Introduction :-

Hearing Impairment in childhood can have a major impact on the development of speech and language. In this booklet we will discuss some of the commom elements of hearing impairments and focus on the more usual forms of hearing impairment and hearing losses that occur in the early years. Hearing Impairment in childhood takes many forms, from the slight reduction in hearing sensitivity to the total inability to hear spoken language. This compilation will help the practitioners and educators for detecting hearing impairment and understanding the degree of hearing loss.

This booklet is a small contribution from Sense International (India) to deafblind field.

For easy accessibility of information for people with sensory impairments this booklet is also available in Braille and Tape on request.

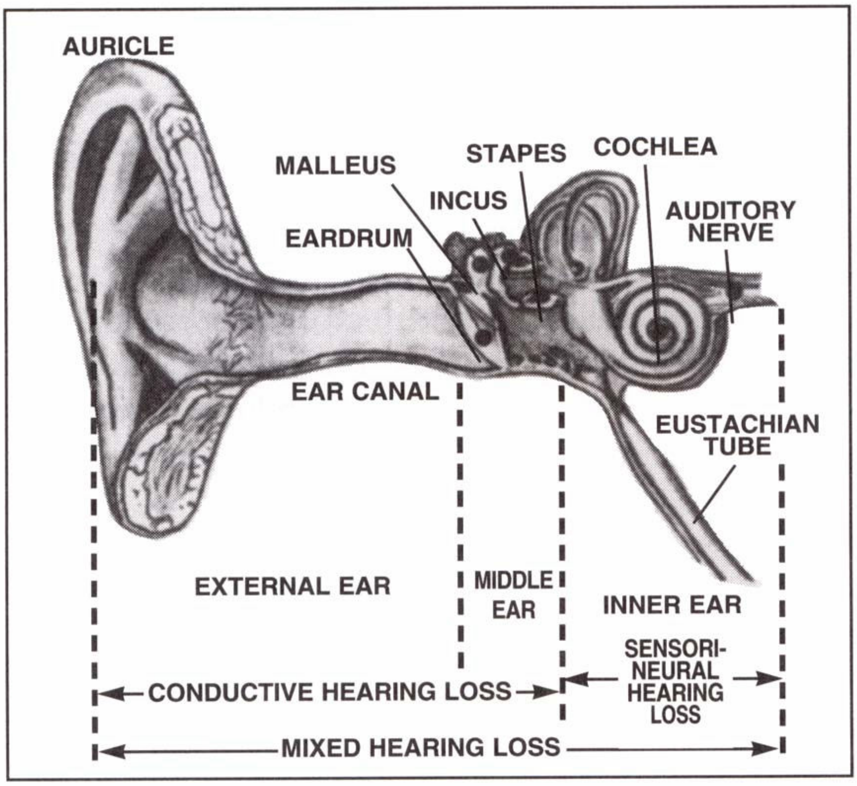
Hearing – Knowing it Better

The Ear And Hearing Loss

Basic Structure and Function of the Ear:

The ear transmits the patterns of all sound vibrations in the surrounding environment to the brain. It helps the individual interpret the pitches and relative intensity of the sounds and the direction from which each sound comes. The process of hearing involves a complex conversion of sound energy, which is mechanical, to electrical energy that can be forwarded and processed in the auditory cortex of the brain.

The ear (peripheral or outside auditory system) has three basic sections: the outer or external ear, the middle ear, and the inner ear. Each section has a distinct role in conveying sound to the brain from the outside world. The specific parts of each section are identified and described in the following sections, with explainations of their importance in the overall process of hearing.



The Outer Ear :-

The structure of the outermost part of the ear, the auricle (pinna), serves to direct sounds into the ear canal. The auricle's shape and sound directing characteristics help the brain determine the direction of the source of a sound.

The ear canal is a little over an inch long in an adult and is curved. The outer half is flexible cartilage that can be touched and moved, although doctors do not recommend it. Beyond that point, the canal is encased in bone - the mastoid portion of the temporal bone. The curvature of the canal offers protection for the fragile parts deeper inside the ear against foreign objects that may enter the canal and cause damage.

The outer ear has a protective lining of a thin tissue containing glands that produce wax and hair cells. The wax, cerumen, helps to trap dirt and creates a moist environment. The next structure beyond the ear canal, the eardrum or tympanic membrane, is normally tight and flexible and completely seals off the ear canal from the structures inside. It requires a relatively constant temperature and humidity to maintain its elasticity and vibrate properly to carry sound information.

The Middle Ear :-

The tympanic membrane is the gateway to the middle section of the ear. Here the mechanical energy of the sound waves undergoes the first conversion into the mechanical energy of vibration as the waves reach the tympanic membrane and set it in motion. The tympanic membrane, in turn, transmits the vibrations to other structures in the middle ear: the three smallest bones in the body, known as the ossicles.

The tympanic membrane is attached to the malleus (hammer) and sets it into motion; the malleus touches the incus (anvil) and sets it into motion; and the incus touches the stapes (stirrup) and sets it into motion. The three ossicles function like a bridge to pass the sound energy to the inner ear. These three tiny bones are able to vibrate so effectively because the middle ear is a cavity in the skull. Air surrounds the ossicles, permitting them to vibrate freely and pass sound energy along in a process of air conduction. Although the cavity is small in comparison to the entir body, it is quite large in relation to the tiny ossicles. The cavity is lined with a mucous membrane, which keeps the area from becoming too dry for the bones to vibrate properly.

The muscles respond reflexively when an exceptionally loud sound comes into the ear. They immediately and automatically contract and tighten the chain of ossicles so that the vibration is diminished. This is a safety mechanism to protect the delicate structures of the inner ear from being overstimulated. It is usually possible to stimulate and see this reflex in children with limited language who cannot easily be assessed for auditory abilities. The audiologist can learn some details about the status of the ossicles by determining whether the reflex is present, which can help the audiologist to prescribe appropriate amplification. In many students who have disabilities, the ossicles are affected by lack of development or other abnormalities. When this sound transmission system is not working well, the student gets diminished or distorted sound information.

The Inner Ear :-

The inner ear begins at the footplate of the third bone, the stapes, fairly deep inside the head. This location is the entrance to the spiral of the cochlea. Thousands of tiny hair cells inside the cochlea are the receptors for the sound energy that has been mechanically transported through the outer ear and middle ear.

The entire inner ear is a series of bony canals, formed into loops and spirals. These inner-ear canals support a complex fluid system that causes movement, or waves, of the hair cells in an extension of the earlier vibrations from the middle ear. The stimulated hair cells convert the sound information to electrical energy that is passed to a system of complex nerve fibers, which send impulses to the brain for interpretation. Specific sounds trigger specific hair cells along the cochlea, which in turn pass along specific sound information to the brain. Not all of the hair cells are stimulated by every sound, or all sounds would seem the same.

A second separate but related inner-ear structure controls balance. The semicircular canals inside the inner ear also contain fluid. If the fluid is flowing routinely, equilibrium (balance) can be easily maintained. If, however, there are problems with the flow of fluid through these canals-for example, if the canals produce too much fluid and there is excessive pressure inside them-extreme balance problems (vertigo) can result.

The cochlea is responsible for the process of hearing and the semicircular canals for balance. Because these two major structures of the inner ear are so closely related, children who are deaf sometimes have problems with balance that are related to their hearing losses.

The Brain :-

Once the inner ear has converted the sound information into a form the brain can handle, that information is passed through the auditory nerve to the brain stem and on to the cerebral cortex in the temporal lobe of the brain. The information is processed, meaning is determined, and appropriate responses to the sound information are formulated. If any of these structures responsible for hearing has an irregularity, however, the process of sound transfer becomes altered, so full and accurate sound information either is not sent to the brain or is not processed for meaning by the brain itself.

Defining Deafness :-

Being “deaf” means having a loss of hearing so significant that it interferes with a person's ability to receive or interpret sound information, including speech information. Most people who are identified as deaf can actually hear some sounds, so the term deaf rarely means a complete inability to hear sound.

“Hard-of-hearing” describes an individual who has a loss of hearing that is especially significant for educational settings. This means that in situations in which instruction is dependent on auditory information (usually spoken), the student is at a disadvantage for getting the information necessary to participate. An individual who is hard-of-hearing has residual hearing that allows reception and sometimes understanding of sounds, including speech, without amplification, but some of the information is missing or distorted.

The Persons with Disabilities Act 1995 defines Hearing Impairment as loss of sixty decibles (60 dB) or more in the better ear in the conversational range of frequnecies. The term “hearing impaired” is sometimes used, rather than hard-of-hearing, but it can also be used to describe a person who is deaf. This is a more general term that refers to the fact that an individual has a hearing loss. Both individuals who are deaf and those who are hard-of-hearing may benefit from amplification (hearing aids or other assistive listening devices). Hearing impairment is classified according to level of severity, type of loss, what caused the loss and the age of onset.

How Hearing Acuity is Measured :-

The measure of volume, loudness, or intensity of a sound is the decibel (dB). The larger the dB notation, the louder a sound will be. The baseline for measuring "normal" hearing is 0 dB, the lowest level at which an average person can first detect a specific pure tone; it does not mean the absence of sound. Normal conversation ranges from about 40 dB to 60 dB.

Sound is produced in invisible waves, rather like the waves that occur when a stone is thrown into water. Hertz (Hz) is the measurement of the frequency of a sound wave, in cycles per second, which gives that sounds pitch (highness or lowness). Sounds rarely involve only one frequency, but usually have frequencies blended, so an individual who has a hearing loss for some frequencies may be able to hear one part of a sound but not other parts. Human beings can hear sounds from as low as about 100 Hz to around 10,000 Hz-roughly the range of the notes on a piano-and some people can hear sounds even lower and higher than these.

Speech sounds occur primarily in the frequency ranges between 250 Hz and 4,000 Hz, known as the speech range. If a student has only an extremely high-frequency loss, his or her ability to hear speech might not be significantly affected for classroom participation. This individual might be missing only a few consonant sounds such as *sh* and *f* that have no voicing and therefore not much volume or sound pressure. The teacher might be able to help the student simply by bringing him or her closer, repeating often, and asking the student to rephrase instructions or information so the teacher can check comprehension. Conversely, if a student's hearing loss affects the speech range, his or her ability to get the information in a classroom might be more limited, and the teacher might need to make more adaptations. The teacher can work with the audiologist and other educational team members to know the extent of each student's hearing loss and to make sure his or her information needs are being met in the classroom.

How are Hearing Losses Classified :-

Hearing losses are classified according to two main factors: type of loss (where it occurs in the hearing mechanism) and degree of loss (how much measured loss exists-at which frequencies and for what volumes). Also of significance are what caused the loss and age of onset.

Types of Hearing Loss :-

Four basic types of losses can affect hearing, depending on what parts of the hearing system are affected: **conductive, sensorineural, mixed,** and **central**. Each type has distinct characteristics and can affect learning, since each one affects the amount and quality of sound information a student receives.

Conductive Hearing Losses :-

The outer ear and middle ear are responsible for mechanical conduction of sound energy into the inner ear, where the energy will be further converted into electrical impulses that can go directly to the brain. Any structural irregularities, infections, or other problems with passage of sound, especially in the middle ear, can lead to conductive hearing loss.

A conductive loss indicates that sound is not passing effectively from the outer ear through the middle ear. This can be caused by something as simple as a foreign object or wax blocking the ear canal or by a congenital structural problem, such as bones that are unable to move or are shaped imperfectly for good vibration. Sounds appear muffled to the individual because there is a problem with air-conducted sounds traveling through the system. Conductive losses can be temporary, as with middle-ear infections that can be cleared, or permanent. Many causes of conductive hearing loss can be corrected with medical treatment, surgery, or appropriate amplification to make the muffled sounds louder.

For many children-with or without disabilities-excess middle-ear fluid produced by the mucous membrane can pose a problem for hearing. This condition is called otitis media inflammation of the middle ear-and is frequently seen early in childhood. In some students with disabilities, the middle ear has abnormalities that can cause the fluid to build up inside the middle-ear cavity.

Because the middle-ear cavity opens directly into the nose, throat, and mouth, an ordinary cold can also pass infection into the middle ear through the eustachian tube, and fluid will develop as congestion from the cold causes swelling, keeping these structures shut and preventing the pressure in the middle ear from being equalized.

Regardless of the cause of otitis media, the result is that the tympanic membrane and the ossicles are prevented from vibrating freely, since they become surrounded by fluid. Whether or not the fluid becomes infected, it interferes with hearing, either temporarily, until the fluid clears out of the cavity, or chronically, and permanent ear damage can result. If left untreated, so much fluid can build up in the middle ear that it will actually rupture the tympanic membrane. Scar tissue may form as the drum heals, which can interfere permanently with vibration. An infection that is left untreated for a long time can even spread beyond the middle ear and affect other parts of the ear as well as the brain. It is vital, therefore, that a child with otitis media see a doctor to help diagnose and rid the ear of excess fluid and infection, if any.

Deafblind children may not be able to describe the pain or pressure they experience from middle-ear infections. It is important for teachers to watch for signs of discomfort-for example, pushing on the ear or trying to stick fingers or other objects inside in an attempt to relieve the discomfort. Also, children with middle-ear infections are likely to refuse to have hearing aids or personal auditory training equipment (amplification systems) in ears that are infected. These children may fuss and pull at hearing aids. They may also have other upper respiratory symptoms, such as runny noses, red and teary eyes, and coughing.

Sensorineural Hearing Losses :-

Losses that occur in the inner ear and nerve pathways are sensorineural. This means that the cochlea the sensory organ that translates the mechanical information of sound to neural impulses or the neural pathway is affected and does not pass sound information to the brain. A sensorineural loss most often involves the cochlea but can also be present in the auditory nerve (eighth cranial nerve). Audiologists and physicians cannot always be entirely sure exactly where a sensorineural loss occurs, but the result is the same, regardless of the site. Sensorineural losses tend to be more significant than conductive losses (although some forms are mild), and they are not as easily corrected. Sometimes they can be traced to a specific cause, such as genetic factors or a prenatal rubella infection. Conversely, sensorineural losses may not become evident until later in childhood or adult life. Sensorineural losses are generally permanent and may be progressive.

Mixed Hearing Losses :-

Many students with hearing losses have mixed losses. This means that they may have both conductive and sensorineural components. Children with disabilities can have middle-ear infections or structural problems in the middle ear in addition to sensorineural hearing loss.

Central Hearing Losses :-

Most baffling of all hearing losses are those that occur in the brain. In what is called "*Central Auditory Dysfunction*", an individual hears and receives auditory information, yet cannot identify the sounds, interpret them, attend to the sounds long enough to understand what is being said, or respond appropriately to the information. Some children have complex multiple disabilities that include cognitive impairments, so it becomes extremely difficult to assess and identify this type of hearing problem. Tumors in the brain are the most easily identified causes of central hearing losses. Assessment typically involves efforts to rule out other causes, rather than pinpointing central brain dysfunction.

Children with central losses often seem inattentive and may have behaviors that are difficult to manage. A neurologist can assist with diagnostic tests when this type of hearing loss is suspected.

Some children may have *functional* hearing losses, which do not fit well into any of the basic classifications described. An individual with a functional loss has a hearing system that is working adequately, but fails to respond as expected to auditory information or responds inconsistently. Emotional problems or psychological factors may be linked to this kind of response pattern. A student with functional hearing loss should be referred to an audiologist to examine for actual hearing loss, medical doctors to examine for illness, and counseling personnel to examine for emotional or psychological factors.

Degrees of Hearing Loss :-

Hearing loss is futher defined by levels, or degress of loss. Some experts define five levels of loss and “normal” hearing, whereas many others have altered their classificationd in recent years to define four levels.

Age of Onset :-

Hearing losses are also defined by age of onset, especially for educational purposes. A congenital loss, which is present at birth, can significantly affect the child's development of language and speech concepts because he or she will never have had the intense auditory input necessary for typical development.

In comparison, an individual with an adventitious loss, one occurring at some point after birth- may have heard spoken language enough to have developed language and speech concepts. If an adventitious loss occurs before approximately age 2, the early auditory input may still provide some benefit for lifelong language and speech development. The later in life an adventitious loss occurs, up to early adulthood, the more auditory input the individual will have experienced, and thus the more language and speech development that will have occurred.

Assessing Hearing Loss :-

The service providers primarily responsible for assessing hearing losses are the audiologist. Before they begin their work, however, a special educator or other service provider may do a screening. A hearing screening is routinely done in schools to make a preliminary identification of students with hearing losses. The brief assessment is often done with a portable device called an audiometer, which delivers pure tones through headphones to the person being tested. Such a device must be used in a quiet room. The person responds when he or she first detects a sound. If the person being screened does not "pass" at specific volume levels for three pitches that are important for understanding speech, a comprehensive assessment by an audiologist will be recommended.

Before the comprehensive assessment, an ENT specialist will examine the person who may have a hearing loss to determine whether there are structural problems with the ears, nose, or throat. Some rough hearing measurements may also be done. The ENT specialist will then refer the patient to an audiologist for complete, comprehensive measurement of hearing acuity. Comprehensive audiological testing usually occurs in a sound isolated room or an audiometric suite. The audiometer used in this kind of testing environment is far more sophisticated than a portable screening audiometer.

Comprehensive testing of hearing acuity can take several forms. Basic forms include pure tone audiometry and speech audiometry, and sometimes sound field testing, supplemented by tympanometry. When these methods are ineffective for a variety of reasons, additional forms of testing may be done.

Pure-Tone Audiometry (Air Conduction) :-

Pure tones (not blended tones as we hear in everyday sounds) are sent directly to the outer ear through headphones and are conducted through the middle ear to the inner ear. Each basic sound frequency is measured separately for each ear, and averages can be calculated to use in describing hearing acuity.

Pure-Tone Audiometry (Bone Conduction) :-

Pure tones are sent directly to the inner ear through a bone vibration device (oscillator) placed on the mastoid bone above and a little behind the outer ear. This is especially helpful in determining whether there is outer or middle ear damage, because the sound bypasses these areas. If the inner ear is not damaged, the individual will be able to hear the sounds presented through vibrations that have bypassed the damaged areas.

Speech Audiometry :-

Speech sounds or specially selected words are presented to help the audiologist identify the minimum volume at which a person can detect that words are present the **Speech Awareness Threshold (SAT),** or, more commonly, the minimum volume at which a person can actually understand and repeat the words, the *speech reception threshold* (SRT). In addition, the speech discrimination score may be determined to measure the ability to identify specific sounds of speech. This test consists of one syllable words, usually presented at an intensity level 20 to 30 dB higher than the previously established speech reception threshold, and requires a high level of understanding. The score is the percentage of correct answers.

Speech audiometry measures are especially important to teachers, since students sometimes hear pure tones differently than speech, and speech is what matters in a classroom. This kind of testing is usually done in a two room testing facility.

Sound Field Testing (Air Conduction) :-

No headphones or direct bone conduction devices are used; instead, sound is presented in the sound isolation booth, under controlled conditions, through loudspeaker type devices. The person being tested sits in the middle of the booth and responds as the sounds are detected. A response can be formal, such as raising a hand when a sound is heard, or less formal, such as turning toward a sound, depending on the person being tested. This method is often used for testing very young children or those who have hearing losses that are already identified. If children being tested wear their own hearing aids for sound field evaluation, the audiologist can determine what they hear with their aids in ideal quiet, without any distracting sound.

Tympanometry :-

Tympanometry measures the flexibility of the eardrum. When combined with other tests, it provides information about middle ear functioning and possible conductive loss for example, if a child has fluid in the middle ear and the eardrum is not moving well. An abnormal tympanogram indicates that the student is not likely to hear everything in the classroom.

Auditory Brain Stem Evoked Responses or BERA :-

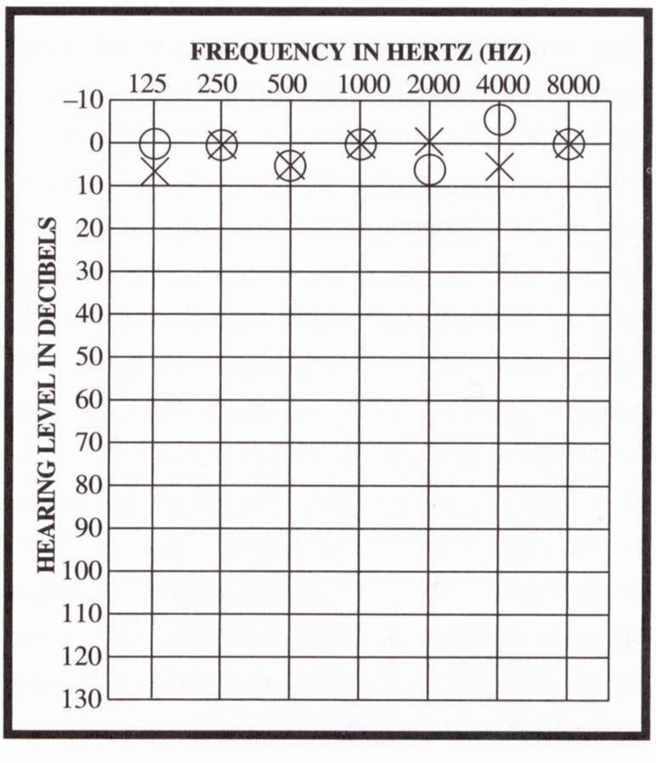
Other forms of audiological assessment are necessary in many cases to supplement standard pure tone audiometry. The auditory brain stem evoked response (ABR) is an objective measure of auditory nerve and brain stem dysfunction. It assesses physiological functioning within the auditory system. This assessment process has proved useful for very young infants, individuals with multiple disabilities, and others who cannot voluntarily respond to audiometric testing. The process involves measurement of the electrical discharge of the auditory nerve and the brain stem through electrodes placed on the head while clicking sounds of various volumes and at various frequencies are presented very rapidly through headphones. An advantage of ABR testing is that it can be administered when the child is asleep and is not affected by sedation. This assessment process reveals the functioning of the peripheral auditory system as well as the auditory brain stem. ABR measurements are utilized by audiologists, neurologists, ophthalmologists, and other specialists. ABR testing is a vital component of the audiological test battery.

Behavioral Observation Audiometry :-

Sometimes audiologists cannot test children accurately with pure tone or speech audiometry because a child may be too young to give satisfactory responses or, as a result of cognitive impairments or minimal language skills, may not understand what kind of response is expected. In Behavioral Bbservation Audiometry (BOA) audiologists set up sound controlled situations in which sound is introduced and the child's responses are observed. Of course, observing a child's behavior in response to any stimulus requires a subjective decision about what the response is and what it means. Information from teachers and parents documenting how a student responds to sounds can be important for the audiologist who is compiling information on the child's hearing needs.

Visual Reinforcement Audiometry(VRA) :-

With visual reinforcement audiometry the child's visual responses can be supported with reinforcement, such as a flashing light, when the child responds by looking in the direction of a sound that has been presented. The child's response to sound stimulation is shaped with the addition of the visual stimulation, and then the visual stimulation can be diminished or dropped to see if the child still responds to sound information. Both VRA and BOA techniques for testing young children for hearing loss are less formal than pure tone or speech audiometry, but both can provide useful information for team members who are planning instructional programs.



Interpreting Audiograms :-

An audiogram is a form or graph that displays information about a person's hearing acuity measurement. Figure shows an audiogram of someone with what would be considered normal hearing. On the left side of the graph, from top to bottom, the numbers represent the decibels (dB), or volume, at which a sound can first be detected by the individual being evaluated.

Note that normal hearing is at the top of the graph, where very low volume is indicated, because this person can detect most of the sounds that are being tested within the normal range of threshold level (between 0 and 10 dB) across the entire range of pitches.

Across the top of the graph from left to right the numbers represent the pitch, or frequency, of a sound in hertz (H_Z). The low pitched soulds are at the left, and the high pitched sounds are at the right. As mentioned earlier most speech sounds occur between 250 H_Z and 4,000 $H_{Z.}$

The audiogram for "normal" hearing shows that the person was tested with headphones presenting pure tone sounds to both the right ear (O) and the left ear (X) at the basic frequencies most people can hear. This person could first detect all of the frequencies within the normal range in both ears, with some freqencies at "better than normal" volume measurements and some at slightly louder than normal volume measurements. In general, this person hears very well for the controlled testing situation. This audiogram does not tell how the person hears with background noise, since noise can affect the way the brain processes sound information. Some people with perfect hearing still do not seem to hear when other noise is present, because their brains cannot sort out the important sounds they hear from the unimportant ones.

A quick glance at the overall configuration of an audiogram can give a basic sense of what the individual does and does not hear. There are three general categories of audiogram shapes :
* A straight loss – the degree of loss is approximately the same at each frequency.
* A sloping loss – the degree of loss is less in the low frequencies and gets progressively worse at each higher frequency.
* A ski – shaped loss – similar to a sloping loss in configuration, but hearing is normal or near – normal at the lower frequencies and then drops off at the higher frequencies. This shaped is characteristic of noise induced hearing loss.

Mild Chronic Hearing Loss :-

When bone conduction testing was done, the responses were all excellent, but when the sounds were passed through the outer and middle ear with pure tone air conduction, there was a distinctive loss. This means that sound is not being passed through the middle ear, but when the middle ear is bypassed, the inner ear processes the sould to the brain and the brains interprets it. This audiogram shows a gap between the results for air conduction and bone conduction, known as an air – bone gap.

High Frequency Hearing Loss :-

Individuals with congenital high frequency losses may have near normal hearing in the lower frequencies but significant loss in the higher frequency range. They may hear speech but lose many of the distinguishing high frequency sounds such as *sh, f* and *s*. These students are consequently unable to grasp the meaning of much of what is said in a classroom. Amplification will usually be quite beneficial for them.

Moderate Hearing Loss :-

The threshold range for moderate hearing loss in this system of classification is between 30 and 50 decibels. A student with this type of hearing loss will have had it since birth, and if it is not solely a sensorineural loss, it will be complicated by a conductive component.

Severe Hearing Loss :-

Individuals with severe hearing losses will likely experience significant language and communication problems. Some audiologist will indicate measurements in the speech spectrum on the audiogram, to show the range of frequencies that are most important for hearing speech sounds. If the threshold of hearing is within or below this range, the individual will require amplification to comprehend communication, particularly in a crowded or noisy setting such as a classroom. This child does not hear anything in the speech range without amplification.

Profound Hearing Loss :-

In people with hearing losses greater than 70 decibels, the use of amplification is important to provide some useful information about environmental sounds. Individuals with losses in this range are hightly dependent on visual cues and systems for communication. In many cases of profound loss, children may have some residual hearing, particularly in the low frequencies.

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