the patient reacts to tinnitus (Martinez et al., 2010). Habituation or adaptation takes place when an originally new stimulus becomes well known and has no relevance for the patient taking any actions. It fails when it leads to the development of comorbid psychological distresses and impairment in the quality of life. It is explained that tinnitus occurs when habituation fails. Research has shown that tinnitus can be equated to any other auditory stimulus to which a patient may or may not attend and the normal response is adaptation to this stimulus (Hallam, 1987). Three variables or factors are influential in the process of habituation and are;

1. *Sensory factors-* The characteristics i.e. intensity and quality of the stimulus. It is assumed that noises which are more irregular in pattern are more require a longer period of adaptation or habituation.
2. *Perceptual factors-* Environmental conditions such as the intensity of other stimuli and the competing demands on attention. Natural sounds will mask tinnitus in some patients. Different daily activities and various competing sensory perceptions should help distract a patient's attention from tinnitus.
3. *Psychological factors-* The more meaningful or threatening a stimulus is the more a patient pays attention to it creating a positive feedback loop i.e. the more attention is paid to tinnitus the more the patient develops negative cognitive emotional processing resulting in various comorbidities.

*Biofeedback, Education and relaxation therapies:* First described for the successful treatment of pain and other stress related disorders, biofeedback in combination with educating patients about their tinnitus and relaxation therapies aim to teach the patients to focus on adapting to the tinnitus and subsequent comorbid psychological stresses (Dobie, 1999). This method of treatment does not eliminate tinnitus but helps improve the patient's quality of life. It in-

volves listening to audio signal produced electromyography (EMG) of the frontalis muscle. This helps to reduce the tinnitus and muscle tension.

### 8.1. Sound modulation therapy

*Hearing aids:* Especially useful for patients with associated hearing loss. For such patients hearing aids with sound generators are used (Henry et al., 2008). Hearing aids can increase the level of ambient sound delivered to the patient which achieves all the objectives targeted for sound therapy. Studies have shown a benefit of hearing aids in patients enrolled in comprehensive tinnitus management programs (Foliner & Carroll, 2006). However, a success rate of 50 percent is recorded.

*Cochlear implants:* These work by masking tinnitus or by electric stimulation of the auditory nerve as mentioned above but are only beneficial in patients who have bilateral profound sensorineural hearing loss.

*Tinnitus maskers:* Create and deliver constant low level wideband sounds to the patient's ear. This helps to give relieve from tinnitus and its attendant psychological stresses. Bedside clocks or radios can be used for those experiencing tinnitus at bedtime. These fill the ambient silence with low level noise which masks the tinnitus.

*Neuromonics:* This is a combination of acoustic stimulation with a structured program of counselling and support given by a clinician trained specifically in tinnitus rehabilitation (Davis et al., 2008).

*Tinnitus feedback retraining:* This method of therapy involves generation of a background sound to make the tinnitus less noticeable. It is based on the neurophysiologic model (Jastreboff & Hazel, 1993) helping patients to understand that tinnitus sounds are actually meaningless. This should also lead to habituation. Another important component of this type of treatment is counselling of patients.

When treatment is finished, the audiologist must assess to determine if the patient needs further psychological counselling. If further counselling is required, the audiologist should consider if there are patient conditions beyond his/her scope of management and refer appropriately. The treatment options may include any combination of biofeedback, imagery training and muscle relaxation. If counselling is unnecessary, the audiologist should measure outcomes and recommend an appropriate patient follow up schedule (Steiger & Hamill, 2004).

**Surgical treatment-** Tinnitus which results from surgical lesions in and around the ears is treated surgically. These lesions as mentioned earlier include acoustic tumours which when excised relieves tinnitus in 50 percent of cases; Meniere's syndrome for which auditory nerve section, endolymphatic shunt, labyrinthectomy and ototoxic antibiotic injections gives relief in 40 to 80 percent of patients the mechanism of which is unknown; temporomandibular joint diseases for which dental orthotics suffice.

Others are glomusjugulare tumours, sigmoid sinus diverticulum and arteriovenous malformation.

## 9. Prevention

A large number of the aetiological factors implicated in tinnitus are unpreventable. However, some precautions can help to prevent tinnitus. These are avoidance of over exposure to noise at social events or gatherings, at work or at home. Turning down the volume of musical appliances will be of help and at work when exposed to loud machinery, using ear protectors or ear muffs are helpful.

Other helpful measures are regular exercises and eating right to prevent cardiovascular diseases that cause tinnitus.

## 10. Conclusion

The treatment of tinnitus is as multifaceted as its aetiology.

Its close association with comorbid psychological distresses requires thorough clinical assessment by an audiologist, psychologist/psychotherapist and neuro-otologist to establish the presence of these comorbidities in order to institute adequate treatment.

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## References

- [1] Adoga AA, Adoga AS, Obindo JT. Tinnitus and the prevalence of comorbid psychological stress. *Nig J Med*. 2008; 17(1): 95-97.
- [2] American Tinnitus Association. ATA's top 10 most frequently asked questions. Available at: <http://www.ata.org/for-patients/faqs>. Assessed July 2nd, 2012.
- [3] American Tinnitus Association. Press Release: August 24<sup>th</sup>, 2011. Available at: <http://www.ata.org/about-ata/news-pubs/press-release#DoDGrant>.
- [4] Agarwal L, Pothier DD. Vasodilators and vasoactive substances for idiopathic sudden sensorineural hearing loss. *Cochrane Database Syst Rev*. 2009; 7(4): CD003422.

- [5] Attias J, Shemech Z, Bleich A, Solomon Z, Bar-oR G et al. Psychological profile of help-seeking and non-help-seeking tinnitus patients. *ScandAudiol*. 1995; 24: 13-18.
- [6] Azevedo AA, Figueiredo RR. Tinnitus treatment with Acamprosate: double blind study. *Braz J Otorhinolaryngol*. 2005; 71(5): 618-23.
- [7] Axelsson A, Ringdahl A. Tinnitus- a study of its prevalence and characteristics. *Br J Audiol*. 1989; 23: 53-62.
- [8] Bennett M, Kertesz T, Young P. Hyperbaric oxygen therapy for idiopathic sudden sensorineural hearing loss and tinnitus: a systematic review of randomized controlled trials. *J Laryngol Otol*. 2005; 119(10): 791-8.
- [9] Brechtelsbauer DA. Adult hearing loss. *Prim Care*. 1990; 17: 249-65.
- [10] Bulbul SF, Muluk NB, Cakir EP, Tufan E. Subjective tinnitus and hearing problems in adolescents. *Int J PedOtorhinolaryngol*. 2009; 73: 1124-1131.
- [11] Crocetti A, Forti S, Ambrosetti U, Bo LD. Questionnaires to evaluate anxiety and depressive levels in tinnitus patients. *Otolaryngol Head Neck Surg*. 2009; 140: 403-405.
- [12] Dalton DS, Cruickshanks KJ, Klein BE, Klein R, Wiley TL et al. The impact of hearing loss on quality of life in older patients. *Gerontologist*. 2003; 43(5): 661-68.
- [13] Davis PB, Wilde RA, Steele LG, Hanley PJ. Treatment of tinnitus with a customized acoustic neural stimulus: a controlled clinical study. *Ear Nose Throat J*. 2008; 87(6): 330-9.
- [14] De Ridder D, Elgoyhen AB, Romo R, Langguth B. Phantom percepts: Tinnitus and pain as persisting aversive memory networks. *ProcNatlAcadSci U.S.A.* 2011; 20: 8075-8080.
- [15] Dobie RA. A review of randomized clinical trials in tinnitus. *Laryngoscope*. 1999; 109(8): 1202-11.
- [16] Fagelson MA. The association between tinnitus and post-traumatic stress disorder. *Am J Audiol*. 2007; 16(2): 107-17.
- [17] Feldmann H. Homolateral and contralateral masking of tinnitus by noise-bands and by pure tones. *Audiology*. 1971; 10(3): 138-44.
- [18] Figueiredo RR, Azevedo AA, Oliveira PM. Correlation analysis of the visual-analogue scale and the Tinnitus Handicap Inventory in tinnitus patients. *RevistaBrasileira de Otorrinolaryngologia*. 2009; 75(1): 76-9.
- [19] Figueiredo RR, Rates MA, Azevedo AA, Oliveira PM, Navano PB. Correlation analysis of hearing thresholds validated questionnaires and psychoacoustic measurements in tinnitus patients. *Braz J Otorhinolaryngol*. 2010; 76(4): 522-6.
- [20] Folmer RL, Carroll JR. Long term effectiveness of ear-level devices for tinnitus. *Otolaryngol Head Neck Surg*. 2006; 134(1): 132-137.

- [21] Folmer RL, Griest SE. Tinnitus and insomnia. *Am J Otolaryngol*. 2000; 21: 287-293.
- [22] Folmer RL, Griest Se, Meikle MB, Martin WH. Tinnitus severity , loudness and depression. *Otolaryngol Head Neck Surg*. 1999; 121: 48-51.
- [23] Griest SE, Bishop PM. Tinnitus as an early indicator of permanent hearing loss: A 15 year longitudinal study of noise exposed workers. *AAOHN J*. 1998; 46:325-9.
- [24] Guitton MJ. Tinnitus and anxiety: more than meets the ear. *Curr Psychiatry Rev*. 2006; 2: 333-8.
- [25] Halford JB, Anderson SD. Anxiety and depression in tinnitus sufferers. *J Psychosom Res*. 1991; 35(4-5): 383- 90.
- [26] Hallam RS. Psychological approaches to the evaluation and management of tinnitus distress. Tinnitus. J. Hazell (Ed). Edinburgh, Churchill Livingstone; 1987: 156-175.
- [27] Hallberg L, Erlandsson SI. Tinnitus characteristics in tinnitus complainers and non-complainers. *Br J Audiol*. 1993; 27: 19-27.
- [28] Harter M, Maurischat C, Weske G, Laszig R, Berger M. Psychological stress and impaired quality of life in patients with tinnitus. *HNO*. 2004; 29(6): 628-634.
- [29] Hebert S, Canlon B, Hasson D. Emotional exhaustion as a predictor of tinnitus. *PsychotherPsychosom*. 2012; 81(5): 324-326.
- [30] Heller MF, Bergman M. Tinnitus in normally hearing persons. *Ann Otol*. 1953; 62: 73-93.
- [31] Henry JA, Schechter MA, Zaugg TL, Myers PJ. Progressive audiologic tinnitus management. *ASHA leader*. 2008; 13(8): 14-7.
- [32] Henry JA, Trune DA, Robb MJ, Jastreboff PJ. Tinnitus retraining therapy: clinical guidelines. San Diego (CA): Plural Publishing, Inc; 2007.
- [33] Henry JA, Zaugg TL, Myers PJ, Kendall CJ, Michaelides EM. A triage for tinnitus. *J FamPract*. 2010; 59(7): 389-93.
- [34] Hoffman HJ, Reed GW. Epidemiology of tinnitus. In: Snow JB.ed. *Tinnitus: Theory and management*. Leviston, NY: BC Decker Inc; 2004: 16-41.
- [35] Holgers KM. Mechanisms and classification of tinnitus: a discussion paper. *Audiol Med*. 2003; 1(4): 238-41.
- [36] Holgers KM, Erlandsson SI, Barrenas ML. Predictive factors for auditory somatic and depression/anxiety related tinnitus. *Audiol*. 2000; 39: 284-291.
- [37] Holgers KM, Zoger S, Svedlund K. Predictive factors for development of severe tinnitus suffering- further characterization. *Int J Audiol*. 2005; 44(10): 584-92.
- [38] Jalali MM, Krusha A, Naghavi SE, Suleiman R, Banan R. The effects of Alprazolam n tinnitus: a cross-over-randomized clinical trial. *Med SciMonit*. 2009; 15(11): 155-60.



- [39] Jastreboff PJ. Phantom auditory perception (tinnitus): mechanism of generation and perception. *Neurosci Res.* 1990; 8: 221- 254.
- [40] Jastreboff PJ, Hazell JWP. A neurophysiological approach to tinnitus: clinical implications. *British J Audiol.*1993; 27: 7-17.
- [41] Johnson RM, Brummett R, Schleuning A. Use of Alprazolam for relief of tinnitus: A double blind study. *Arch Otolaryngol Head Neck Surg.* 1993; 119(8): 842-5.
- [42] Kalcioglu MT, bayindir T, Erdem T, Ozturan O. Objective evaluation of the effects of lidocaine on tinnitus. *Hear Res.* 2005; 199(1-2): 81-8.
- [43] Kamalski DM, Hockstra CE, van Zanten BG, Grolman W, Rovers MM. Measuring disease specific health related quality of life to evaluate treatment outcomes in tinnitus patients: a systematic review. *Otolaryngol Head Neck Surg.* 2010; 143(2): 181-5.
- [44] Kazdin AE. *Research design in clinical psychology.* 2003. 4<sup>th</sup> ed. Needham heights, MA: Allyn& Bacon.
- [45] Knipper M, Muller M, Zimmerman U. Molecular mechanisms of tinnitus. *Springer handbook of Auditory Research.*2012; 44: 59-82.
- [46] Kompis M, Neuner NT, Hemmeler W, Hausler R. Tinnitus. *Ther Umsch.* 2004; 61(1): 15-20.
- [47] Krog NH, Engdahl B, Tambs K. The association between tinnitus and mental health in a general population sample: results from the HUNT study. *J Psychosom Res.* 2010; 69: 289-298.
- [48] Langguth B, Kleinjung T, Landgrebe M. Tinnitus: the complexity of standardization. *Eval Health Prof.* 2001; 34(4): 429-33.
- [49] Lenarz T, Schreiner C, Snyder RL, Ernst A. Neural mechanisms of tinnitus. *Eur Arch Otorhinolaryngol.* 1993; 249(8): 441-446.
- [50] Lipsey MW. *Design sensitivity: Statistical power for experimental research.* 1990. Newbury Park, CA: Sage Publications, Inc.
- [51] Londero A, Peignard P, Malinvaud D, Avan P, Bonfils P. Tinnitus and cognitive behavioural therapy: results after 1 year. *PresseMedicale.* 2006; 35(9): 1213-1221.
- [52] Martines F, Bentivegna D, Martines E, Sciacca V, Martinciglio G. Assessing audiological, pathophysiological and psychological variables in tinnitus patients with or without hearing loss. *Eur Arch otorhinolaryngol.*2010; 267: 1685-1693.
- [53] Martinez-Devesa P, Perera R, Theodoulou M, Waddell A. Cognitive behavioural therapy for tinnitus. *Cochrane Database Syst Rev.* 2010; 8(9): CD005233.
- [54] Mazureck B, Olze H, Haupt H, Klapp BF, Adili M et al. Molecular biological aspects of neuroplasticity: approaches for treating tinnitus and hearing disorders. *HNO.* 2010; 58(10): 973-82.



- [55] Meikle MB, Henry JA, Griest SE, Stewart BJ, Abrams HB et al. The Tinnitus Functional Index: development of a new clinical measure for chronic intrusive tinnitus. *Ear Hear.* 2012; 33(2): 153-76.
- [56] Meikle MB, Stewart BJ, Griest SE, Henry JA. Tinnitus outcomes assessment. *Trends Amplif.* 2008; 12: 223-235.
- [57] Meyerhoff WL, Cooper JC. Tinnitus. In: Paparella MM, ed. *Otolaryngology*. 3d ed. Philadelphia: Saunders. 1991:1169-75.
- [58] Mrena R, Svolainen S, Kuokkanen J, Ylikoski J. Characteristics of tinnitus induced by acute acoustic trauma: a long term follow up. *AudiolNeurotol.* 2002; 7(2): 122-30.
- [59] Noble W. Treatments for tinnitus. *Trends Amplif.* 2008; 12(3): 236-41.
- [60] Nondahl DM, Cruickshanks KJ, Huang GH, Klein BE, Klein R et al. Tinnitus and its risk factors in the Beaver Dam offspring study. *Int J Audiol.* 2011; 50: 313-20.
- [61] Nondahl DM, Cruickshanks KJ, Wiley TL, Klein R, Klein BE et al. Prevalence and 5 year incidence of tinnitus among older patients: the epidemiology of hearing loss study. *J Am Acad Audiol.* 2002; 13: 323-331.
- [62] Park J, White AR, Ernst E. Efficacy of acupuncture as a treatment for tinnitus: a systematic review. *Arch Otolaryngol Head Neck Surg.* 2000; 126(4): 489-92.
- [63] Rauschecker JP, Leaver AM, Muhlau M. Tuning out the noise: limbic-auditory interactions in tinnitus. *Neuron.* 2010; 66: 819-826.
- [64] Reynolds P, Gardner D, Lee R. Tinnitus and psychological morbidity: a cross-sectional study to investigate psychological morbidity in tinnitus patients and its relationship with severity of symptoms and illness perceptions. *Clin Otolaryngol Allied Sci.* 2004; 29(6): 628-634.
- [65] Robinson SK, McQuaid JR, Viirre ES, Betzig LL, Miller DL et al. The relationship of tinnitus questionnaires to depressive symptoms, quality of well-being and internal focus. *Int tinnitus J.* 2003; 9(2): 97-103.
- [66] Rubak T, Kock S, Koefoed-Nielsen B, Lund SP, Bonde JP et al. The risk of tinnitus following occupational noise exposure in workers with hearing loss or normal hearing. *Int J Audiol.* 2008; 47: 109-14.
- [67] Saunders JC. The role central nervous system plasticity in tinnitus. *J Commun Disord.* 2007; 40: 313-34.
- [68] Schaaf H, Dolberg D, Seling B, Martner M. Comorbidity of tinnitus and psychiatric disorders. *Nervenarzt.* 2003; 74(1): 72-5.
- [69] Schecklmann M, Landgrebe M, Poepl TB, Kreuzer P, Manner P et al. Neural correlates of tinnitus duration and distress: A positron emission tomography study. *Human Brain Mapp.* 2011; 22: doi 10.1002/hbm.21426.

- [70] Schleuning AJ 2<sup>nd</sup>. Management of the patient with tinnitus. *Med Clin North Am.* 1991; 75: 1225-1237.
- [71] Shargorodsky J, Curhan SG, Curhan GC, Earvey R. Change in prevalence of hearing loss in US adolescents. *JAMA.* 2010; 304: 772-778.
- [72] Shargorodsky J, Curhan GC, Farwell WR. Prevalence and characteristics of tinnitus among US adults. *Am J Med.* 2010; 123: 711-718.
- [73] Sharma DK, Kaur S, Singh J, Kaur I. Role of Acamprosate in sensorineural tinnitus. *Indian J Pharmacol.* 2012; 44(1): 93-6.
- [74] Simpson JJ, Davies WE. Recent advances in the pharmacological treatment of tinnitus. *Trends Pharmacol Sci.* 1999; 20(1): 12-8.
- [75] Sindhusake D, Golding M, Newall P, Rubin G, Jakobsen K et al. Risk factors for tinnitus in a population of older adults: the blue mountains hearing study. *Ear Hear.* 2003; 24: 501-507.
- [76] Steiger JR, Hamill TA. A proposed clinical pathway for tinnitus evaluation and management. *Hear J.* 2004; 57(7): 26-28.
- [77] Stouffer JL, Tyler RS. Characterization of tinnitus by tinnitus patients. *J Speech Hear Disord.* 1990; 55(3): 439-453.
- [78] Sweetow RW. Cognitive aspects of tinnitus- patient management. *Ear Hear.* 1986; 7: 390-396.
- [79] Sziklai I, Szilvassy J, Szilvassy Z. Tinnitus control by dopamine agonist pramipexole in presbycusis patients: a randomized, placebo-controlled double-blind study. *Laryngoscope.* 2011; 121(4): 888-93.
- [80] Tan J, Tange RA, Dreschler WA, vdKleij A, Tromp EC. Long-term effect of hyperbaric oxygenation treatment in chronic distressing tinnitus. *ScandAudiol.* 1999; 28(2): 91-6.
- [81] Tyler RS, Baker LJ. Difficulties experienced by tinnitus sufferers. *J Speech Hear Disord.* 1983; 48: 150-154.
- [82] Van de Heyning P, Vermeire K, Diebl M, Nopp P, Anderson I et al. Incapacitating unilateral tinnitus in single sided deafness treated by cochlear implantation. *Am OtolRhinolLaryngol.* 2008; 17(9): 645-652.
- [83] Vernon J. Attempts to relieve tinnitus, *j Am Audiol Soc.* 1977; 2(4): 124- 31.

