teacher

Tutor guide

Second Year Medical Students Physiology Labs
EMG and Nerve Conduction

Objectives:

At the end of the session the students should be able to:

- Understand the basic principle of EMG and NCS.
- Perform the EMG and NCS by themselves.
- For the EMG: students should know the appearance and characteristics of a normal EMG study and enumerate a few abnormalities that may be seen in neuromuscular diseases.
- For the NCS: Determine and calculate motor nerve conduction velocity of the major peripheral nerves.

ELECTROMYOGRAPHY (EMG):

An electrodiagnostic technique for recording the electrical activity (action potentials) of skeletal muscles.

Principle:

In the clinical setting, the EMG is performed by inserting a small sharp needle (recording electrode) through the skin into the muscle under study. The needle electrode is inserted into the belly of the muscle, near the expected region of the motor endplate. Depending on the muscle, this is either midway through the length or at the junction between the proximal and middle thirds of the muscle. In general, the endplate region is the thickest part of the muscle belly.

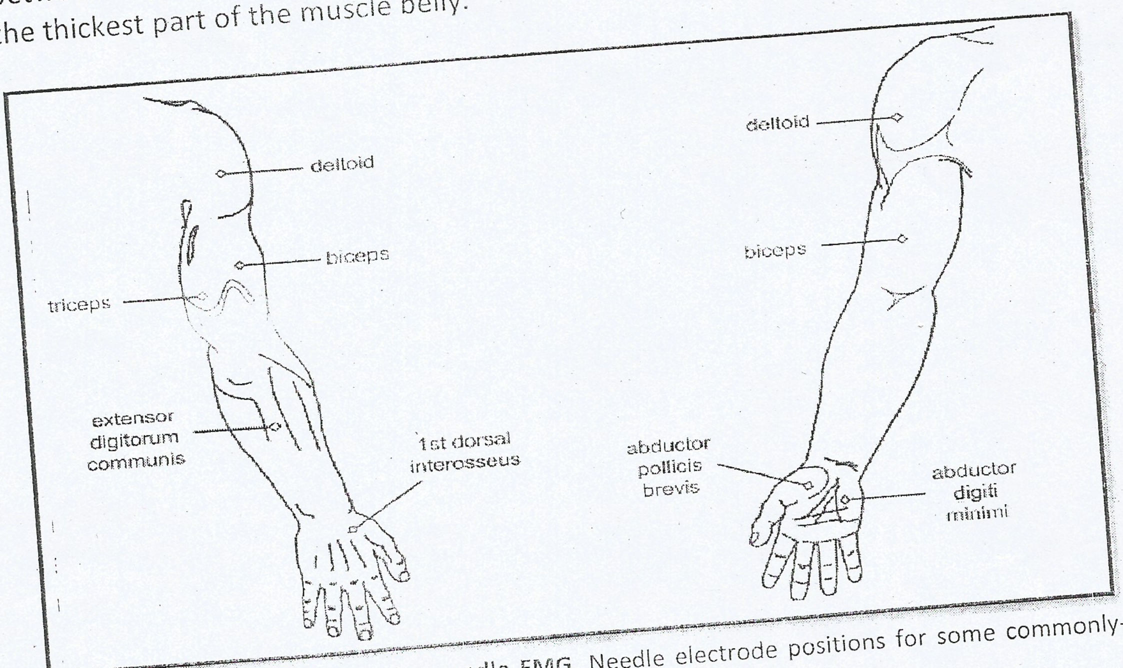


Figure 1. Electrode placement for needle EMG. Needle electrode positions for some commonly-tested muscles. The electrodes are inserted perpendicularly to the skin.

After insertion of the needle, the electrical activity of the muscle will be recorded at rest, during mild-moderate muscle activity, and during maximal muscle contraction. The recording is observed in each case.

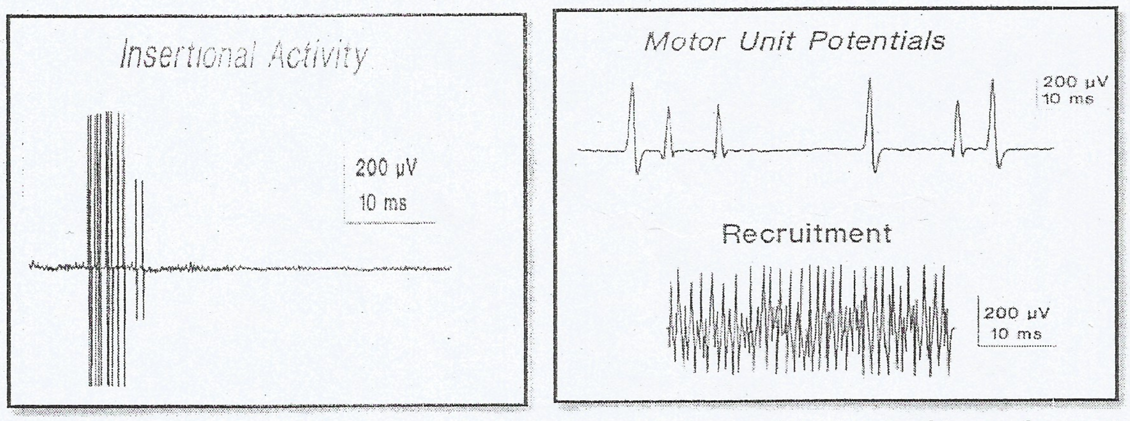


Figure 2: Normal EMG activity. Normal EMG patterns. Insertional activity is a brief burst of potentials. Resting activity is absent. Motor unit potentials (MUPs) are brief biphasic and triphasic potentials. Recruitment with vigorous contraction results in activation of many MUPs at fast rates, obscuring the background.

Normally the muscle is silent at rest. However, little electrical activity may be seen during electrode insertion which evokes a brief discharge (insertional activity).
After assessment of rest and insertion activity, the patient is asked to make a slight contraction of the studied muscle. This will evoke motor unit potentials (MUP).
Maximal contraction: Increasing force of contraction results in recruited units discharging at a faster rate and new units being recruited. This eventually produces a massive discharge with maximal contraction in which the baseline is not visible and individual units are not discernible. This is the interference pattern.
In our physiology student lab, surface electrodes will be used instead of needle electrodes and the same steps will be followed. However, one major difference should be kept in mind. Instead of showing the MUPs, surface electrodes record the sum of all the MUPs occurring in the muscle which is called "the compound motor action potential".

Table 1: Normal EMG potentials.

Pattern	*Recorded*	*Findings*
Resting activity	Muscle relaxed and needle not moving	No activity.
Insertional activity	Movement of the needle in an otherwise relaxed muscle	Brief volley of action potentials.
Motor unit potentials	Needle is not moved while patient makes slight contraction.	A few motor unit action potentials, biphasic or triphasic, short duration
Recruitment	Patient makes progressively stronger muscle contraction until reaching maximum force.	Increase number of functioning movements until the baseline is obscured.

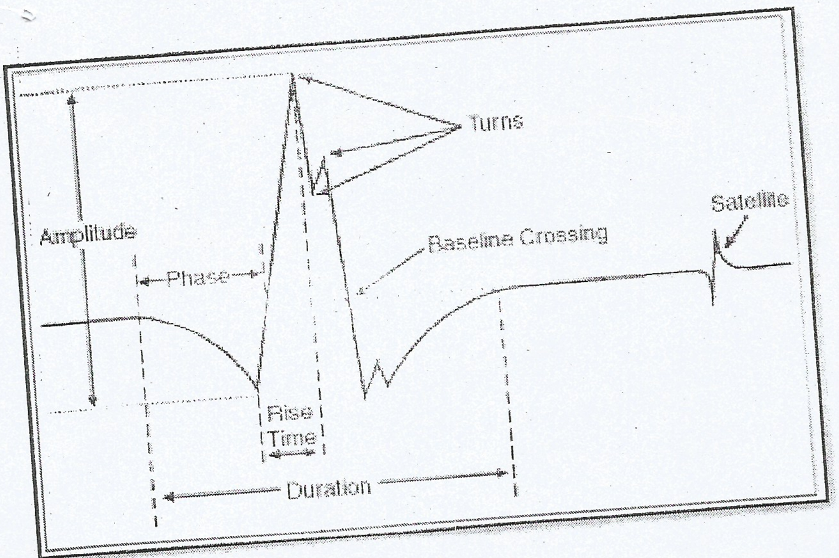


Figure 3. A Normal MUP.

Procedure:

Recordings will be obtained from the APB muscle in the hand

1. Select a volunteer and explain the procedure to him/her.
2. Three surface electrodes need to be placed on the volunteer. An electrode jell should be applied to each electrode before placement;
   a. The ground is placed on the dorsum of the hand where the muscle will be tested.
   b. The recording electrode is placed on belly of the APB "midbelly".
   c. The reference electrode is placed approximately 2-3 cm away from the recording and on a bony prominence.
3. Once the electrodes are in place, start recording;
   a. At the beginning, ask the subject to relax (not to contract the muscle), and record the muscle electrical activity during this period.
   b. Then, ask the subject to exert mild to moderate voluntary effort while you continue recording.
   c. Finally, ask the subject to do maximum contraction of the muscle and record the electrical activity during this period.

Indications for EMG:

EMG is a major diagnostic tool for identifying and characterizing disorders of the motor unit, including anterior horn cells, peripheral nerves, neuromuscular junctions, and muscles.

Along with NCS, EMG can help;

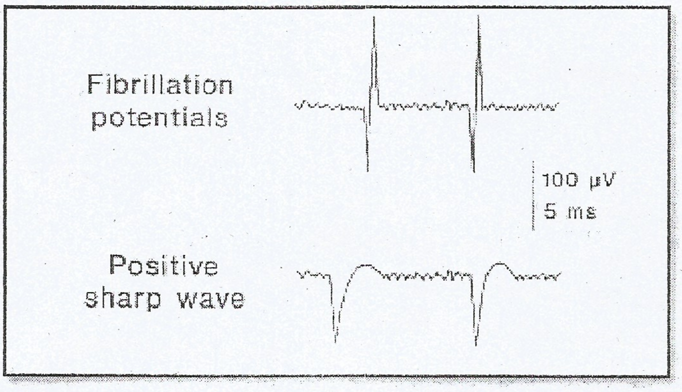
- Confirm a diagnosis.
- Grade the severity of the disease.
- Define evolution, stage, and prognosis.

EMG Abnormalities:

Abnormalities in EMG can be seen in any part of the study i.e. at rest and during muscle contraction.

At rest, a normal muscle is electrically silent. Any spontaneous electrical activity seen during this period should be considered abnormal. There are many kinds of abnormal spontaneous electrical activities, e.g.

- Positive sharp waves.
- Fibrillation.
- Fasciculation.



During muscle contraction, abnormalities can be seen in the MUPs as well as the recruitment;

- MUPs:
  - Abnormal duration: too long or too short.
  - Abnormal amplitude: too high or too low.

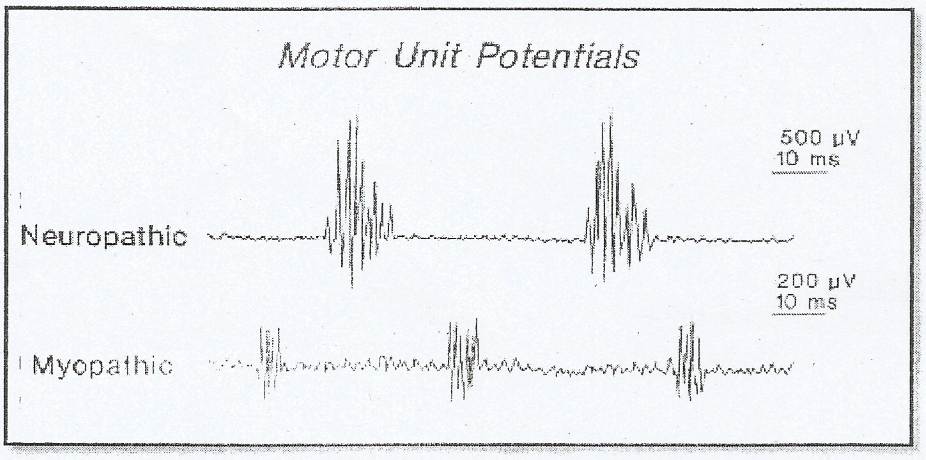


Figure 5. Different abnormal patterns of MUPs. Neuropathic MUPs are polyphasic, have a long duration, and of a high amplitude (giant MUPs). Myopathic MUPs are polyphasic, have a short duration, and a low amplitude.

- Recruitment:
    - Rapid recruitment.
    - Reduced recruitment.

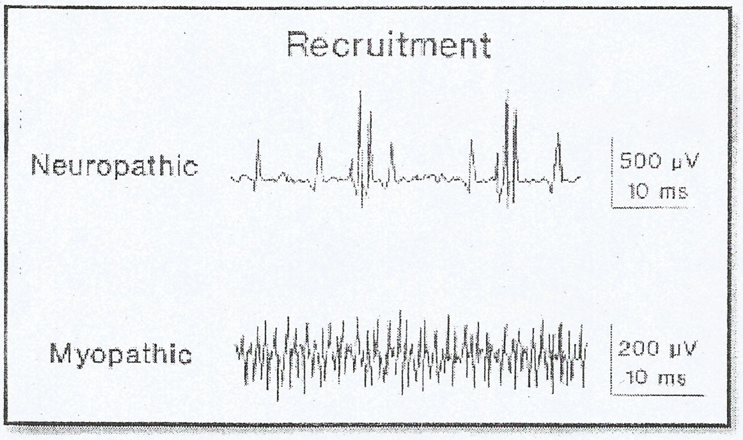


Figure 6. Different patterns of abnormal recruitment. In neuropathy there is reduced recruitment. Where as myopathy shows full interference (rapid recruitment) but with a low amplitude.

Table 2. Abnormal EMG potentials.

Finding	Characteristics	Causes
Resting activity		
Fibrillation potentials	Are the action potentials of single muscle fibers that are twitching spontaneously in the absence of innervation. They typically have a slow, regular firing patter, which is like the "ticking of a clock"	Neuropathy, myopathy
Positive sharp waves	Positive sharp potentials with a fast downstroke and slower return to baseline	Neuropathy, myopathy
Fasciculation potentials	Are randomly discharging action potentials of a group of muscle fibers innervated by an anterior horn cell. The random occurance sounds like "large raindrops on a roof".	Neuropathy, motoneuron disease. Normal in some patients.
Motor Unit Potentials (MUPs)		
Neuropathic motor unit potentials	Polyphasic potentials which are of long duration and usually high amplitude.	Neuropathy, neuronal degeneration
Myopathic motor unit potentials	Polyphasic potentials which are short duration and small.	Myopathy
Recruitment		
Reduced recruitment	Rapid discharge of a few motor units which often have a polyphasic appearance.	Denervation
Rapid recruitment	Many small motor units recruited at a low degree of tension.	Myopathy

Study Questions:

1. What is meant by "the motor unit"?

2. What is meant by "motor unit potentials (MUPs)"?

3. What will a normal recording of a muscle show in each of the following states;

   - Rest:
   - Mild muscle contraction:
   - Maximal muscle contraction:

4. The following is an EMG recording of a denervated muscle. What are the characteristic findings that do you see in this EMG study.

5. The following is an EMG recording of a myopathic muscle. What are the characteristic findings that do you see in this EMG study.

NERVE CONDUCTION STUDIES:

A Nerve conduction study (NCS) is a test used to evaluate the function of peripheral nerves. It involves the study and measurement of conduction velocity and response latency of peripheral nerves. Motor and sensory nerve conductions are studied separately and require different techniques.

The most common nerves tested in the upper limb are the median, ulnar, and radial nerves. During the student Physiology lab only motor NCS will be performed.

Principle:

Motor NCS are performed by electrical stimulation of a peripheral nerve and recording from a muscle supplied by this nerve. A nerve potential is initiated at the stimulation electrode and is conducted along the nerve fibers to the muscle. When the muscle contracts, the compound muscle action potential is recorded and observed on the display screen. The ***latency*** of the response (the time it takes for the impulse to travel from the stimulating to the recording site) is measured in milliseconds (ms). The size of the response (the *amplitude*) is also noted. The motor amplitudes are measured in millivolts (mV).

This is repeated by stimulating the motor nerve at a second site along its path. The distance between the two stimulation points is measured and the difference in latency times determined. By dividing the distance between stimulation points by the difference in latency times, the motor nerve conduction velocity can be calculated.

Conduction velocities are used to diagnose and monitor diseases that affect the peripheral nerves. Most neuropathies produce a slowing of conduction velocity, which is particularly apparent in demyelinating diseases. Other causes of slowing of conduction velocity include nerve compression or entrapment.

Nerve conduction velocity can be affected by; nerve temperature, age, nerve diameter, and whether the nerve is myelinated or nonmyelinated.

Procedure:

The MNCV will be measured for the median nerve.

1. Select a volunteer and explain the procedure to him/her.
2. Clean the area of the skin where the electrodes will be placed to improve skin conductivity.
3. Surface electrodes are used for MCNS and are placed as follows;
   a. The recording electrodes are placed on the muscle supplied by the nerve under study (the APB for the median nerve) so that the cathode or negative (active) electrode is placed over the belly of the muscle, while the anode or positive (reference) electrode is placed over the distal tendon.
   b. The grounding electrode should be placed between stimulating and recording electrode, preferably, over bone rather than muscle.

c. The stimulating electrodes are placed between the flexor carpii radialis tendon and the Palmaris longus tendon with the cathode electrode placed distally to the anode. This will stimulate the median nerve at the wrist. A recording of the compound muscle action potential (CMAP) is obtained and the latency is noted.

d. The median nerve is then stimulated at the elbow medial to the biceps tendon and over the pulse of the brachial artery (antecubital fossa). A recording of the CMAP is obtained and the latency is noted.

e. The distance between the two stimulating electrodes is measured. And the median nerve conduction velocity is calculated using the following formula;

$$MNCV = \frac{Distance\ (mm)}{L1 - L2\ \ (msec)}$$

MNCV= Motor nerve conduction velocity (m/sec)
Distance= distance between the two stimulating electrodes.
L1= latency at elbow.
L2=latency at wrist.

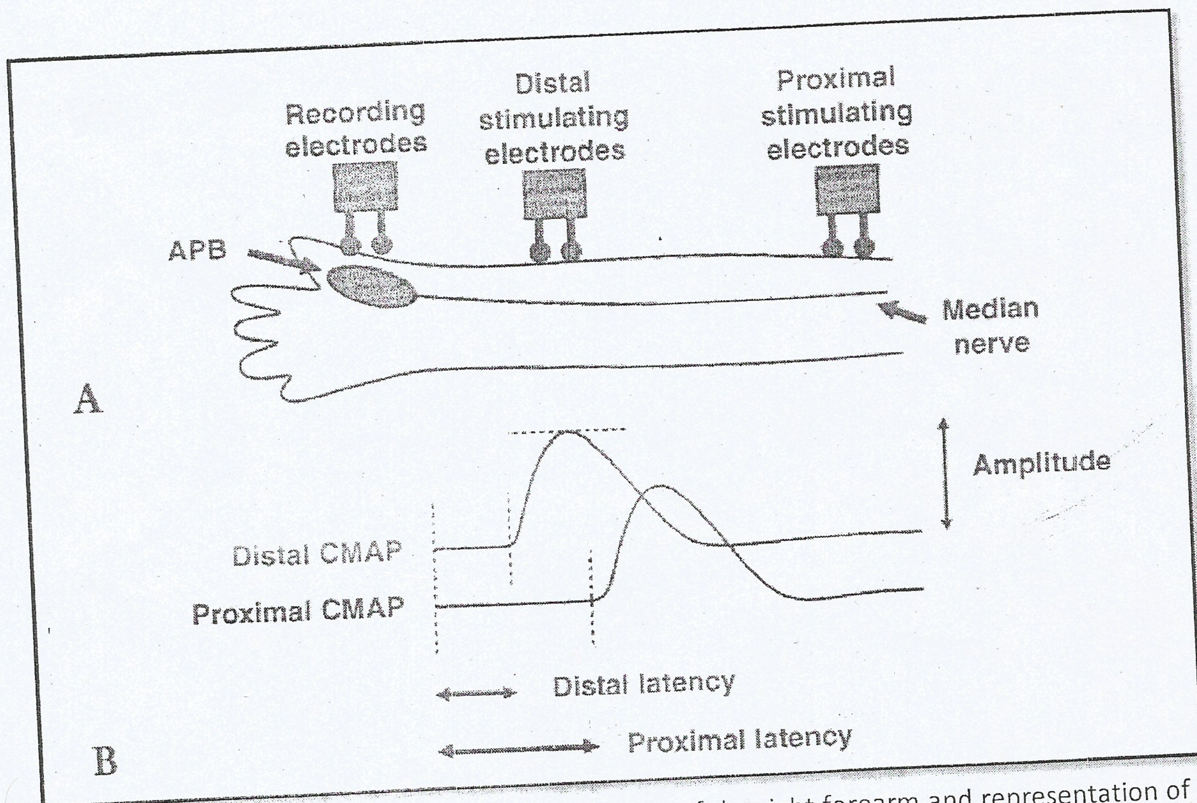


Figure 7: Motor nerve conduction study. A: Diagram of the right forearm and representation of the electrode positions for median nerve conduction study. B: Sample recording of median motor compound motor action potentials (CMAPs).

Study Questions:

1. What is the importance of NCS in clinical practice?

2. How can the conduction velocity of the Ulnar nerve be calculated?

3. In general, what is the normal motor nerve conduction velocity in the upper limb?

4. What is meant by a slow conduction velocity in the median nerve? Name a few causes of such an abnormality?

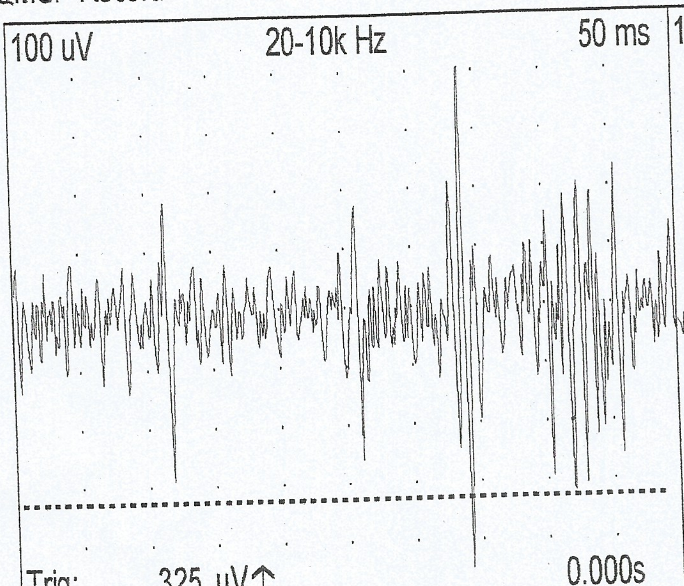
Alnare nerve

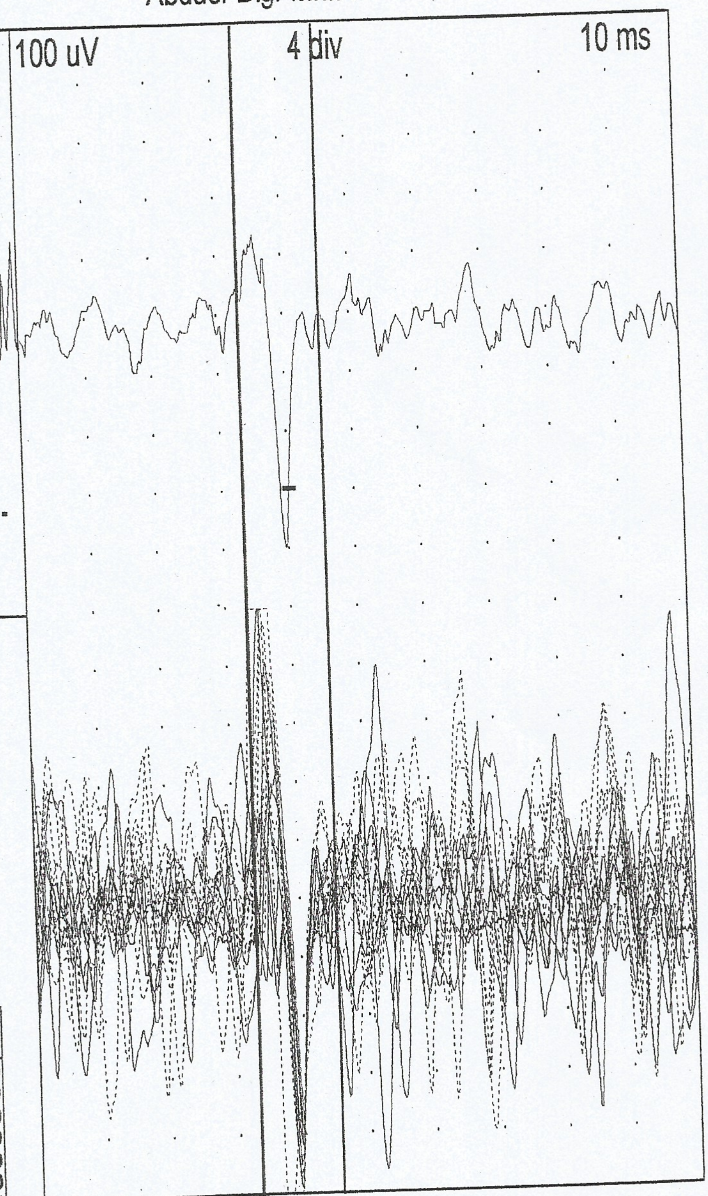
EMG

FILE ID: ANONYMOUS 6.4.0e 27 Sep 10 10:43

Nicolet VikingQuest Nicolet Biomedical

QMUP Record #47 mujeeb C-8, T-Q Abduc. Dig. Mn.R 10:43:05





Switch: Collect / **Analyze**

- Fibrillation
- Pos. Waves
- Fascics.
- Polyphasics
- MUP Amp uV
- MUP Dur ms
- Max Amp mV
- MUP Pattern
- Max Effort

Polyphasic: 0 of 3 (0.0%)

QMUP Data	Mu 3	All MUPs Mean	All MUPs SD	NonPolyph. Mean	NonPolyph. SD
Duration ms	12.2	12.2	0.0	12.2	0.0
Amplitude uV	539	539	0	539	0
Phases	2	2.0	0.0	2.0	0.0
Spike Dur ms	10.8	10.8	0.0	10.8	0.0
Risetime ms	1.9	1.9	0.0	1.9	0.0
Area uVms	1320	1320	0	1320	0
Size Index	1.91	1.91	0.00	1.91	0.00

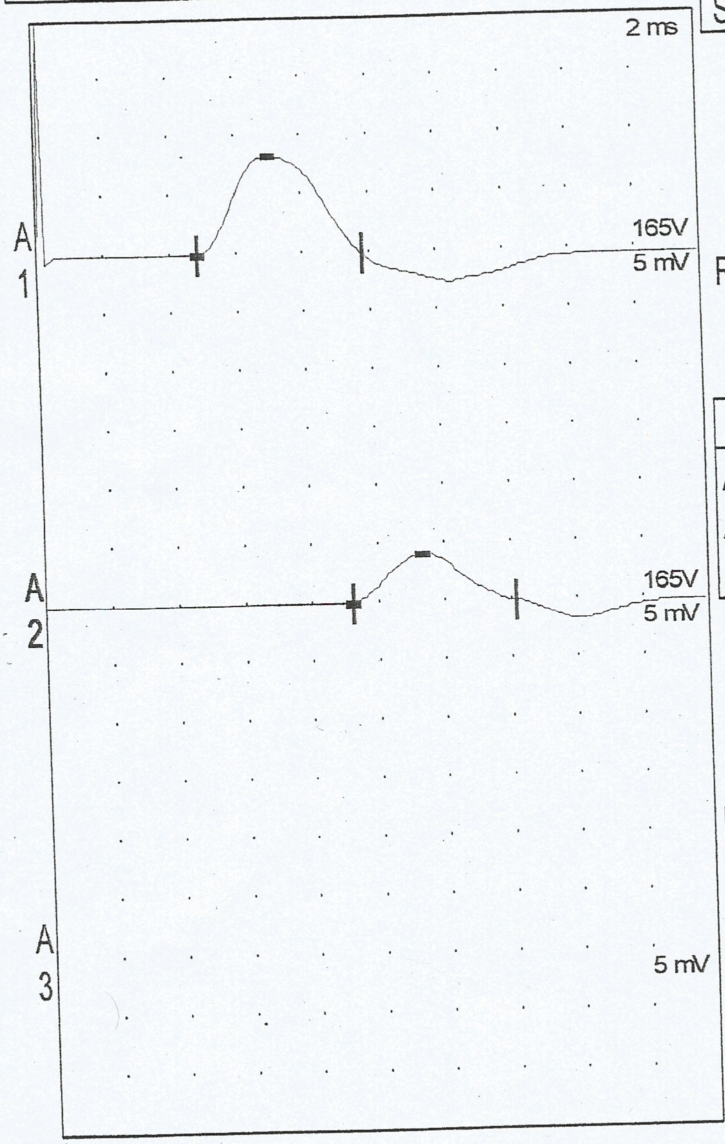
FILE ID: ANONYMOUS   6.4.0e   27 Sep 10 12:34

Nicolet VikingQuest   Nicolet Biomedical

MNC Record   #65 mujeeb   Median nerve.L   12:34:47

Switch: N-R	Rate:Non-Recurrent	Level: 165 V	Dur: 0.1 ms	Single
			Step: 2	Average: Off

6.1.0



Recording Site : APB

Stimulus Site	Lat1 ms	Dur ms	Amp mV	Area mVms
A1: Wrist	4.8 +3.9	4.9	8.3 +1.3	23.5
A2: Elbow	9.2 +2.6	4.9	4.2 -1.1	10.5
A3: Axilla				

Segment	Dist mm	Diff ms	CV m/s
Wrist-Elbow	250	4.4	57 -0.2
Elbow-Axilla			

CHARACTERISTIC ELECTROMYOGRAPHIC WAVEFORMS

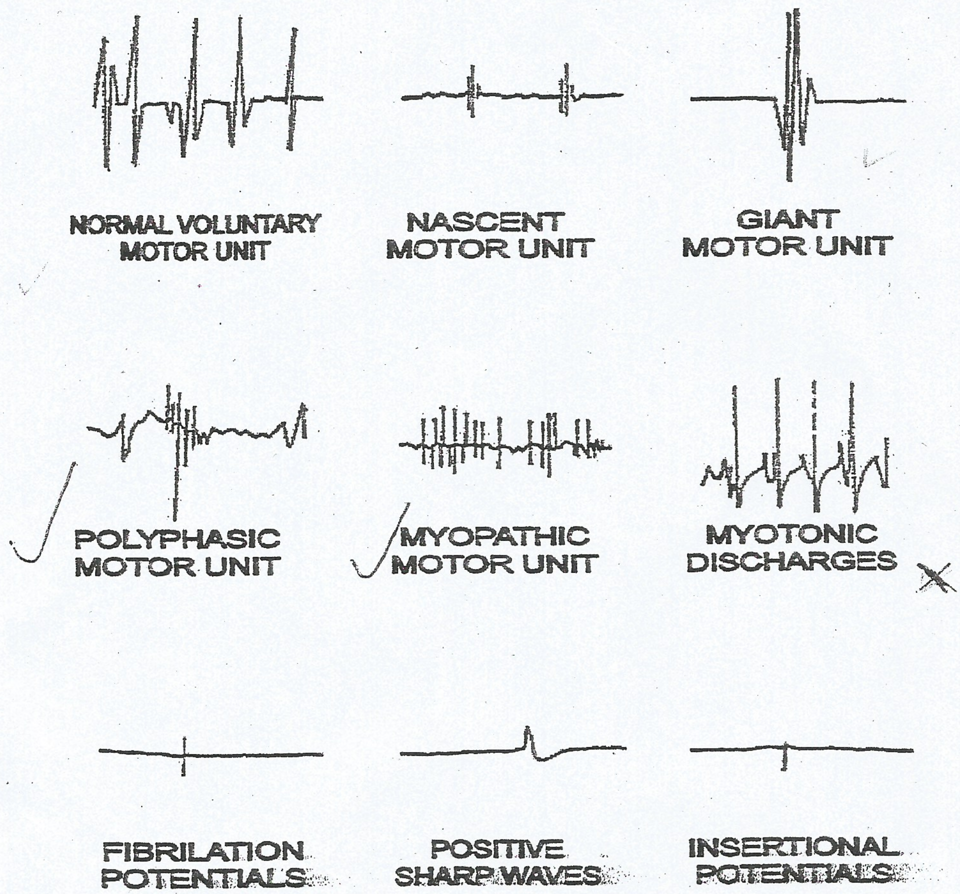


Figure - 3

Hearing Tests and Pure Tone Audiometry

Objectives:

At the end of the session, the students should be able to:

- Determine the type, degree, and configuration of hearing loss.
- Describe the techniques of Tuning Fork tests.
- Plot the frequency-intensity recording and construct the audiograms.
- Interpret the audiograms.

Some Important Terminology Related To This Practical

Air conduction

This test assesses the transmission of sound waves through air to the auditory cortex via auditory nerve involving outer, middle and inner ears. The sound is amplified 22 times when it is transmitted through air conduction by the tympanic membrane (17 times) and the ossicles (1.3 times). That is why, air conduction is always better than bone conduction in a normal person.

Bone conduction

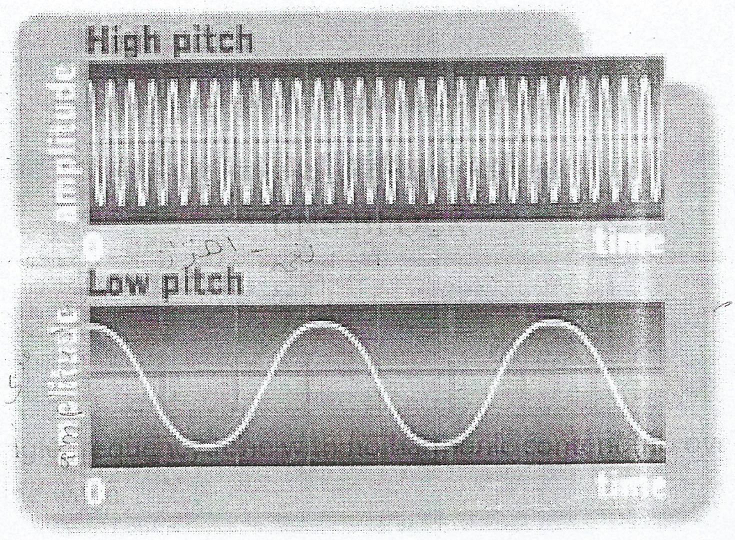
This test assesses the transmission of sound waves through the bones of the skull to the cochlea and then through the auditory pathways to the auditory cortex, bypassing the outer and middle ears.

Masking Sound

Masking sound is the sound present in the background that interferes with the sound that we want to listen. It is provided constantly to the right ear during the whole audiometry procedure if the left ear is tested so that whatever pure tone is given to the left ear is heard only by the left ear, because the right ear will be busy in listening to the masking sound. In the same way, the masking sound will be provided to the left ear, if the right ear is tested.

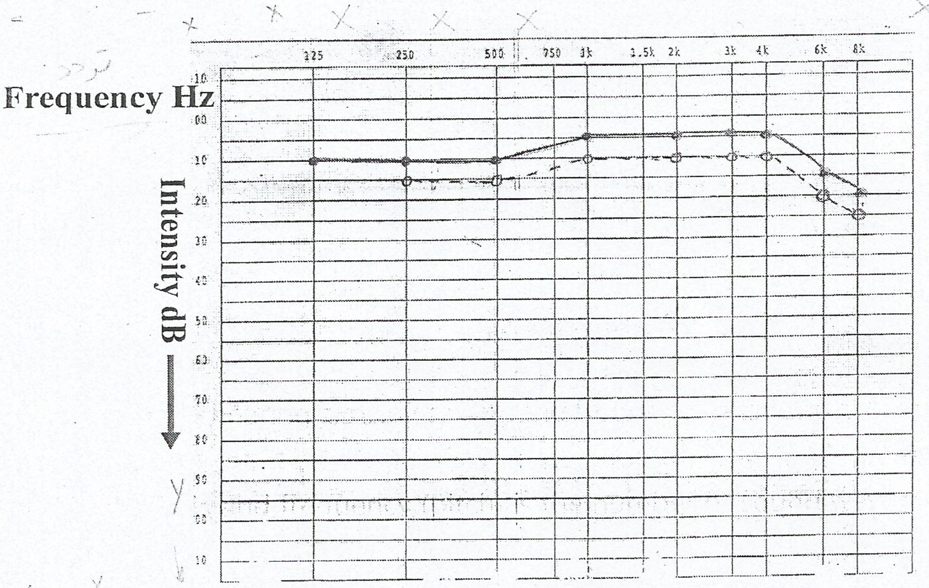
Pure tone

A **pure tone** is a single frequency tone with no harmonic content (no overtones). This corresponds to a sine wave.



Audiogram

An **audiogram** is a chart of hearing sensitivity with the frequency of sound plotted on the X- axis and the intensity of sound on the Y-axis. Intensity (loudness) is the level of sound power measured in decibels and frequency (pitch) is the number of sound waves per second measured in Hertz.



Pure tone Audiometry

Audiometry is the procedure by which the nature of hearing disabilities e. g. conductive or sensory neural deafness is determined. The instrument used is known as Audiometer which is simply an electronic oscillator capable of emitting pure tones of various frequencies through earphone to the subject.

The instrument is calibrated in such a way so that zero intensity (0 dB) level of sound at each frequency is the loudness that can be barely heard by the normal person.

The audiometer is also equipped with an electronic vibrator for testing bone conduction from the mastoid process to the cochlea.

When performing the test, one should test approximately 8 to 10 frequencies covering the auditory spectrum, one at a time and the hearing loss is determined for each of these frequencies. Then the air and bone conduction audiograms are plotted for interpretation.

Technique:

1] The subject is seated comfortably in a sound proof room.

2] Earphones are applied which are color coded (Red for right ear, Blue for left ear).

3] Masking sound is delivered to the non-test ear.

4] Pure tones are delivered to the test ear starting with a frequency of 125Hz. & intensity of 0 dB.

5] The intensity (dB) is gradually increased till the subject hears the sound & respond.

6] That intensity is marked on the audiogram paper and is termed as the hearing threshold.

7] The frequency is changed and the hearing threshold is determined for each frequency and is marked on the audiogram paper.

8] Marks are joined to produce a curve for air conduction.

9] Bone vibrator is placed over the mastoid process.

10] Pure tones are delivered through the bone vibrator & the hearing threshold is determined for different frequencies of sound and marked with a different sign on the audiogram paper.

11] Marks are joined to produce a curve for bone conduction.

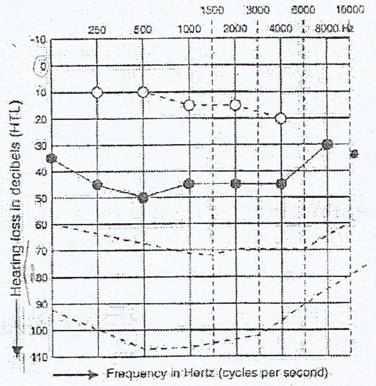
12] Whole procedure is repeated for the other ear.

DEGREES OF HEARING LOSS

Given below are the ranges of hearing thresholds for a given frequency of sound that determine the severity of hearing loss in a subject tested by audiometry:

DEGREE OF HEARING LOSS	RANGE OF HEARING THRESHOLD
Normal hearing	**0-25 dB**
Mild hearing loss	**26-40 dB**
Moderate hearing loss	**41-55 dB**
Moderate-severe hearing loss	**56-70 dB**
Severe hearing loss	**71-90 dB**
Profound hearing loss	**>90 dB**

ABNORMAL AUDIOGRAM



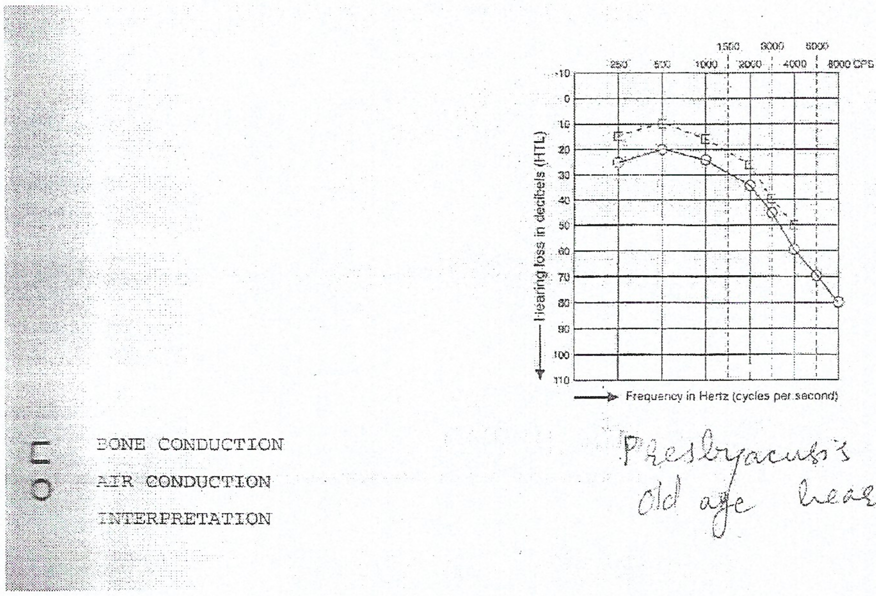
Conductive deafness
otosclerosis

○ BONE CONDUCTION

● AIR CONDUCTION

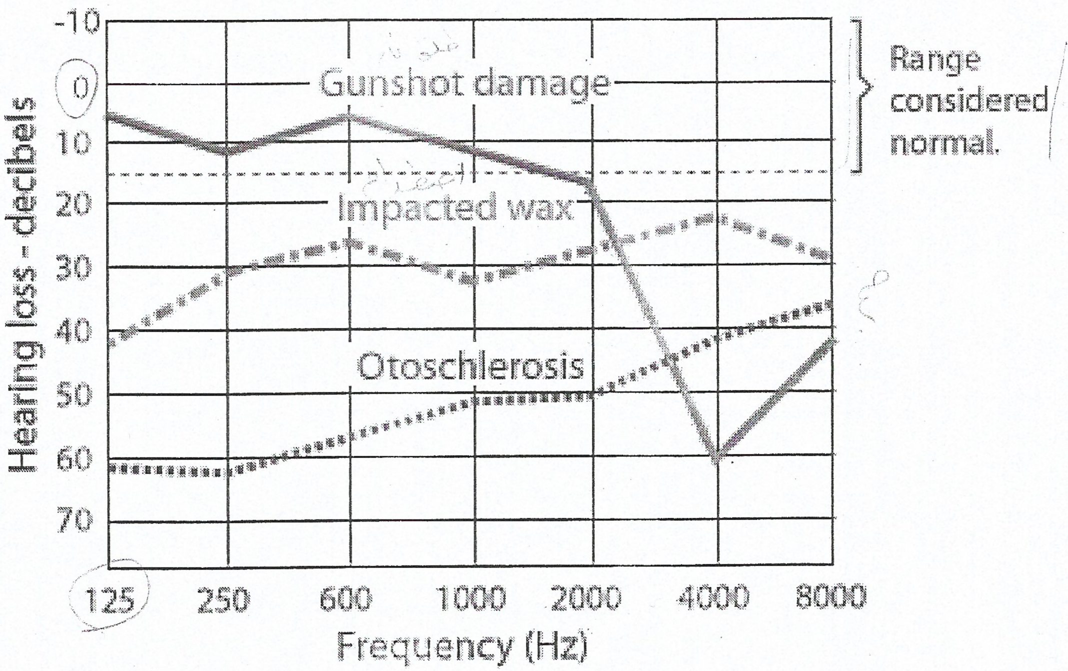
INTERPRETATION

The above audiogram is showing conductive deafness, caused by Otosclerosis.



Presbyacusis
Old age hearing loss

The above audiogram is showing sensorineural deafness at higher frequencies, and is commonly seen in old age and the condition is called Presbyacusis.



The above depicted diagrams of audiograms show various patterns of air conduction curves seen in different cases such as gunshot, impacted wax and otosclerosis.

In the Noise-induced hearing loss, the hearing threshold is affected in only one particular frequency; most likely 4000 Hz as shown in the above air conduction curve in a case of gunshot damage.

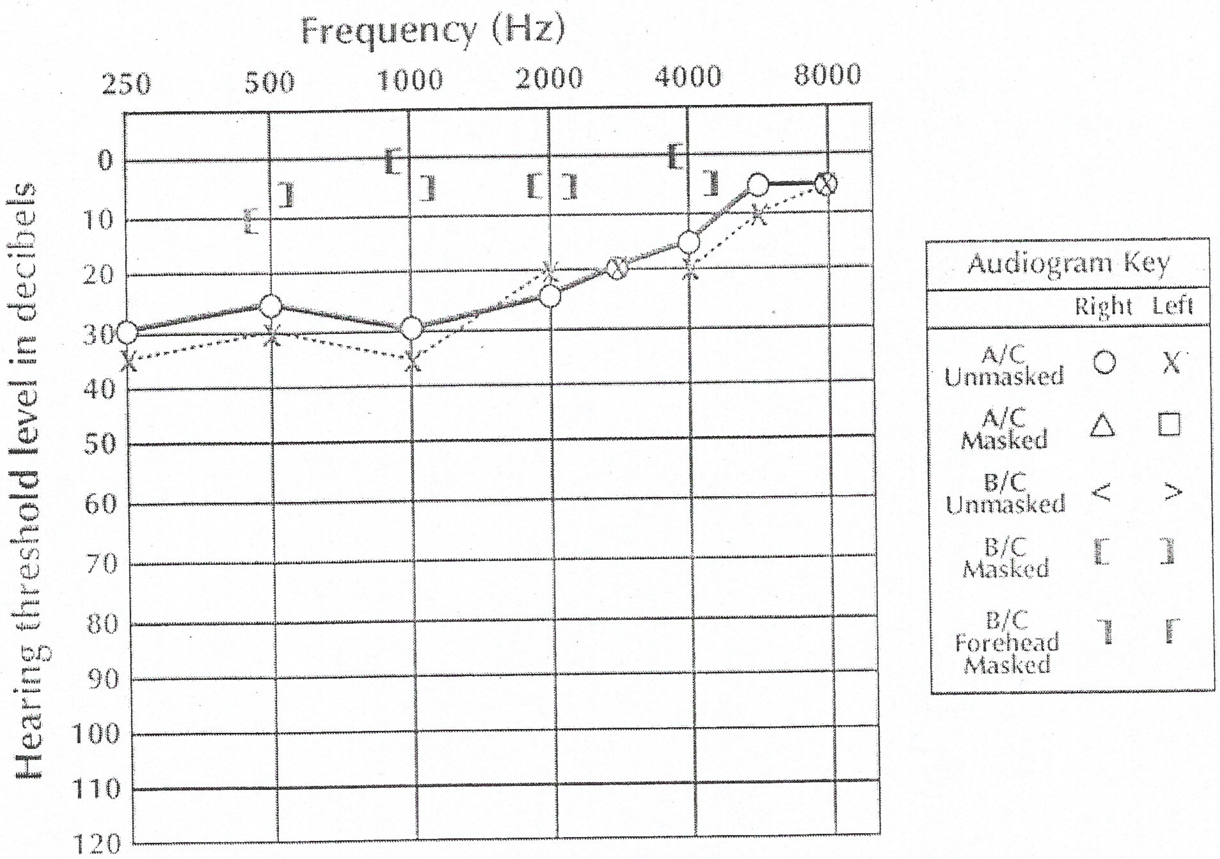
TYPES OF HEARING LOSS (DEAFNESS)

- Conductive hearing loss
- Sensorineural hearing loss
- Mixed hearing loss

Conductive Hearing loss (deafness)

Conductive deafness reduces the effective transmission of sound through air conduction, but it does not affect the bone-conduction because it bypasses the outer or middle ear and in the conductive deafness, the problem is either in the outer or in the middle ear. So bone conduction becomes better than air conduction due to the loss of amplification of sound in all cases of conductive deafness.

The causes of conductive deafness include wax in the ear canal, ruptured tympanic membrane, fluid in the middle ear system (otitis media), and fixation of the footplate of stapes to the oval window (Otosclerosis).



In the above audiogram, bone conduction is better than air conduction, so it is a case of Conductive deafness. Most likely cause of conductive deafness in this case is Otosclerosis, as we can see the two curves for air conduction and bone conduction are merging with each other at higher frequencies.

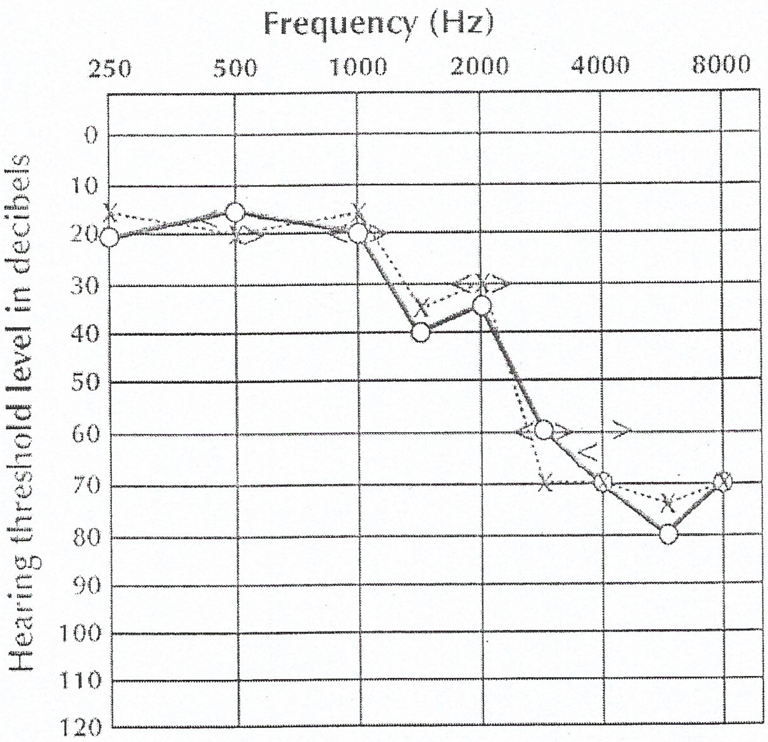
Sensorineural Hearing loss (deafness)

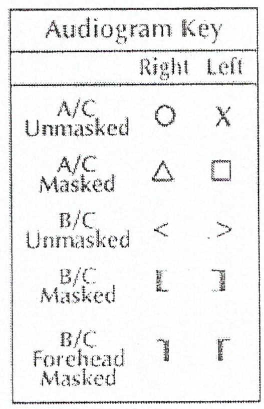
Sensorineural hearing loss occurs when there is damage to the inner ear (cochlea), or to the nerve pathways from the inner ear to the brain. Sensorineural hearing loss reduces the ability to hear faint sounds. Even when speech is loud enough to hear, it may be unclear or sound muffled. Air conduction is better than bone conduction but the difference between them is within 10 db in each frequency of sound. The hearing threshold should be more than 25 db in one frequency of sound at least.

Some possible causes of Sensorineural hearing loss include:

- Illnesses like labyrinthitis (inner ear infection) and Meniere's disease
- Drugs that are toxic to hearing

- Hearing loss that runs in the family (genetic or hereditary)
- Aging
- Head trauma
- Malformation of the inner ear
- Exposure to loud noise



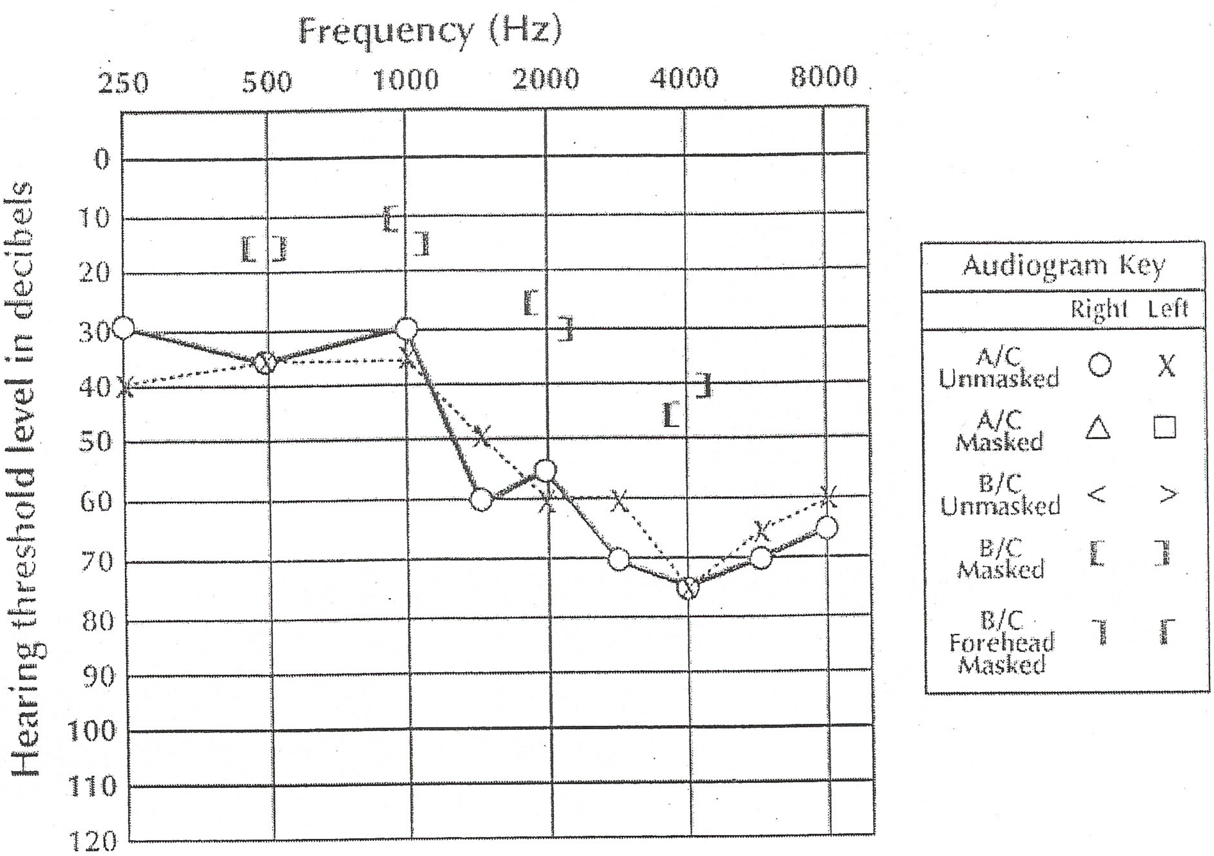


In the above audiogram, air conduction is better than bone conduction and the hearing threshold is more than 25 db at higher frequencies, so it is a case of sensorineural deafness at higher frequencies or **Presbycusis** due to old age.

Mixed Hearing loss

Sometimes a conductive hearing loss occurs in combination with a sensorineural hearing loss . In other words, there may be damage in the outer or middle ear and in the inner ear (cochlea) or auditory nerve. When this occurs, the hearing loss is referred to as a **mixed hearing loss.**

In these cases, bone conduction is better than air conduction and the difference between them is more than 10 db and the hearing thresholds for air conduction in most of the frequencies is more than 25 db.



In the above audiogram, bone conduction is better than air conduction and the difference between them is more than 10 db in all frequencies and also the hearing threshold for air conduction in most of the frequencies is more than 25 db, so it is a clear case of mixed hearing loss.

COMMON AUDITORY DISORDERS

- **Presbyacusis** is defined as a progressive bilateral symmetrical age-related sensorineural hearing loss. The hearing loss is most marked at higher frequencies.
- **Otitis media** is an inflammation of the middle ear, usually caused by bacteria, that occurs when fluid builds up behind the eardrum in the middle ear cavity.
- **Noise-induced hearing loss** is usually caused by exposure to excessively loud sounds. Noise-induced hearing loss can result from a one-time exposure to a very loud sound, blast, or impulse, or from listening to loud sounds over an extended period of time. It can be conductive deafness if only ear drum is ruptured by loud sound, or it may be sensorineural deafness if only cochlea is damaged by the loud sound, or it may be mixed hearing loss if both the tympanic membrane and the cochlea are damaged by the loud sound.
- **Otosclerosis** is a hereditary condition in which the hearing loss occurs slowly, over time. It is caused by the growth of the fibrous tissue over the margin of footplate of stapes (3rd Ossicle) that fixes it with the margin of the oval window, immobilizing the ossicles and causing conductive deafness.
- **Ménière disease** is an inner ear disorder that affects balance and hearing. It is characterized by episodes of vertigo and tinnitus and progressive hearing loss, usually in one ear. It is thought to be caused by increased pressure of endolymph within the inner ear cavity.

TUNING FORK TESTS

The Rinne's Test:

This test compares the air conduction with the bone conduction.

Technique

1] Strike a 512 Hz tuning fork softly on the palm to produce vibration.

2] Place the vibrating tuning fork on the base of the mastoid bone.

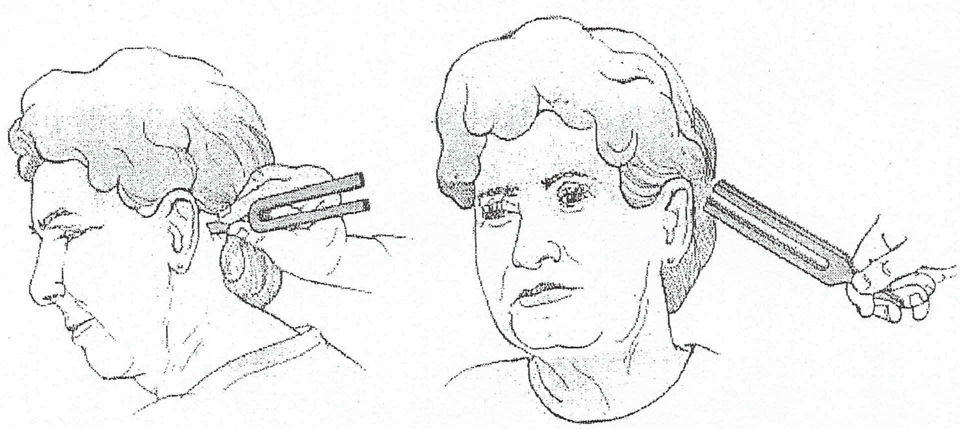
3] Ask the subject to tell you when the sound is no longer heard.

4] Immediately bring the tuning fork just in front of the ear.

5] Ask the subject to tell you whether he still hears it or not.

Interpretation:

- Normal subjects will hear sound through air conduction twice as long as bone conduction. They will still hear it in front of the ear when they can't hear anymore from the base of the mastoid bone.
- With conductive deafness, bone conduction will be better than air conduction. In this case, when the subject stops hearing sound from the mastoid bone and brings the tuning fork in front of the ear, he will not hear any sound there too.
- With sensorineural deafness, the sound through air conduction is heard longer than bone conduction in affected ear, but less than twice longer as is the case in normal subjects.



The Weber's Test:

This test distinguishes between conductive and sensorineural deafness.

Technique:

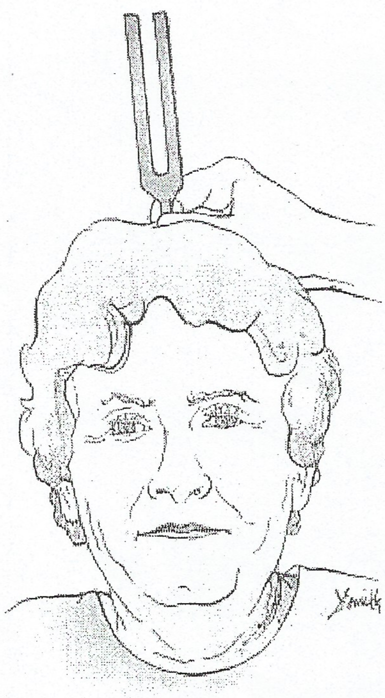
1] Strike a 512 Hz tuning fork softly on the palm to produce vibration.

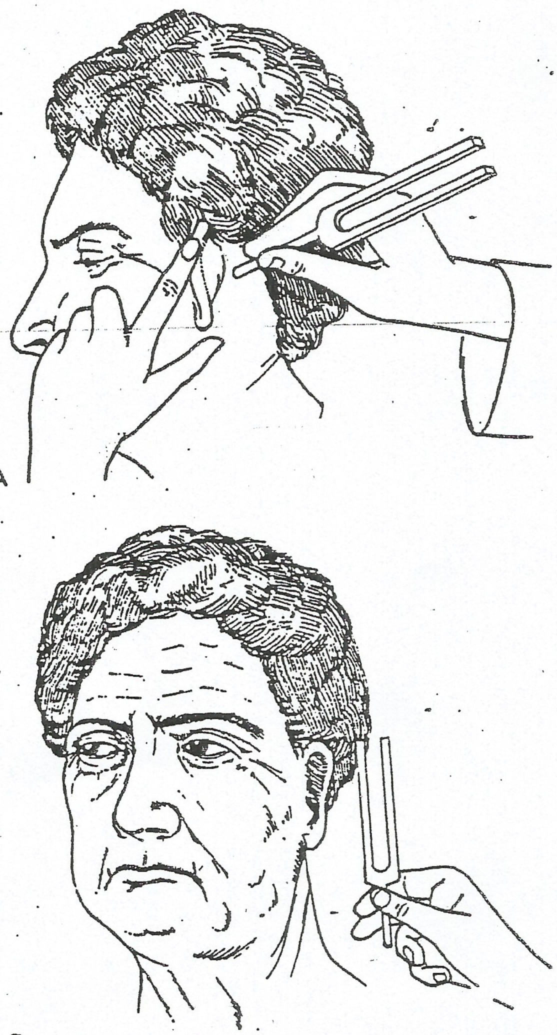
2] Place the vibrating tuning fork on the vertex of the subject.

3] Ask the subject if the sound is heard better in one ear or the same in both ears.

Interpretation:

- If the hearing is normal, the sound is heard equally in both ears.
- The sound is heard better in the affected or diseased ear in a subject with conductive deafness because of the loss of masking effect of the environment and all the receptors for hearing in the affected ear are free to hear the sound.
- The sound is obviously heard better in the normal ear than the affected ear in a subject with sensorineural deafness because the cochlea and the neural pathway is intact on the normal side.

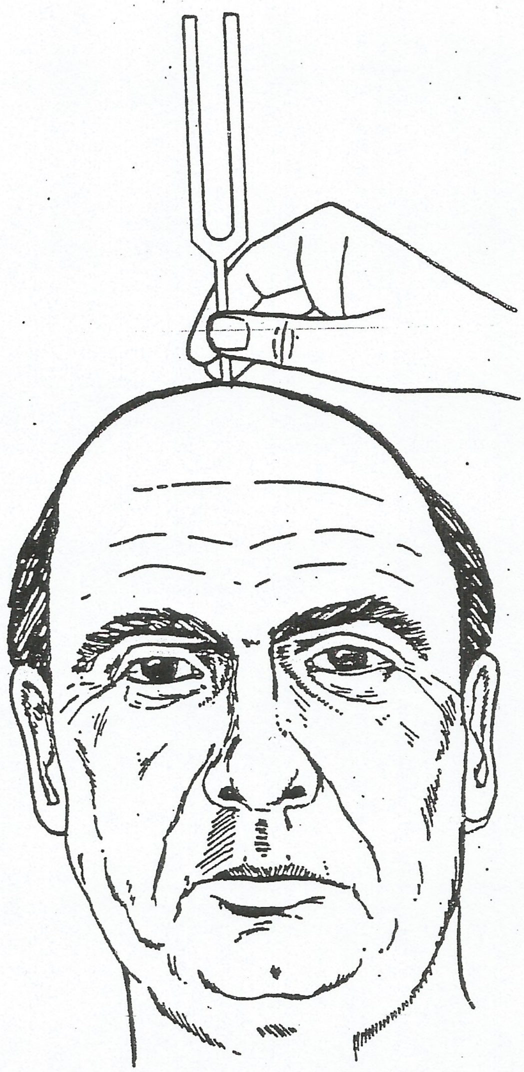




A

B

Rinne's test. (A) Bone conduction. (B) Air conduction.



Weber's test.

Common tests with a tuning fork to dintinguish between nerve and conduction deafness.

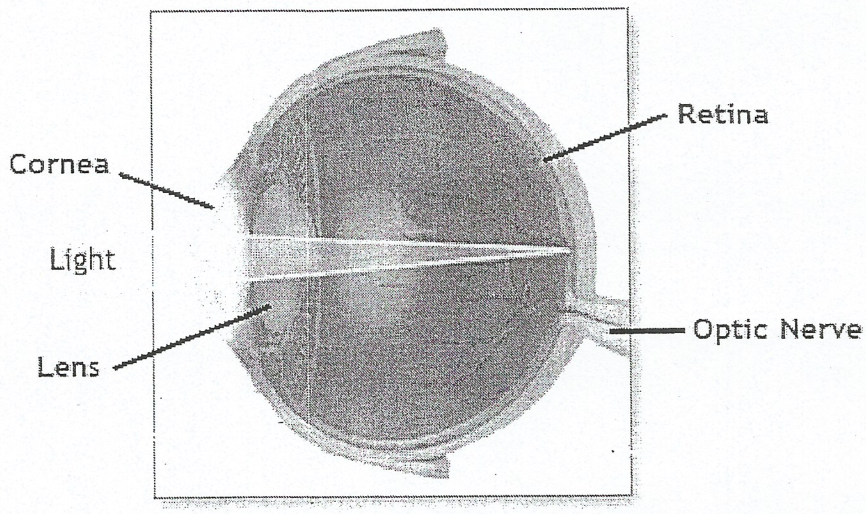
	Weber	Rinne
Method	Base of vibrating tuning fork placed on vertex of skull.	Base of vibrating tuning fork placed on mastoid process until subject no longer hears it, then held in air next to ear.
Normal	Hears equally on both sides.	Hears vibration in air after bone conduction is over.
Conduction deafness (one ear)	Sound louder in diseased ear because masking effect of environmental noise is absent on diseased side.	Vibrations in air not heard after bone conduction is over.
Nerve deafness (one ear)	Sound louder in normal ear.	Vibration heard in air after bone conduction is over, as long as nerve deafness is partial.

VISUAL ACUITY

Visual Acuity is defined as the shortest distance by which two lines can be separated and still perceived as two lines.

It depends on the refractive ability of the refractive media (Cornea and lens) of the eye and the density of the photoreceptors. Refractive ability refers to the ability of the eyes to bend parallel rays of light coming from infinity to focus on the retina.

The fovea centralis is the place of greatest visual acuity during the daylight and the mid-peripheral portion of the retina is the place of greatest visual acuity in the dim light.



Normal Vision - Images focus on the Retina

TEST FOR FAR VISION

Equipment:

Snellen's Chart

Procedure:

- Ask the subject to stand about 6-meter (20-feet) away from the Snellen's chart. This distance is referred to as "d".
- Remove eye glasses if any.
- Cover one of his eyes with an eye patch.
- Ask him to read the chart from the other eye and find out the smallest letters he could read.
- Note the distance written below the last line he is able to read fully. This distance is referred to as "D".
- Repeat the same procedure for the other eye.

Interpretation:

$$\text{Visual Acuity (VA)} = \frac{d}{D}$$

Where,

d = the distance from where the subject is reading the chart

D = the distance from which a normal subject can read that line.

Suppose the smallest letter that can be read by the subject is in the line below which the distance is mentioned "9 meter", then the Visual Acuity of that eye is:

$$\text{Visual Acuity (VA)} = \frac{6}{9}$$

It means that the subject is able to read from 6 meters only which a normal person can read from 9 meters, so his visual acuity for the far vision is disturbed. Normal Visual Acuity for far vision is 6/6 (in meters) or 20/20 (in feet).

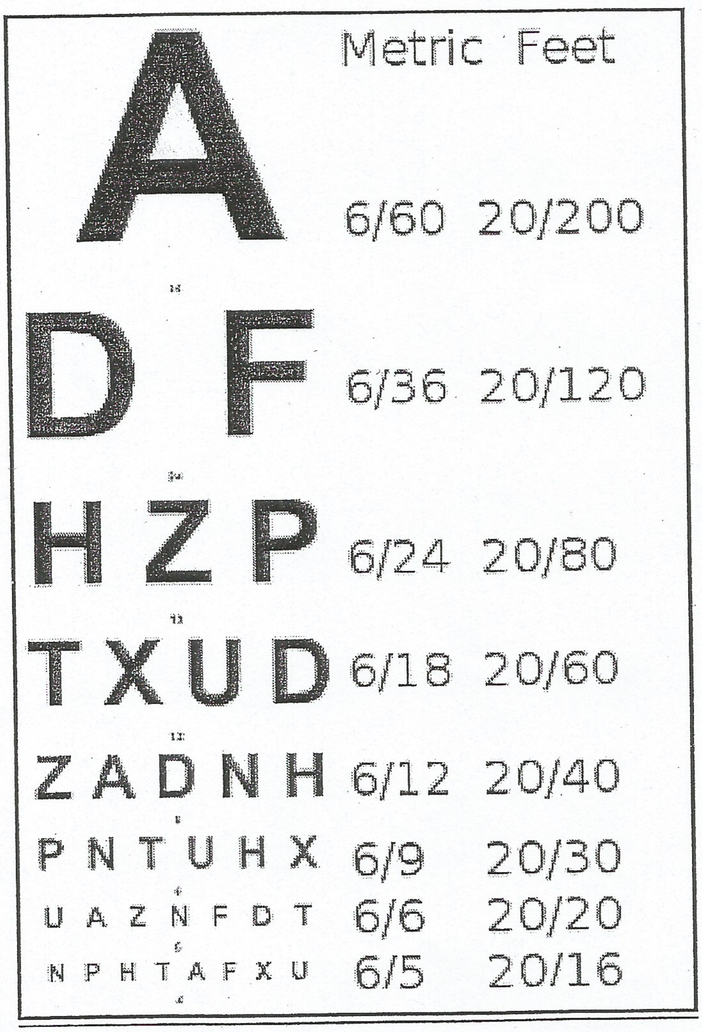
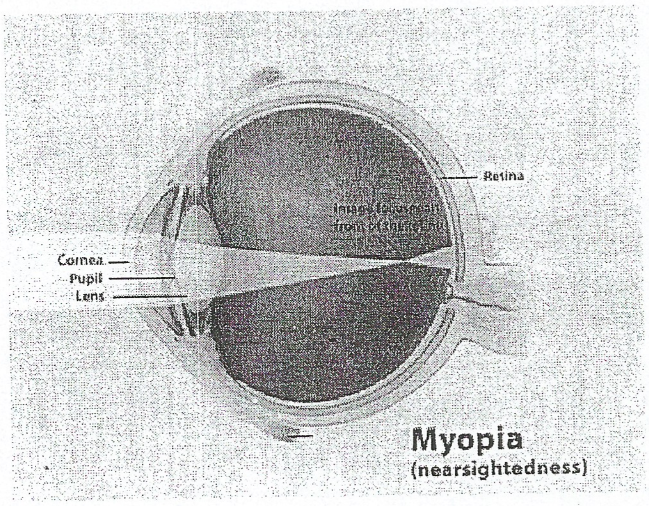


DIAGRAM OF SNELLEN'S CHART

REFRACTIVE ERRORS:

MYOPIA:

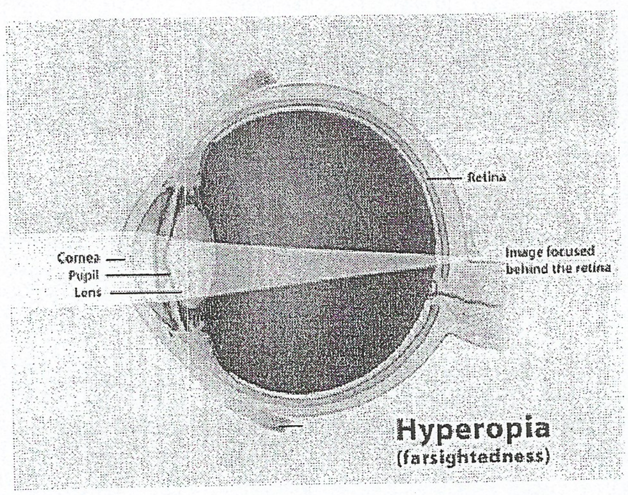
Myopia is a refractive error in which close objects are seen clearly, but the far objects appear blurred, that is why this condition is also called ***nearsightedness***. It occurs if the eyeball is too long or the cornea has too much curvature. As a result, the light entering the eye from a distant object isn't focused exactly on the retina but focuses in front of it, so that distant object looks blurred. This refractive error can be corrected by applying ***concave (minus) lenses*** in front of the eyes or performing surgery to flatten cornea that will decrease the refractive ability of the cornea and the light rays from a far object will focus on the retina.



Myopia
(nearsightedness)

HYPERMETROPIA / HYPEROPIA:

If the eyeball is smaller or the lens is weak, the image from a near object is focused behind the retina, making the object look blurred. In these cases near vision is affected and the distance vision remains intact, so this refractive error is known as ***farsightedness*** or in medical terms, hypermetropia. These patients need ***convex (plus) lenses*** in front of eye so that the light rays entering the eyes from any near object will focus exactly on the retina and the near objects can be seen clearly then.



Hyperopia
(farsightedness)

TEST FOR NEAR VISION

The near vision test is measuring your ability to read and see objects within an arm's distance from the body. This test is important if you have hypermetropia or presbyopia.

Most clinics record the near vision as a Snellen fraction (distance equivalent) or as a Jaeger notation such as J1, found on the side of reading cards adjacent to the line of print. In performing the near visual acuity assessment it is of great importance to note at what distance the chart is to be held from the patient. Some charts are calibrated for 12, 14, or 16 inch testing distances. Patients should be wearing their corrective lenses even if they are for distance viewing. If the patient wears specific reading glasses, they should be worn rather than the distance glasses.

Equipment:

Jaeger's Chart

Procedure:

- Ask the subject to hold a Jaeger's chart at a distance of 14 inches (36 cm) from his eyes.
- Keep wearing eye glasses if any.
- Cover one of his eyes with an eye patch.
- Ask him to read from the largest line to the smallest line that he can read easily or ask him to recognize the smallest size of the picture drawn in the chart and take note.
- Repeat the same procedure for the other eye.

Interpretation:

The Jaeger type scale ranges from J1+ to J16 with J1+ being the smallest type. J1+ is considered the equivalent of 20/20 distance visual acuity at the reading distance indicated on the card (14 inches from your eyes), so a person with normal near vision should be able to read upto this line.

Suppose that the subject can read or recognize the picture up to the line marked J3, it means that he can read or recognize at 36 cm distance from his eye which can be read or recognized by a normal subject at 72 cm.

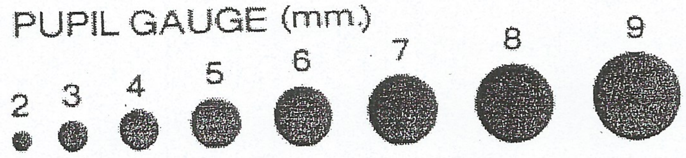
ROSENBAUM POCKET VISION SCREENER

	Point	Jaeger	distance equivalent
9 5			20/800
8 7 4			20/400
2 8 4 3	26	16	20/200
6 3 8 E Ш Ǝ X O O	14	10	20/100
8 7 4 5 Ǝ m Ш O X O	10	7	20/70
6 3 9 2 5 m E Ǝ X O X	8	5	20/50
4 2 8 3 6 5 Ш E m O X O	6	3	20/40
3 7 4 2 5 8 Ǝ Ш Ǝ X X O	5	2	20/30
9 3 7 8 2 6 Ш m E X O O	4	1	20/25
[illegible]	3	1+	20/20

Card is held in good light 14 inches from eye. Record vision for each eye separately with and without glasses. Presbyopic patients should read thru bifocal segment. Check myopes with glasses only.

DESIGN COURTESY J. G. ROSENBAUM, M.D

PUPIL GAUGE (mm.)



Source: Fauci AS, Kasper DL, Braunwald E, Hauser SL, Longo DL, Jameson JL, Loscalzo J: *Harrison's Principles of Internal Medicine*, 17th Edition: http://www.accessmedicine.com

TEST FOR ASTIGMATISM

Astigmatism is a type of refractive error that causes blurred vision mainly due to the irregular shape of the cornea and sometimes uneven curvature of the lens inside the eye can also cause Astigmatism. An irregular shaped cornea or lens prevents light from focusing properly on the retina. Astigmatism frequently occurs with other vision conditions like nearsightedness (Myopia) and farsightedness (Hypermetropia). Slight amounts of astigmatism usually don't affect vision and don't require treatment. However, larger amounts of astigmatism cause distorted or blurred vision, eye discomfort and headaches and need to be treated by adding ***cylindrical lenses*** in eyeglasses that will correct the astigmatism by altering the way light enters your eyes.

Equipment:

Astigmatism Chart

Procedure:

- Ask the subject to stand at a 6-meter (20-feet) distance from an Astigmatism chart.
- Remove eye glasses if any.
- Cover one of his eyes with an eye patch.
- Ask him to see the chart from the other eye. This chart consists of a number of dark lines radiating from a central point, like spokes of a bicycle wheel. If astigmatism is present, some of the spokes will appear sharp and dark, whereas the others will appear blurred and lighter because they come to focus either in front of or behind the retina when they pass through uneven curvature of the cornea.
- Repeat the same procedure for the other eye.

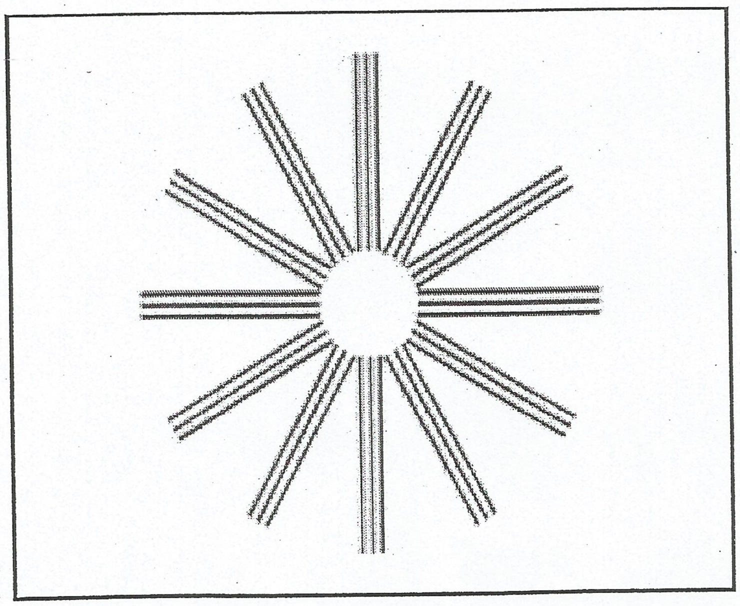


DIAGRAM OF ASTIGMATISM CHART

DEMONSTRATION OF BLIND SPOT

A blind spot, also known as a scotoma, is the place in the visual field where an object cannot be seen keeping one eye closed. This is due to the light rays from that part of the visual field focus on the optic disc of the retina which lacks the light-detecting photoreceptor cells. The optic disc of the retina is located medial to fovea centralis and is the part of retina through which the optic nerve and blood vessels pass. Since there are no photoreceptors to detect light on the optic disc, a part of the field of vision is not perceived. The brain fills in the blind spot with surrounding detail and there is also information from the other eye, so the blind spot is not normally perceived when both eyes are open.

Equipment:

Blind Spot Card

Procedure:

- Hold the blind spot card in your right hand and bring it in front of your face about 20 inches away from your right eye.
- Close your left eye.
- Focus on the "plus" sign which can be easily done if the "plus" sign is positioned in line with your right eye.
- Keeping your right eye focused on the "plus" sign, gradually bring the blind spot card closer to your face until the "circle" drawn on the blind spot card disappears. This is the blind spot of your right eye. If you move the blind spot card further close to your right eye, the circle will reappear.
- Repeat the same procedure for the left eye, but this time you will focus on the circle and the plus sign will disappear.

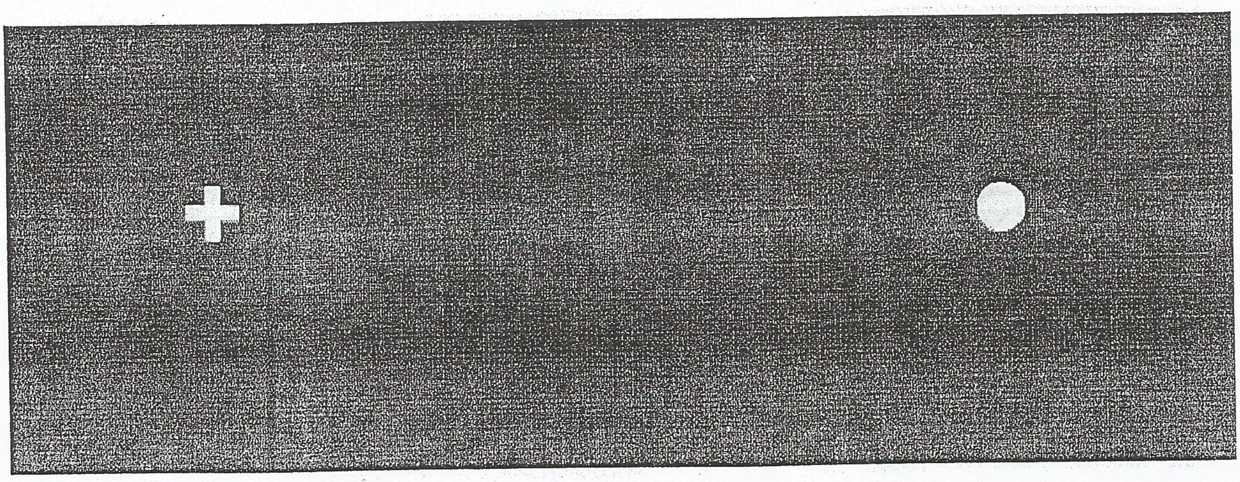


DIAGRAM OF A BLIND SPOT CARD

DETERMINATION OF NEAR POINT

Near point is the nearest possible distance at which the near object can be clearly seen. The near point of vision changes dramatically with age, averaging about 8cm at the age of 10 and about 100 cm at the age of 70.

AGE	NEAR POINT
10 YEARS	8 cm
20 YEARS	10 cm
30 YEARS	12.5 cm
40 YEARS	18 cm
50 YEARS	40 cm
60 YEARS	83 cm
70 YEARS	100 cm

Equipment:

Common Pin

Procedure:

- Ask the subject to sit comfortably.
- Select the test eye and close the other eye.
- Hold a common pin at an arm's length (about 10 inches) in front of his eye and ask him to look at the pin-head.
- Keeping the pin-head in focus, gradually bring the pin closer to his eye.
- Ask the subject to indicate when the pin-head first appears to be blurred or cannot be seen.
- Measure the distance with a ruler.
- Repeat the same procedure for the other eye.

TEST FOR ACCOMMODATION

The process of accommodation can be tested by observing Purkinje-Sanson images in a dark room.

PURKINJE-SANSON IMAGES:

If a small bright light, usually a candle, is held in front of and a little to one side of the eye in a very dark room, three images are seen:

1. The first image comes from the cornea and it is small, bright and upright.
2. The second image comes from anterior surface of the lens. It is large, upright but less bright.
3. The third or last image comes from posterior surface of the lens and it is small, bright and inverted.

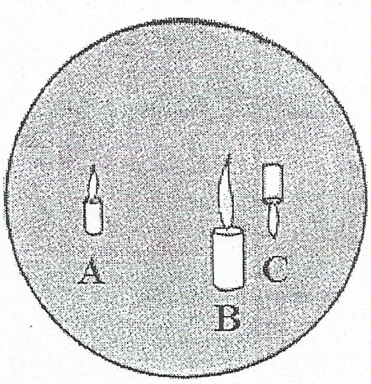
During accommodation, the second image comes closer to the first image and also becomes smaller than when the eye was at rest. And since an image reflected from a convex surface is diminished in proportion to the convexity of that surface, it is obvious that the front of the lens became more convex when the eye adjusted itself for near vision and this is how we can observe the process of accommodation by using these images.

Equipment:

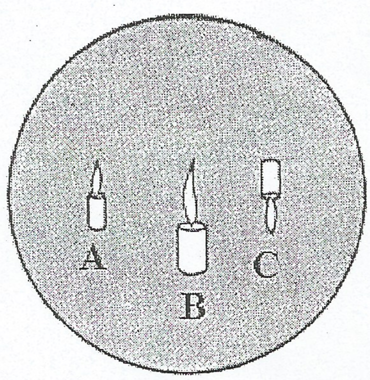
A candle and a dark room

Procedure:

- Make the subject comfortably seated in a dark room.
- Ask him to look at a distant object.
- Hold a candle light in front of and a little to the side of the subject's any one eye.
- Look into the subject's eye from the side opposite to the candle.
- Observe how many images of the candle light are reflected in the subject's papillary area and take note of the relative size, brightness and position of the images.
- Now ask the subject to look at a nearby object and observe carefully the changes that are produced in the size, brightness and position of the images.



Before Accommodation



After Accommodation

A = First image from Cornea

B = Second image from anterior surface of lens

C = Third image from posterior surface of lens

TEST FOR COLOR VISION

Color vision is the function of the cones. There are three types of cones in our eyes; red, green and blue. Relative lack or deficiency of one, two or all of them will lead to a defect in color vision. The gene that causes defect in color vision is carried on the X chromosome, making the handicap more common among men (who have just one X chromosome) than among women (who have two, so must inherit the gene from both parents to have the defect).

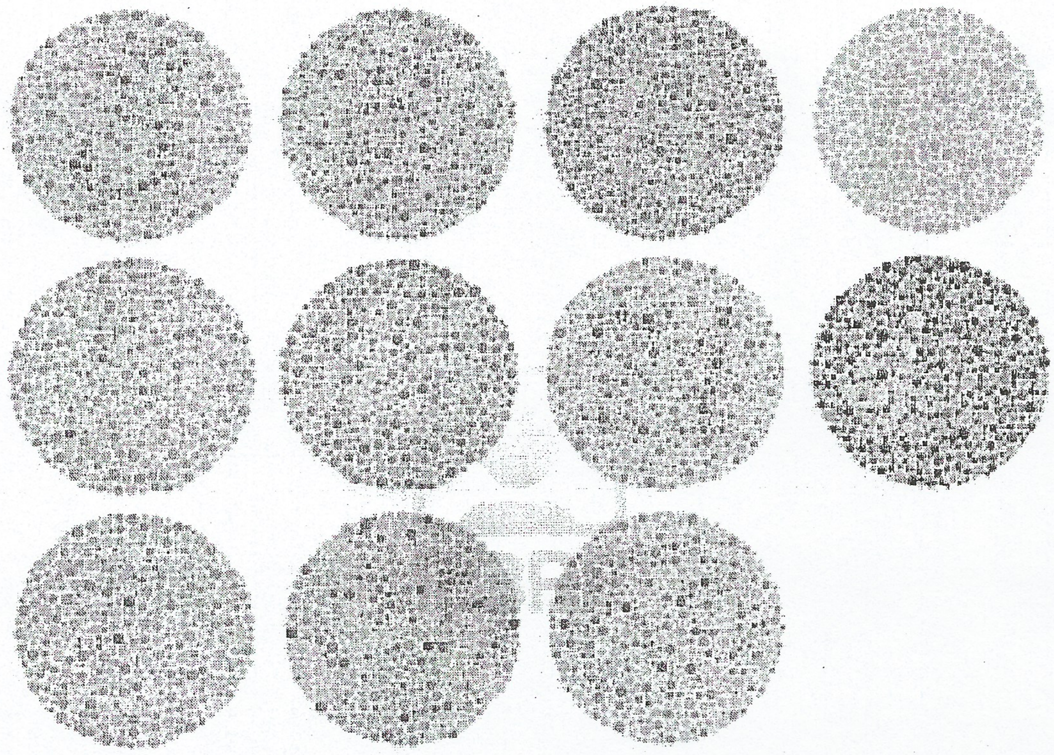
TYPE OF COLOR BLINDNESS	DEFINITION & PATHOLOGY
PROTANOPIA (RED BLINDNESS)	A form of colorblindness characterized by defective perception of red and confusion of red with green or bluish green due to the complete absence of red cones.
DEUTERANOPIA (GREEN BLINDNESS)	A form of colorblindness characterized by insensitivity to green, moderately affecting red–green hue discrimination due to the complete absence of green cones.
TRITANOPIA (BLUE BLINDNESS)	A very rare visual defect characterized by the inability to differentiate between blue and yellow due to the complete absence of blue cones.
PROTANOMALY	A type of anomalous trichromatic vision with defective perception of red due to less sensitivity of red cones.
DEUTERANOMALY	A type of anomalous trichromatic vision in which the green cones have decreased sensitivity, mildly affecting red–green hue discrimination.
TRITANOMALY	A rare type of anomalous trichromatic vision in which the blue cones have decreased sensitivity, affecting blue–yellow hue discrimination.

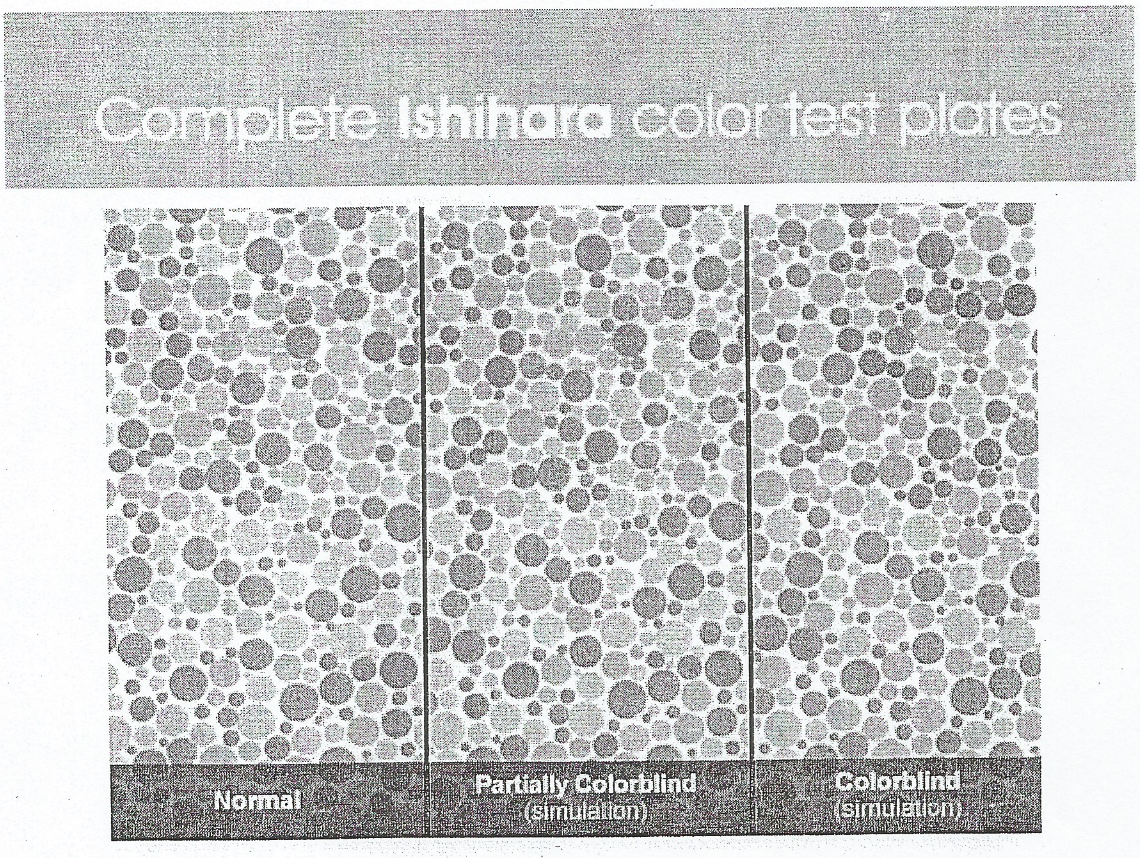
Equipment:

Ishihara's Colored Plates

Procedure:

- Select the eye for testing and close or cover the other eye.
- Ask the subject to read the numbers showing in several colored Ishihara's plates or trace the zigzag pathway given in some plates.
- Note if the subject has difficulty or fails to read the number or trace the path correctly in a plate and then refer to the key given for that plate to decide which type of color blindness he is having.
- Repeat the same procedure for the other eye.




Complete Ishihara color test plates
Normal
Partially Colorblind
(simulation)
Colorblind
(simulation)