CHAPTER – I

1.1. INTRODUCTION

Communication makes the humans different from animals. Speech is the most efficient medium of communication known to man. So much so that efforts are on to make speech as a medium of communication even between men and machines.

Speech is defined as audible manifestation of language by a complex and still rather mysterious process called as encoding. The speaker converts an idea he has in his mind into a stream of sounds, moving his lips, tongue and jaws in precise gestures.

According to Kent and Read (1992:1) speech is a complex, highly skilled motor act. The refinement and stabilization of speech motor patterns probably continues well into the teens. In the hearing impaired individuals, there is a difficulty in the same due to the loss of the auditory feedback.

The reception and expression of language takes place in the brain, but for this it requires several initial processes. Our ears pick up the sounds and reay them to the brain for interpretation of these arbitrary set of symbols. These sounds make up the words used in the particular language. During the whole process, the auditory system is used rather effortlessly for the development of speech and language. Expression of language can be spoken or written. Speech as a form of spoken language gives enormous opportunities at personal, academic, social, occupational levels which is otherwise not possible.
1.2. SYSTEMS INVOLVED IN SPEECH PRODUCTION

The movements of the speech organs such as the tongue, lips, velum, and vocal folds – result in sound patterns that are perceived by the listener. Scholars (Eguchi and Hirsch 1969) hold the view that speech is more than audible sounds; otherwise we would not bother to distinguish the speech sounds from those of other bodily movements, such as clapping or breathing. Speech gains unique importance as the primary means by which language expresses ideas and thought in all human cultures. The end-product of speech is an acoustic signal that represents the communicative message of the speaker.

Speech has three major arenas of study: the physiologic arena (articulatory phonetics), the acoustic arena (acoustic phonetics), and the perceptual arena (auditory phonetics). An understanding of speech requires the study of each of these arenas in relation to the others.

1.2.1. The physiological arena of speech / articulatory phonetics

The physiological arena is identified physically with the speech apparatus, consisting of three major anatomic subsystems: respiratory, phonatory and articulatory. These subsystems work closely together in speech and are often highly interactive (Kent and Read 1992:1-7).
1.2.2. The respiratory subsystem

The respiratory subsystem consists of the trachea, lungs, rib cage, and various muscles. Besides providing for ventilation to support life, this system produces most of the aerodynamic energy of speech. The aerodynamic parameters are air volume, flow, pressure and resistance. Volume is a measure of the amount of air and is measured with units such as litre (l) or millilitre (ml). Flow is the rate of change in volume and is expressed in units such as liters/minute or millilitres/millisecond (ml/ms). Pressure is force per unit area and is commonly expressed in Pascals. In speech studies, pressure often is recorded with a different unit, such as centimeters of water (cm H2O). Resistance is a variable that relates flow and pressure, according to Ohm’s law. Ohm’s law may be expressed in the following alternative form:

Pressure = flow*Resistance
Flow = Pressure / Resistance
Resistance = Pressure / Flow

Flow is directly proportional to pressure and indirectly proportional to resistance. If resistance is held constant, an increase in air pressure will result in an increase in airflow. If air pressure is held constant, an increase in resistance will cause a decrease in airflow.

Speech is produced with a relatively constant lung pressure of about 6-10 cm H2O or about one K Pa (Kilopascal or 1000 Pascal’s). A simple demonstration of this would be as follows: Dip a straw to a depth of 6
cm in water, filled glass, and blow into the straw until bubbles begin to form at the end of the water-immersed straw. This corresponds to a pressure of 6-10 cm H2O. There is only a little loss of air pressure from the tiny air sacs of the lungs up to the larynx, so that this air pressure (subglottal) is approximately equal to the air pressure in the lungs. If the larynx or the upper airways were not closed, air pressure developed by the respiratory system would be immediately released through the open tract into the atmosphere. Speech is generated by valving or regulating the air pressure and flow is generated by the respiratory subsystem. Therefore, the respiratory subsystem is an air pump, providing aerodynamic energy for the laryngeal and articulatory subsystems. The speaker inspires air by muscular adjustments that increase the volume of the respiratory system. Lungs then release air by combinations of passive recoil and muscular activity, depending on the aerodynamic requirements. In most languages, speech is produced by expiratory air. Therefore, speech has to be interrupted whenever the speaker breathes in. The typical respiratory pattern for speech is a quick inspiration followed by a much slower expiration on which speech is produced. During rest breathing, the inspiratory and expiratory phases of a breathing cycle are nearly equal in duration, but for speech the expiratory phase is prolonged relative to the inspiratory phase.

1.2.3. The laryngeal subsystem

The larynx is situated at the top of the trachea and opens above. It consists of 3 paired cartilages and 3 unpaired cartilages and a number of muscles. Of particular importance are the vocal folds that adduct to close the
airways or abduct to open the airway. The vocal folds are a multilayered structure, which are capable of generating various frequencies. The rate of vibration of the vocal folds basically determines the frequency, which is perceived as pitch.

The length of the vocal folds varies from 8 mm to 16 mm. The frequency generated by the vocal folds depends on the mass, length and tension of the vocal folds. In general, adult males have low frequencies and adult females have comparatively high frequencies. Children have higher frequencies than adult males and females. The frequency of vocal folds also undergoes changes from childhood to senescence. In young children the frequency is high and at puberty it is lowered. In old age frequency decreases in females and increases in males.

The larynx is very important for speech not only because it is the first valve, which converts the expiratory air stream (noise) into puffs (voice), but also because it valves the air moving in or out of the lungs. When the vocal folds close tightly, no air movement will occur; when they open air moves to the upper airways. Finally, a partial abduction of the vocal fold is used to generate whispering. Larynx contributes little to the phonetic differentiation of speech sounds. Certainly it differentiates voiced from voiceless sounds. But laryngeal functioning is highly similar within voiced/voiceless groups of sounds. The sounds are made distinct by the shaping of the articulatory system.
1.2.4. The articulatory subsystem

The articulatory system extends from the larynx up through the lips or nose. This is termed as vocal tract and includes the oral and the nasal tracts. Energy can be transmitted through the oral cavity or the nasal cavity. The articulators are movable structures and include the tongue, lips, jaw, and velum.

The articulators shape the vocal tract, which determines the resonance frequencies. Energy from the vibrating vocal folds passes through the articulatory system and activates the resonance system of the vocal tract. Changing the articulatory position and height changes the resonance frequencies and thus the phonemes are made distinct. Speech articulation is described in terms of articulatory contacts and positions. Vowels are described in terms of tongue position, tongue height, and lip shape. Thus the speech production requires the coordination of all the above four sub systems.

1.3. IMPORTANCE OF HEARING IN SPEECH AND LANGUAGE DEVELOPMENT

The function of hearing became the foundation stone upon which our intricate human communication system was constructed. The structure of language is unique to homosapiens, although experimenters have demonstrated that signed symbols and other visual language forms can be taught to chimpanzees. Scholars believe that the beginnings of true language
are evidenced in these primates (Premack and Premack 1972, Savage-Rumbaugh et al. 1980). Other investigators insist that the conceptual system learnt by these primates is not linguistic; i.e. they (the primates) do not “think in words”; instead they use a signalization system that is far removed from the higher symbolization and syntax of human language (Terrace et al. 1979).

The human baby appears to be born with “preexistent knowledge” of language—specialized neural structures in the brain that waits for auditory experience with language to trigger them into functioning. These structures are dependent on auditory stimulation for their emergence, providing of course that other developmental factors are normal (Northen & Downs 1991:1).

The auditory-linked acquisition of language is further unique to human beings because it is a time-locked function related to early maturational periods in the infant’s life. The longer auditory language stimulation is delayed, the less efficient will be the language facility. The reason is that critical periods exist for the development of biologic functions, and language is one of the biologic functions of humans (Chomsky 1965:203). The normal hearing child is continuously exposed to sounds from birth or even before birth. It is through this continuous auditory stimulation that a normal child attains speech. The task is however very difficult for a child born deaf. Thus hearing controls speech, and without hearing speech fails to develop. Hearing impairment has a marked effect on the child’s ability to acquire speech (Northen & Downs 1991:1).
Hearing is essential for the natural development of speech and language, and communication is interfered with by the presence of a hearing loss. The oral communication skills of the hearing impaired children have long been of concern to educators of the hearing impaired, speech pathologists and audiologists, because the adequacy of such skills can influence the social, educational and career opportunities available to these individuals.

1.4. EFFECTS OF HEARING LOSS

Hearing loss in the children is a silent, hidden handicap. It is hidden because children, especially infants and toddlers, cannot tell us that they are not hearing well. It is a handicap because, if undetected and untreated, hearing loss in children can lead to delayed speech and language development, social and emotional problems, and academic failure (Northen & Downs 1991:2).

Skinner (1978; cited in Northen & Downs 1991: 8-9) listed a number of liabilities to a child’s language learning when a mild hearing loss exists:

- **Lack of Constancy of Auditory Clues when Acoustic Information Fluctuates**

  When a child does not hear speech sounds in the same way from time to time, there is confusion in abstracting the meanings of words due to inconsistent categorization of speech sounds.
• **Confusion of Acoustic Parameters in Rapid Speech**

   Even the normal hearing child suffers from variations of speech occurring between speakers and even in the same speaker. Frequency, duration and intensity vary as a result of differences between speakers of age, sex and personality. The child with a mild hearing loss will be confused in language acquisition as a result.

• **Confusion in Segmentation Prosody**

   The child with a mild loss may miss linguistic boundaries such as plural markers, tenses, intonation, and stress patterns. These factors are a prerequisite to meaningful interpretation of speech.

• **Masking of Ambient Noise**

   According to French and Steinberg (1947), the normal child requires a signal-to-noise ratio of +30 dB at 200-6000 Hz in order for speech learning to take place. It is rare in our modern culture for such a ratio to be present. Public school classes have no better signal-to-noise ratio than +12 dB. A child with even mild loss is handicapped in such situations.

• **Breakdown of Early Ability to Perceive Speech Sound**

   Almost at birth infant begins to learn to discriminate speech sounds. Studies have shown that at 1-4 months the infant can discriminate between most of the English speech sound pairs. By 6 months the infant recognizes many of the speech sounds of language and is making ongoing
cataloging of speech sounds as discussed. If these sounds are not perceived early, due to a hearing loss, learning can be impeded.

- **Breakdown in Early Perception of Meanings**

  Often, during ordinary speech, the normal listener misses some unstressed or elided words or sounds that he or she is able to fill in by context. But when an infant's hearing loss results in missing many of these soft or inaudible sounds, there is confusion in word naming, difficulty in developing classes of objects, and misunderstanding of multiple meanings.

- **Faulty Abstraction of Grammatical Rules**

  When short words are soft or elided as they often are, it becomes more difficult for a slightly hearing impaired child to identify the relationships between words and to understand word order.

- **Subtle Stress Patterns Missing**

  The mild conductive hearing loss is worse in the low frequencies than in the high frequencies. The emotional content of speech, its rhythm, and its intonation are communicated through the low frequencies. When these are lost, the emotional content of speech is confused – a condition that would impair learning of the speech milieu.

  Developing an auditory feedback loop for self-monitoring of speech production underlies intelligible speech. Children with congenital or early reduced or defective hearing sensitivity do not cause one specific kind of communication problem. The effects of a hearing loss depend primarily on
its degree, configuration, and stability and on the age of onset. In the hearing-impaired child the extent and type of early training; the type and timing of amplification; visual, emotional, and intellectual factors; and family attitude also influence language development. Age of onset of the hearing loss is an especially important factor in language development. A child who sustains significant hearing loss after he or she has acquired language will have a less severe linguistic deficit than the child whose hearing loss is present at birth or develops within the first few months of life. The major effect of a hearing impairment is the loss of audibility for some or all of the important acoustic speech cues. Elderly persons with hearing loss typically complain of their inability to understand speech. Conversation may be loud enough for them, but they cannot understand the words because they miss part of the acoustic information clues (Northern & Downs 1992:13).

Angelocci (1962) noted that hearing impaired speech is characterized by abnormal control over duration and fundamental frequency. In particular, duration of words or sentences often sees excessively long and pitch contour over individual words are excessively too high, too monotonous or simply ‘inappropriate’.

Onset of hearing impairment will have difficulty developing this auditory feedback mechanism, unless appropriate early amplification and training are implemented. Greater access to the speech signal results in increased opportunities to develop and use the auditory feedback loop. However, even children with minimal available hearing can learn to self monitor their speech and develop good articulation and voice quality.
Auditory feedback is important to realize self monitored speech perception, rather than perception of pure tone thresholds (Ross et al 1991:432-434).

Hearing loss of any degree or configuration will interfere with the development of speech perception categories. Reduced sensitivity of hearing at high frequency region negatively affects speech perception, making it more difficult for the child to learn to use acoustic cues of speech. A child with normal hearing is consistently exposed to an audible, clear speech signal despite interference from noise and distance, and so effortlessly acquires auditory perceptual skills. The hearing impaired child must try to cope with the distortion produced by the loss and the amplification while attempting the difficult, but not impossible, task of categorizing phonemes according to their acoustic features. Early identification of auditory management will enable the child to learn to use whatever multiple cues are available through amplification. This is especially true in the case of cochlear-implanted children who receive it earlier.

Developing an auditory loop for self-monitoring of speech production underlies intelligible speech. Children with congenital or early onset of hearing impairment will have difficulty developing this auditory feedback mechanism, unless appropriate early amplification and training are implemented. Greater access to the speech signal results in increased opportunities to develop and use the auditory feedback loop. However, even children with minimal available hearing can learn to self-monitor their speech and develop good articulation and voice quality. Auditory feedback is
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Young cochlear implant or hearing aid users who speak relatively well typically have good speech recognition skills. However, some children who have good speech recognition skills do not necessarily acquire good speech production skills. Children who have profound hearing impairment also attend to visual speech information to acquire the sounds and words of their speech community. That is, children are more likely to produce “visible” phonemes and words correctly than “non-visible” phonemes and words”. Children who have profound hearing impairment and received cochlear implantation may become less reliant on visual information for acquiring speech and more reliant on auditory information. However irrespective of the type of device, the ultimate goal of the speech pathologist is to achieve speech intelligibility within an acceptable range. Hence, there is need to assess the function of the newly emerged bioelectrical device.
1.5. AURAL REHABILITATION AND REHABILITATION TECHNOLOGY FOR THE HEARING IMPAIRED

Aural Rehabilitation refers to services and procedures for facilitating adequate receptive and expressive communication in individuals with hearing impairment. Selection of amplification device is a crucial component of aural rehabilitation process (Katz 1994: 638).

Rehabilitation Technology refers to systems that improve signal to noise ratio by transmitting amplified signal directly to the listener, transforms sound into visual or tactile signal. Rehabilitation technology devices are also called assistive listening devices.

**Categories of Assistive Listening Devices (ALDs)**

Assistive listening devices are broadly classified as:

a. Sound enhancement technology
b. Television enhancement technology
c. Telecommunication technology
d. Signal alerting technology
1.5.1. Sound Enhancement Technology

These devices transmit sound directly from the source to the hearing impaired listener. e.g. individual hearing aids, group hearing aids (Induction loop system, hard wire system, Infrared system and FM system). These systems are used by hearing impaired in different listening situations like in Speech and language training, class rooms, theatres, family environment, television viewing, work place, conference halls, public places, etc.

Examples for sound enhancement technology

Fig. 1.1. Body level and behind the ear hearing aid

Ref: http://images.google.com/images
Fig. 1.2. In the ear hearing aid

Ref: http://images.google.com/images.

Fig. 1.3. Completely in the canal

Ref: http://images.google.com/images.
Implants

Fig. 1.4. Cochlear Implant and Bone anchored hearing aid

Ref: http://images.google.com/images.

1.5.2. Television Enhancement Technologies

These include devices used to improve perception of televised signal. Signal is transmitted to the listener via a, infrared or frequency modulation system. Closed captioning is also used for individuals with severe to profound hearing loss or for those with poor speech recognition ability.

Fig. 1.5. Television enhancement technologiess

Ref: http://images.google.com/images.
1.5.3. Telecommunication Technologies

Activation of T-switch on hearing aid is still used as an alternative way for hearing aid users to understand telephonic conversation. Telephone amplifiers, like amplified handsets, in-line amplifiers, and portable strap on amplifiers are also used for better telephonic signal for hearing impaired. Visual systems, like text telephone or teletypewriters are been used in other countries for hearing impaired with poor speech recognition ability.

![Telephone Amplifier and Text Telephone](http://images.google.com/images)

**Telecommunication technology**

![Telephone and ALD](http://images.google.com/images)

**Fig. 1.6. Telephone amplifier and text telephone**

1.5.4. Signal alerting technology

Auditory activities of daily living, like telephone ring, doorbell, baby crying, waking up alarm may not be heard by hearing impaired by using any amplification device, so certain signal alerting devices are available for these special needs, for example pillow vibrator for alarm, vibrotactile wristband for telephone ring and baby cry, visual (light) signal for door bell and vibro tactile wrist watches.

**Fig. 1.7. Signal alerting devices**

Ref: http://images.google.com/images.
1.6. Hearing Aids

Hearing aids are electronic or battery-operated devices that can amplify and change sound. A microphone receives the sound and converts it into sound waves. The sound waves are then converted into electrical signals, which are amplified and converted back to sound waves.

1.6.1. Operation of hearing aid

A microphone receives the sound and converts it into sound waves. The sound waves are then converted into electrical signals, which are amplified by the amplifier and converted back to sound waves at the level of the receiver. Hearing loss affects people in different ways; so a hearing impaired person needs to get the right device for himself/herself.

1.6.2. Types of Hearing Aids

Body level Hearing Aids

The body of the instrument is worn on the body. It ‘hooks’ over dress. It is attached via wire with a receiver tubing to an earmould, which holds it in place in the ear.

Fig. 1.8. Body worn hearing aid

Ref: http://images.google.com/images.
**Behind the Ear (BTE)**

The body of the instrument is worn behind the ear. It ‘hooks’ over the pinna. It is attached via plastic tubing to a nearmould, which holds it in place in the ear.

*Fig. 1.9. Behind the ear hearing aid*


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**In the Ear (ITE)**

The complete hearing aid is in the ear or ear canal. The hearing aid is housed in a hard plastic shell which is often custom made by taking an ear impression.

*Fig. 1.10. In the ear hearing aid*


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**Completely in the canal (CIC) Hearing Aids**

These are "invisible" hearing aids, that is, hearing aids that fit completely within the ear canal, so they are not seen even when someone is looking directly into the ear.

*Fig. 1.11. Completely in the canal hearing aid*

Spectacles type

In the spectacle type the hearing aid components are incorporated with in a spectacle frame. It is useful for persons who require glasses along with hearing aids.

Fig. 1.12. Spectacle type of hearing aid

Ref: http://images.google.com/images

Hearing aids are distinguished by their technology or circuitry. In early days hearing aid technology involved vacuum tubes and large heavy batteries. Today there are micro chips and digitized sound processing used in hearing aid design.

At present, two technologies are in vogue, the analog and digital technology. The simplified block diagrams of analog and digital hearing instruments are shown in figures 1 and 2 respectively. The conventional analog hearing instruments consist of a microphone, a pre-amplifier, a mean processor, an amplifier and a receiver. During analog processing, the microphone transduces the acoustic input signals into electrical input signal. The pre-amplifier amplifies the electrical input signals and the mean processor spectrally shapes the frequency response. After spectral shaping, the amplifier amplifies the electrical signals, which are then transduced by the receiver into acoustic output signals (Holube and Velde 2000:285-322).

In analog hearing instruments, both the acoustic and electrical signals are continuous in time and amplitude. Between any two moments in time, there are an infinite number of instants when the signal exists and there are an
infinite number of possible amplitude values of the signal at that single
moment. This technology is least expensive and can be appropriate for
different types of hearing aids.

Analog hearing instruments may be digitally programmable; however signal amplification is still accomplished via analog means. Digitally programmable analog hearing instruments allow settings such as frequency response and gain to be manipulated digitally using a computer or hand-held programmer, however, digitally programmable analog hearing instruments do not provide true digital signal processing.

Fig. 1.13. Simplified block diagram of digital hearing instrument.
Ref: http://images.google.com/images.s
Research into digital processing began in the 1960s within Bell laboratories. Because of the slow speed of computer then, the necessary calculations could not be performed quickly enough. It was not until the late 1970s that the computers were fast enough for the output to be synchronized with the input and it was not until the 1980s that power consumption and size were decreased sufficiently to make wearable hearing aids. But it was not a commercial success. Later almost after 10 years in 1996, the first entirely digital behind the ear (BTE) hearing aids, in which digital signal processing (DSP) was used, became commercially available (Dillion 2001:16-17).

Digital programmable hearing aids have all the features of analog programmable hearing aids but use digitized sound processing to convert sound waves into digital signals. Digital hearing instruments consist of a microphone, a pre-amplifier, an analog-to-digital converter, a digital signal processor, a digital-to-analog converter, an amplifier and a receiver. During digital signal processing, the microphone transduces the acoustic input signal into an electrical input signal. The electrical input signals are amplified by the pre-amplifier and are digitized by the analog-to-digital converter. The digital signals are spectrally shaped by the digital signal processor and are converted into analog electrical signals by the analog-to-digital converter. The electrical signals are amplified by the amplifier and transduced into an acoustic output signal by the receiver (Lybarger and Lybarger 2000:1-35).

In digital hearing instruments, neither the acoustic nor the electrical signals are continuous in time and amplitude. The input signal is sampled at discrete points in time and each sample is truncated or rounded to
a specific quantity within a discrete set of values. The digital technology is very expensive, but it allows improvement in programmability, greater precision in fitting, management of loudness discomfort, control of acoustic feedback and noise reduction.

1.6.3. Advantages of hearing aids

The client will have greater control on the device as he can try different hearing aids to see which one is qualitatively better, so that he can purchase a new device every couple of years. As the costs of accessories are minimal the client can afford to buy new device after a short gap. There will be greater flexibility and accessibility for repairs and client can adjust controls on these devices. These are easy to maintain and retain the residual hearing for later use of optimal hearing aid technology if any for those with severe hearing loss it may be great ease in discriminating low frequency sounds, e.g. /m/, /e/ and may better enjoy bass sounds of music.

1.6.4. Disadvantages of hearing aids

The hearing aids provide very less amplification in high frequency region. Ear-moulds and their acoustic feedback issues may be repetitive, time consuming and aggravating. Loud noises are bothering for those using linear amplification because as the level of input sound to the microphone of the hearing aid increases, output sound also increases in the same proportion. Hearing aids assist moderate to moderately severe and to some extent to severe hearing impaired persons but does not benefit profoundly hearing impaired persons due to poor aided responses. Hence hearing aids for those
with severe to profound loss need to be fitted carefully, assertively and with proper monitoring.

1.7. Cochlear Implants

A cochlear implant is a technologically advanced medical device that helps adults and children who have bilateral severe to profound hearing loss and are not receiving satisfactory benefit from hearing aids or tactile devices to understand speech. An implant does not restore normal hearing. Instead, it can give a deaf person a useful representation of sounds in the environment and help him or her to understand speech.

1.7.1. Parts of the Cochlear Implant

The implant is surgically placed under the skin behind the ear. These are two basic parts of the device, i.e. external and internal.

External device

The components which are worn outside the body constitute the external device. It consists of a microphone which picks up sound from the environment, speech processor which selectively filters sound to prioritize audible speech and sends the electrical sound signals through a thin cable to the transmitter, a transmitter, which is a coil held in position by a magnet placed behind the external ear, and which transmits the processed sound signals to the internal device by electromagnetic induction.
Internal device

The components which are surgically implanted inside the ear constitute the internal device. A receiver and stimulator secured in bone beneath the skin, which converts the signals into electric impulses and sends them through an internal cable to electrodes, an array of up to 22 electrodes wound through the cochlea, which send the impulses to the nerves in the scala tympani and then directly to the brain through the auditory nervous system.

1.7.2. How does a Cochlear Implant Work?

A cochlear implant is very different from a hearing aid. Hearing aids amplify sounds so they may be detected by damaged ears. Cochlear implants bypass the damaged portions of the ear and directly stimulate the auditory nerve. Signals generated by the implant are sent by way of the auditory nerve to the brain, which recognizes the signals as sounds. Hearing through a cochlear implant is different from normal hearing and takes time to learn or relearn. However, it allows many people to recognize warning signals, understand other sounds in the environment, and enjoy a conversation in person or by telephone.
1.7.3. Candidacy for Cochlear Implant

There are a number of factors that determine the degree of success to expect from the operation and the device itself. Cochlear implant centers determine implant candidacy on an individual basis and take into account a person's hearing history, cause of hearing loss, amount of residual hearing, speech recognition ability, health status, and family commitment to aural habilitation/rehabilitation.

A prime candidate for cochlear implant

- having severe to profound sensorineural hearing impairment in both ears, having a functioning auditory nerve,
- having lived a short amount of time without hearing (approximately 70+ decibel loss, on average),
- having good speech, language, and communication skills, or in the case of infants and young children, having a family willing to work toward speech and language skills with therapy,
- not benefiting enough from other kinds of hearing aids,
- having no medical reason to avoid surgery,
- living in or desiring to live in the "hearing world"
- having realistic expectations about results,
- having the support of family and friends.
1.7.4. Types of Cochlear Implants

A channel is a pathway through which information is transmitted from the implant to the auditory nerve. There are two types of channel system in Cochlear implants.

Single channel Cochlear Implant

A single channel system generally implies the insertion of a single electrode to which the signal is delivered through one pathway. The early single channel implants provide electrical stimulation at a single site in the cochlea using a single electrode. These implants are of interest because of their simplicity in design and their low cost compared to multi channel implants e.g. House/3M single channel implant, Vienna/3M single channel implant.

Multi-channel Cochlear Implant

In these implants, the signals are transmitted through several independent channels. They provide electrical stimulation at multiple sites in the cochlea using an array of electrodes, thereby exploiting the place mechanism for coding frequencies. The principal of these implants is, larger the number of electrodes, finer is the place resolution for coding frequencies. However frequency coding is also dependant on the number of surviving neurons e.g. Nucleus multi channel cochlear implant system, Med-El cochlear implant, Clarion multi channel implant, All Hear cochlear implants.
1.7.5. Contra-indication for Cochlear Implant

Meningitis, labyrinthitis ossificans, advanced otosclerosis and neuro fibromatosis II are contradictions for cochlear implant. Apart from these hearing impaired individuals associated with mental retardation, psychosis and organic brain dysfunctions, are not good candidates for Cochlear Implant.

Lack of speech production data as a function of devices and degree of hearing loss is one of the difficulties faced by the clinician while evaluating the speech production skills of the hearing impaired. Acoustic research on the speech production of the cochlear implant and hearing aid users speech is one of the most direct ways to determine the benefit from auditory prosthesis. In the recent years there has been rapid increase in the fitting of the cochlear implant for both prelingual and postlingual hearing impaired individuals, irrespective of age. Nevertheless, hearing aids for the hearing impaired is still preferred in developing country like India.

In order to develop more effective speech training procedure for children with hearing impairments, it is necessary to know their speech deviation from that of the normally hearing children and the effect of various errors and abnormal speech patterns on the intelligibility.

An acoustic analysis of speech is a method to check the speech production ability, and it is an objective description of the finer aspects of the speech. This will give information regarding the physical and temporal aspects of speech. This, in turn, helps in categorizing the patterns of speech of an individual as correct or incorrect production.
The review of literature shows that the acoustic analysis is an important measure in terms of diagnostic and intervention point of view, but there are very few studies on the hearing impaired speech with reference to the Telugu language.

The information obtained from the acoustic analysis will help in making use of the advances in technology with maximal effectiveness in facilitating the oral production skills of the persons with hearing impairment.

The present study aims at finding the temporal, physical analysis of speech of Telugu speaking individuals who use hearing aids and cochlear implants with that of normal hearing peers.

1.8. Need for the Study

- Research on acoustic analysis of speech of the children with hearing-impairment will help to determine which acoustic correlates are impaired and to what extent. It also acts as a precursor to plan the therapy accordingly. This is, in turn, improves speech intelligibility.

- Acoustic research on the speech of the children with hearing-impairment using hearing aids and cochlear implants helps to determine how the affected acoustic characteristics correlate with intelligibility.

- No study so far has investigated all these acoustic aspects systemically in the children with hearing-impairment using hearing aids and cochlear implants in Telugu language.
1.9. AIM OF THE STUDY

This study analyzes the speech characteristics of Telugu speaking children with normal hearing, children with hearing impairment using hearing aids and cochlear implants, spectrographically in terms of average fundamental frequency (F0), formant frequencies (F1, F2 and F3), bandwidth characteristics (B1, B2 and B3), vowel duration and word duration of both long and short vowels in VCV syllable production.

- The following are the objectives of this study:
  a) To evaluate and compare acoustically, the speech of children with normal hearing and children with hearing impairment who are using hearing aids.
  b) To evaluate and compare acoustically, the speech of children with normal hearing and children with hearing impairment who are using cochlear implants.
  c) To evaluate and compare acoustically, the speech of children with Hearing Impairment who are using cochlear implants and hearing aids.
1.10. HYPOTHESES

There is no significant difference in terms of fundamental frequency (F0), formant frequencies F1, F2, F3, bandwidth (B1, B2, B3) vowel duration and word duration of VCV syllable productions between


b) Children with normal hearing versus children with hearing impairment using cochlear implants.

c) Children with hearing impairment using hearing aids versus children with hearing impairment using cochlear implants.