

**An Overview of**

# **TINNITUS**

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## **DEFINITIONS**

Tinnitus is the perception of sound or noise within the ear(s) or head. This sound usually cannot be heard by other people (or physicians). This type of tinnitus is known as subjective. In unusual circumstances, the tinnitus can be heard by other people. In the latter case, the tinnitus is known as objective.

## **SIGNIFICANCE**

Tinnitus is very common. More than 50 million people in the United States suffer with tinnitus. Some studies estimate that as many as one in three people are affected.

Though most people tolerate tinnitus without too much impact on their daily lives, it can be very disturbing. One in four tinnitus sufferers have sought medical help, and the lives of 1 in 50 may be severely affected. Problems attributed to tinnitus have included interference with sleep, work and social functions. People more severely affected by tinnitus may have problems with sensitivity to loud sounds (hyperacusis) and depression. In many ways, tinnitus is the hearing system's equivalent to chronic, incurable pain.

## **THE AUDITORY SYSTEM**

Everyone may experience tinnitus when in very quiet settings. Tinnitus that is noticed in louder settings is commonly, but not always, caused by some problem in the ear or the part of the brain that handles the perception of sound. In order to understand the possible causes of tinnitus, one must have some knowledge of the hearing mechanism. This mechanism is made up of five main divisions: the external ear, the middle ear, the inner ear, the hearing nerve, and the brain.

***External Ear:*** The external ear consists of the auricle and the external ear canal. These structures collect sound waves like a funnel and transmit them to the eardrum. External ear problems that may cause tinnitus include wax build-up, foreign bodies (even insects!), and outer ear infections.

***Middle Ear:*** The middle ear lies between the eardrum and the inner ear. This chamber contains the three hearing bones: the malleus, the incus and the stapes (hammer, anvil and stirrup). Vibrations of the eardrum are transmitted across the middle ear space by these three small bones. Movement of the third bone (stapes) results in fluid waves in the inner ear.

The middle ear chamber is lined by a membrane similar to the lining of the nose and contains secreting glands and blood vessels. This chamber is connected to the back of the nose by a small channel called the Eustachian tube. The Eustachian tube serves to maintain equalization of pressure between the middle ear chamber and the outside atmosphere, as evidenced by the popping sensation noted in the ear during swallowing, yawning, or altitude changes.

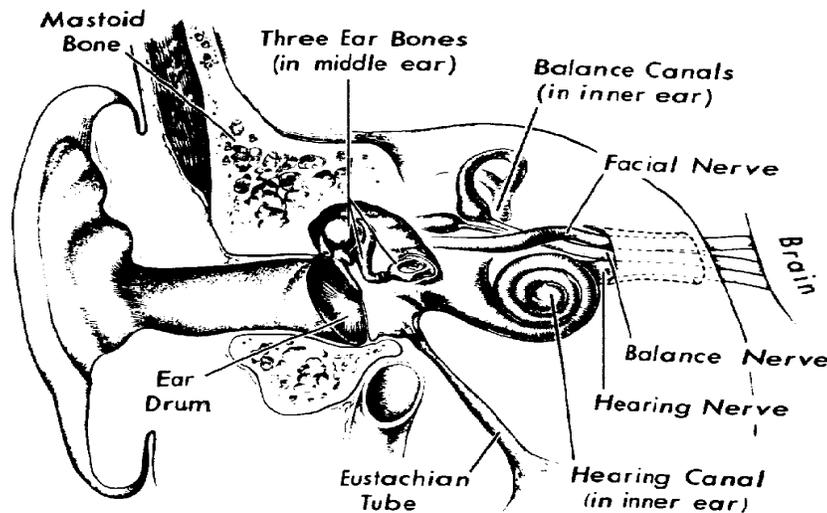
Many problems affecting the middle ear may lead to tinnitus. These include, middle ear infection, environmental or food allergies, damage to the middle ear bones, a hole (perforation) in the ear drum, and cysts or tumors of the middle ear.

**Inner Ear:** The inner ear is enclosed in dense bone and contains fluid and the tiny hair cells--known for the very fine hair-like “stereocilia” on their surface. The hair cells lie between two delicate membranes. Fluid waves, resulting from movement of the stapes, cause displacement of the stereocilia, which results in the generation of electrical impulses.

Problems in the inner ear are the most common causes of tinnitus. Aging, genetic predisposition, noise exposure, and certain medications (eg, aspirin and aspirin-like products) cause loss of the hair cells, and ultimately, tinnitus.

**Hearing Nerve:** The electrical impulses created by the hair cells of the inner ear are transmitted to the brain by the hearing nerve. The nerve pathways leading to the brain are enclosed in a small bony canal along with the nerve of balance and the nerve that stimulates movement of the facial muscles. Damage to the hearing nerve may be caused by tumors, compression by blood vessels, infection around the brain (meningitis), trauma, and aging.

**Brain:** The hearing nerve pathways divide as they reach the lower part of the brain (brainstem), into an inter-communicating system far more complex than the most extensive telephone exchange. Nerve impulses are then transformed into recognizable sound by the upper portions of the brain (auditory cortex on the cerebral hemispheres). Studies in recent years has revealed that a portion of the cerebellum, which is more commonly recognized as important for balance, may control tinnitus loudness.



## UNDERLYING CAUSES

When discussing the causes of tinnitus, it is most helpful to classify these as pulsatile or non-pulsatile, because the underlying causes are usually significantly different. Pulsatile tinnitus is a repetitive sound that is usually caused by some bodily function, such as blood flow, breathing, or muscle contraction. Non-pulsatile tinnitus, which is far more common, is

usually caused by problems in the hearing system.

### **Pulsatile Tinnitus**

As indicated above, pulsatile tinnitus is generally caused by bodily functions (known as somatosounds). It is very important to inform your physician if you have pulsatile tinnitus. Though most cases are not serious, persistent or recurring pulsatile tinnitus can be a sign of a more serious medical condition. It is also important to note if these sounds match the heartbeat (known as pulse-synchronous), the breathing (respiration-synchronous), or are influenced by any body positions or movements.

***Muscular Tinnitus:*** There are two muscles in the middle ear: the stapedius, attached to the stapes bone (stirrup) and the tensor tympani, attached to the malleus bone (hammer). These muscles normally contract briefly in response to very loud noise or as a result of a startle reaction. On occasions one or both of these muscles may begin to contract rhythmically for no apparent reason, for brief periods of time. Because the muscles are attached to the middle ear bones these contractions may result in a repetitious noise in the ear. Similar noises may be heard with contraction of muscles that control movement of the soft palate, as these are adjacent to the tensor tympani muscle and attached to the Eustachian tube.

Such muscle spasms are usually caused by irritation of these muscles or the nerves to the muscles. The clicking, although annoying, is harmless and usually subsides without treatment. Should the muscle spasm continue (known as myoclonus) or recur, medical evaluation may be necessary to exclude more serious causes (eg, compression of the nerves to these muscles). In very unusual circumstances will medical treatment (muscle relaxants or anti-seizure medicines) or surgery (cutting the spastic muscle) be necessary.

***Vascular Tinnitus:*** There are two large blood vessels intimately associated with the middle and inner ear: the jugular vein and the carotid artery. These are the major blood vessels supplying the brain. Both pass directly adjacent to the inner ear. It is not uncommon to hear one's heart beat or to hear the blood circulating through these large vessels (pulse-synchronous tinnitus). This may be particularly noticeable when an individual has a fever or after engaging in strenuous exercise. The circulation sound in these instances is temporary and is not audible to others.

Smaller blood vessels supply the ear structures. If blood flow or the pressure of the blood flowing through these vessels is increased, the heartbeat may be audible as well. The most common causes for increased flow to the blood vessels of the ear are middle ear infection and otosclerosis (a disease of the inner ear bone).

On occasions the sound of blood circulation will become persistent or even audible to others. This can be due to thickening of the blood vessel wall (a normal occurrence as one grows older), a kink in the vessel or an abnormal growth on the vessel wall. Further testing may be necessary to determine the cause and treatment indicated in these uncommon cases.

***Respiratory Tinnitus:*** As air passes through the nose, the pressure in the Eustachian tube opening decreases (inhalation) and increases (exhalation). These pressure changes are usually not noticeable, because the Eustachian tube is normally closed. However, in certain individuals, the Eustachian tube may remain open at rest (known as patulous). This will

lead to transmission of pressure and sound through the Eustachian tube, to the middle ear. Such problems are most common after radiation treatment to the head and neck, profound weight loss, and menopause. Treatment may be directed at closing the Eustachian tube with nose drops, hormones, injection of the Eustachian tube, or surgery.

### **Non-Pulsatile Tinnitus**

This type of tinnitus may be described in many ways: humming, chirping, whistling, rustling, static, high tension wire, roar (train, jet, or ocean), sizzling, clear tone, buzzing, transformer noise, hissing, or ringing. Most cases of non-pulsatile tinnitus are associated with problems within the hearing system. Interestingly, the severity of the tinnitus does not correlate very well with the degree of hearing loss or damage to the hearing system.

The underlying causes are not fully understood. Experimental evidence has supported a number of possible explanations, including abnormal spontaneous activity of hearing nerves, regulation problems with key brain structures, and abnormal cross-over in the brain with non-hearing nerves.

Two analogies are helpful in understanding the cause of non-pulsatile tinnitus. First, consider tinnitus as the background noise within the ear and head. Some degree of background noise is normal. If enough sound from the outside world is stimulating the ear and the brain, then the background noise will not be perceived. This is analogous to our ability to see the stars in the sky. During the day, the stars cannot be seen because they are relatively dim compared to the sunlight (similar to ear noise with normal ears and hearing mechanisms). At night, the stars seem bright in the absence of other light. This is known as the signal (hearing) to noise (tinnitus) ratio. This analogy does not explain all forms of tinnitus.

Another helpful analogy is one of phantom limb pain. People that have lost limbs due to accidents or medical problems often think that they can “feel” the limb that they lost. This is in part because the nerves in the brain that were responsible for “feeling” the limb did not go away when the limb was lost. Those nerves that provided sensation to the limb may be stimulated by other things, but the brain perceives them as being from the lost limb. This same process can cause tinnitus in the auditory system.

***Other Causes:*** A number of other conditions unrelated to the ear have been associated with tinnitus. One of the more common causes is temporal-mandibular dysfunction (TMD).

TMD is caused by problems in and around the jaw joint. Tinnitus may be the most distressing complaint by people with TMD. Sufferers also note fullness of the ear and tenderness of the jaw joint. Less commonly, dizziness will be a problem. The cause for this is not well-established. In some individuals, it is thought that an abnormal connection between the jaw muscles and the middle ear bones may be the cause.

## **EVALUATION**

All persons presenting with tinnitus should have a basic evaluation of their ears and their general medical health. This includes a thorough ear examination and hearing testing. More specialized testing may include radiographic studies (CT or MRI scans), blood tests, and additional hearing testing. The specific tests that need to be performed are based on the nature of the tinnitus, the findings on the ear examination, and the results of the initial hearing test.

## **TREATMENT**

“Any management which is based upon a single panacea for the treatment of a symptom and not a disease will result in failure.”

Victor Goodhill, 1950

As indicated above, there are many causes for tinnitus. Accordingly, there are many different treatment options. Treatment must be tailored to the individual. If the examination reveals a local or general cause of the tinnitus (eg, allergies or aspirin consumption), correction of the problem may alleviate the tinnitus. In many cases, however, there is no medical or surgical treatment that will *completely eliminate* tinnitus. Lots of therapies for tinnitus promise to yield good results, but many have not been well studied. This should not, however, be cause for discouragement. If one treatment option fails, there are others to be considered.

### **General Measures**

1. Avoid nervous anxiety, for this only stimulates an already tense auditory system.
2. Obtain adequate rest and avoid over-fatigue.
3. Avoid the use of nerve stimulants. Therefore, excessive amounts of coffee (caffeine) and smoking (nicotine) should be avoided.
4. Learn as quickly as possible to accept the existence of the head noise as a reality and then ignore it as much as possible.
5. Tinnitus will not cause you to go deaf, will not result in your losing your mind or cause death, so immediately dismiss such distracting and terrifying thoughts.
6. Tinnitus is usually more marked after one goes to bed and his surroundings become quiet. Any noise in the room, such as a fan, will serve to mask the irritating head noise and make them much less noticeable.
7. If one sleeps in an elevated position with one or two pillows, less congestion to the head will result and the tinnitus may be less noticeable.

8. Sedatives of various types should be used occasionally for only temporary relief.

### **Non-Medical Treatment**

For most people, just understanding that tinnitus is not a sign of a serious medical condition will alleviate any distress that it may cause. For those that remained bothered by the tinnitus, many non-medical and non-surgical treatment options should be considered.

**Hearing Aids:** Tinnitus is often associated with a hearing loss. If this hearing loss can be corrected or improved, the tinnitus may improve. In many cases, hearing aids will improve the hearing loss and may reduce the tinnitus.

**Masking:** This involves modifying the signal to noise ratio. By raising the background sound level, the internal noise of the ear and head will become less noticeable. For most tinnitus sufferers, white noise is more effective than the sound of the television or the radio. Sounds of running water are usually described as the most soothing. This includes the sounds of a fountain, a running brook, rain falling on a tin roof, a thunderstorm, a waterfall, and the surf. Other sounds, like the static of the radio between stations, may be very effective. All of these sounds are available in recorded form (eg, compact disks). They may also be generated by small electronic devices that are available through a number of electronics, department, and hardware stores, as well as many catalog suppliers and hearing aid dealers. Masking will be sufficient treatment for the vast majority of individuals with tinnitus.

While most people find masking necessary only when going to bed or working in a quiet environment, others may need to use masking during their normal daily activities. In such cases a masking device that sits on the outer ear or in the ear canal may be helpful. Masking devices may also be incorporated into hearing aids so that they provide sound amplification as well.

**Biofeedback:** This is a psychological technique used to push the awareness of the tinnitus back out of the consciousness and to improve relaxation. This treatment option is usually taught by a psychologist through a series of sessions. Usually only more severely affected people will find this treatment necessary.

**Habituation Therapy:** This technique involves getting the brain accustomed to the noise, much as one might do naturally with an offensive environmental odor. The brain will usually adapt to the presence of this externally generated sound. Unfortunately, the effect usually doesn't last after the sound is discontinued.

**Tinnitus Retraining Therapy:** This is a comprehensive program that has been introduced in recent years. It involves a elements of masking, habituation, and biofeedback. Generally, this will require long-term, intensive work with a trained professional. The results reported with this technique have been excellent, even for the most severely affected individuals.

**Magnets & Electrical Stimulation:** Application of magnets or low current electrical

stimulation to the ear has been reported to provide relief of tinnitus. Application of stronger magnetic fields has been used for the treatment of both tinnitus and depression.

***Laser Treatment:*** A number of centers have begun to offer low level laser stimulation to treat tinnitus. Scientific studies have failed to support the effectiveness of this treatment.

***Dental Intervention:*** In some cases tinnitus may be related to jaw joint problems. Wearing a dental splint can lead to significant improvements in tinnitus in many patients with jaw joint arthritis.

### **Medical Treatment**

Western medicine has favored the use of “pills” to alleviate ailments such as tinnitus. Unfortunately, there is no one pill for tinnitus, as there is aspirin for a headache. All the medical therapies have yielded either modest results or serious side effects that limit their use.

***Anesthetics, Anticonvulsants, & Antiarrhythmics:*** These medicines are thought to work by quieting down excess activity in the affected nerves. One drug, lidocaine, is highly effective at reducing tinnitus. This drug must, however, be administered intravenously, it has potentially serious side effects on the heart, brain, and liver, and there is no lasting benefit. Other drugs like lidocaine, which may be taken orally, have been tried, but the benefits have been less uniform and side effects remain high.

***Anxiolytics:*** The most common of these drugs is Valium. These drugs have many effects, such as promoting sleep, quieting excess nerve activity, and reducing anxiety. Many tinnitus sufferers will note a reduction in the loudness of the tinnitus or a reduction in the impact that the tinnitus has on their ability to function. Such drugs are tranquilizers that are habit forming. Hence, they are not used for most patients.

***Antidepressants:*** These drugs have been shown to be of benefit, particularly for patients with depression associated with their tinnitus. This class of medicine also promotes sleep.

***Sleeping Pills:*** Many drugs, like valium, antidepressants, and antihistamines can help tinnitus sufferers fall to sleep. The quality of the sleep may, however, be adversely affected. These medicines should only be used for short periods of time or under the supervision of your physician.

One safer alternative to these drugs is melatonin. This is a natural product that regulates the sleep-wake cycle. It is available over the counter at most pharmacies and health food stores. It can take many weeks to appreciate the full effects of melatonin.

***Other Medicines & Herbal Medicines:*** Many other substances have been promoted as beneficial for tinnitus. These include ginkgo and other vitamins. While most are unlikely to have any harmful effects on healthy individuals, they can have side effects, particularly for those people with other medical problems, taking prescribed medications. Please check with your physician to ensure such interactions and side effects.

### **Surgical Treatment**

In certain cases, surgery may be indicated to help with the tinnitus. If tinnitus is associated with hearing loss due to middle ear problems, surgical correction (ear drum repair, middle ear bone repair or replacement, placement of a ventilation tube) may be of benefit. If hearing loss is profound (ie, deafness), placement of a cochlear implant (an artificial ear) will not only restore some degree of hearing in many individuals, but it may also help reduce the loudness of the tinnitus. Similarly, tinnitus has been treated by implanting electrodes in different areas of the brain (eg, brainstem and cortex). Cutting the hearing nerve will lead to certain deafness, so this is not an option for most patients. Some surgeons have reported successful treatment of tinnitus with decompression of blood vessels from around the hearing nerve. That treatment requires a craniotomy, and most tinnitus sufferers are not inclined to consider such drastic measures. Stimulation of the vagal nerve, via an implanted device, like a pacemaker, has been reported to reduce tinnitus.

### **OTHER SOURCES OF HELP**

If you have questions about your condition, please consult with your physician or ask for a referral to other individuals that may be of help. The main source of information about tinnitus in the United States is the American Tinnitus Association (by mail at PO Box 5 Portland, OR 97207-0005; by telephone at (800) 634-8978; or by the web at [www.ata.org](http://www.ata.org))