ACOUSTIC AND TEMPORAL PARAMETERS IN MALAYALAM SPEAKERS USING DIFFERENT TYPES OF T.E.P. PROSTHESIS

Sunitha (M)
Reg. No. M. 9219

A dissertation submitted as part fulfilment for the degree of M.Sc. (Speech and Hearing) to the University of Mysore

ALL INDIA INSTITUTE OF SPEECH AND HEARING
MYSORE-570 006

MAY 1994

To

My Dearest Parents

Two people who Know me best

who love me more man I deserve

whose life long bond I cherish

&

'Dr. Nataraj ana Rajshekar Sir

{Tne field is proud to have you and

I am proud to be your Student}

CERTIFICATE

This is to certify that the dissertation entilted "ACOUSTIC AND TEMPORAL PARAMETERS IN MALAYALAM SPEAKERS USING DIFFERENT TYPES OF T.E.P. PROSTHESIS" is a bonafide work, done in part fulfilment for the Degree of Master of Science (Speech and Hearing), of the student with Reg. No. M9219.

MYSORE
MAY 1994

Dr. (MISS). S. NIKAM
DIRECTOR
All India Institute of Speech and Hearing
MYSORE - 6

CERTIFICATE

This is to certify that the dissertation entilted "ACOUSTIC AND TEMPORAL PARAMETERS IN MALAYALAM SPEAKERS USING DIFFERENT TYPES OF T.E.P. PROSTHESIS" has been prepared under my supervision and guidance.

MYSORE
MAY 1994

Dr. N.P. Nataraja
H.O.D., Dept. of Speech Sciences
All India Institute of Speech and Hearing
MYSORE - 6

DECLARATION.

I hereby declare that this dissertation entilted "ACOUSTIC AND TEMPORAL PARAMETERS IN MALAYALAM SPEAKERS USING DIFFERENT TYPES OF T.E.P. PROSTHESIS" is the result of my own study under the guidance of Dr. N.P. Nataraja, H.O.D., Department of Speech Sciences, All India Institute of Speech and Hearing, Mysore, and has not been submitted earlier at any University for any other Diploma or Degree.

MYSORE
MAY 1994

Reg. No. M9219

ACKNOWLEDGEMENTS

I am indebted to my guide and teacher, Dr. Natraja, Professor and Head of Department of Speech Sciences, All India Institute of Speech & Hearing, Mysore, Sorry Sir, I cannot. express anything else. Everytime, I try to build up the arabesques of words for you, they fall into shades, revealing that they are unable to acknowledge for what you are and what you have done.
My sincere thanks are due to Dr. S. Nikam. Director, All India Institute of Speech and Hearing, Mysore for giving me the permission and opportunity to undertake this dissertation.

You build a bond in childhood that deepens with each day and You are a special part of all the memories I hold Dear [MY Dearest Chettan and Chechi].

Meaning of true friendship is what I have understood from You three [Kiran, Ruku, Viji].

My Dearest Subjects - For the pains You undertook travelling all the way to make my work successfull. My gratitude is inmeasurable.

Things wouldnot be the same without You three around [Divya, Priya M. & Mamtha].

You are someone Special, Special for what You do and for what You are - Special in everyway [Dear Shankar & Gokul].

Sunil for being the best critic I have ever seen.

Nandhu, Thank You would be do little for all that You have done for me dearest brother.

No matter what I do, where I go I know You people are always there for me [Sowmy N., Shanthi, Anu & Suju].

You people have made my life a litle sweeter, a litle nicer and a lot more fun [Swapna, Sonia, Mini, Pradeep, Sara & Binu].

Thanks for being there whenever I needed Your help Dear Rohini Madam, Sreedevi Madam and Venkatesh Sir.

Ramesh Babu Sir for helping me go through the vast literature in the library.

S.V. Computer Services for extending a helping hand during the last stages of this work.

Life would have been a monotony if not for my acquaintance with You [Vanaja Madam, G.P. Sir and Manjual Madam].

Dullard! is what I would call myself when I sit in front of Computer if not for Your help Suresh I would not have done it.

My Dear classmates, thanks for putting up with me for the past five years.

CONTENTS

INTRODUCTION

INTRODUCTION

"If all my possessions were taken from me with one exception I would choose to keep the power of Speech for by it I would soon regain all the rest" (Daniel Webester 1970).

"Let no one underestimate the psychic trauma incident to laryngectomee. It is as serious as the physical trauma itself. When given the choice between an early death and total removal of the voice box [The patient suffers shock from which he never compeletely rallies"] (Greene 1947).

Cancer of the larynx calls for surgical or radiological intervention. These can be partial or total removal of the larynx and this may lead to significant alterations or complete loss of speech.

Laryngectomy is frequently life-saving but through the loss of speech the means of expressing personality thoughts and emotions man suffers. The effect on communication with family and friends and on employement, security and social acceptance may be devastating. And the victim fears are further intensified by fear of Cancer. The vast majority of Laryngectomy operations are caused out for this reason.

Thus speech rehabilitation of the Laryngectomized patients is vital and interesting as it amounts to a new life for them. So voice restoration following total Laryngectomy remains a challenging problem for both Head and Neck Surgeon and Speech Pathologist .

A plan for the comprehensive care of the Laryngectomee requires decision about the most appropriate method for vocal rehabilitation requiring both subjective and objective evaluation of communication skills.

Since the original Laryngectomy many different techniques have been utilized to restore speech. Conley et al (1958) introduced an internal Tracheoesophageal tunnel, Assai procedure in 1959, Voice Bank Prosthesis by Taub and Spiro in 1972, Phonatory neo-glottis by Staffiere in 1976. But none of the above mentioned surgical procedures have been accepted form of rehabilitation because most of them suffered from the problem of aspiration.

Since the first laryngectomy surgeons have sought to restore speech by the creation of a fistula between the trachea and pharynx. Unfortunately results were inconsistent and frequently complicated by Salivary leakage. It is only in the last ten years, with the improvement in surgical tehcniques and developement of voice prosthesis, that the success rates have increased . to an acceptable level where there is now a viable alternative to oesophageal and artificial laryngeal mode of communication.

Blom-Singer (1979) introduced a technique of Tracheo-Esophageal puncture with placement of a one-way Silastic valve. They gave the fundamental impetus for the development of new prosthesis. Aspiration with this prosthesis is minimal. After this range of prosthesis were developed in different parts of the World [Blom-Singer's Low pressure prosthesis, Panje Voice Button, Groningen prosthesis, H.C. prosthesis, Provox prosthesis, Indian prosthesis etc.]. They were developed due to the following reasons:

1) By knowing and correcting the drawbacks of existing prosthesis may begets renewed proshtesis.

2) To make it available indigeneously rather than importing from other places.

3) To reduce the expenses.

A plan for the comprehensive care of the Laryngectomee requires decision about the most appropriate method for vocal rehabilitation of communication skills. The knowledge of the acoustic properties and temporal properties of T.E. speech represents an important body of information and a significant area of theoritical and applied study and can be intrepreted in such a manner as to enlarge understanding of speech production following T.E.P. There has been studies which compare different types of prosthesis. They concentrate only on frequency and intensity parameters. This study was undertaken to compare 3 types of prosthesis [Blom-Singer's Duck-Bill, Low pressure hypothesis and Indian prosthesis] on frequency, intensity and majority of the temporal parameters. Acceptability and intelligibility of Speech are also studied to know which one is more accepted. Hence the present study was planned with the following objectives.

AIM OF THE STUDY

1. Analysis of temporal parameters of T.E speech when the same laryngectomee used different types of prosthesis.

2. Analysis of acoustic parameters when the same laryngectimee used different types of prosthesis.

3. To accept the acceptability and intelligibility of T.E speech with different types of prosthesis.

Hypothesis:- There is no significant difference in terms of the parameters studied between:-

1) Duck Bill prosthesis aided and B.S low pressure prosthesis aided T.E speech.

2) B.S duck bill prosthesis aided and Indian prosthesis aided T.E speech.

3) B.S low pressure prosthesis aided and Indian prosthesis aided T.E speech.

Four subjects who had undergone secondary-TEP earlier were selected for the study. Three trials of phonation of !a! !i! and !u!, was word list consisting 38 words and a standard passage in Malayalam (containing all consonants and vowels) were recorded.

Implications of the study:

1) It would help in knowing the various parameters which are affected in the T.E. speakers and thus guide us on the

therapeutic management.

2) It would help us in knowing about the temporal and acoustic parameters of different kinds of prosthesis.

3) It would help us in knowing whether the changes in the different parameters of the different kinds of prosthesis is language dependent.

4) It would thus help in improving the prosthesis.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

"It is impossible to know the fundamentals of a phenomenon without having solid knowledge of its origin, development and the chain of causes, conditions and circumstances determining its actual existence". [Kiml 1936]

"The great functional vulnerability of the vocal organs may, atleast in part, derive from a paradoxical situation, for the delicate task of self expression a set of structures originally was not created for this purpose. The sphincteric action of the larynx and the pharynx makes them more suitable for closure, for shutting off, than for emission". (Brodnitz, 1959)

The one form of communication which people use most effectively in inter-personal relationships is Speech. With it, they give form to their innermost thoughts, their dreams, ambitions, sorrows and joys. Without it, they are reduced to animal noises and unintelligible gestures. In a real sense, Speech is the key to human existence. It bridges the differences and distances and helps to give meaning and purpose to their lives. (Fisher, 1975)

The ability to use the vocal apparatus to express the feelings, an event and establish communication is unique to human beings. According to Boone (1985), " the act of speaking is very specialised way of using the vocal mechanism, demanding a combination or interaction of respiration, phonation, resonance and articulation.

Weinberg (1986) considers human Speech production as a diverse and fascinating endeavour, the diversity of which is highlighted by the capacity for human communication by Speech to be examined at several levels, physiological, acoustical, psychophysical, linguistic and psycholinguistic levels underlying of both production and perception of Speech. He considered these underlying levels or processes to be interrelated parts of a uniquely human endeavour. Further, he stated that major questions, issues and clinical and investigative activities to deal with the interrelationships among physiological, acoustic, psychological and linguistic levels of Speech performance.

Normal Speech production is accomplished by generating Speech sounds in the larynx at various sites in the vocal tract and differentially modifying these sounds by acoustic filtering. The normal Speech production is executed by exhaling pulmonary air to provide energy to generate sounds within the vocal tract by interrupting exhaled air with the vocal folds to produce a Quaseperoidic sound or voice. In either circumstance, pulmonary air is used to energize the source, and the sound generated is differentially modified by resonant properties of the vocal tract (Weinberg 1986).

The underlying basis of Speech is "Voice". " Voice plays the musical accompaniment to Speech rendering it tuneful, pleasing, audible and coherent and is an essential feature of efficient communication by the spodken word "(Creene,1964).

The production of Voice depends on the synchronisation between the respiratory, the phonatory and resonatory septums. Any anatomical, physiological or functional deviation in any of these systems would lead to a Voice disorder. It is well established that Voice has both linguistic and non-linguistic functions in any language. The degree of dependence of language on these functions varies from language to language. "Tone Languages" for example, rely more on the voice or pitch, more specifically than other languages.

Variations in Voice, in terms of pitch and loudness provide rhythm and break the monotony. This function establishes the voice as the carrier of Speech and draws attention in Voice disorders. Voicing (presence of Voice) has been found to be a major "distinctive" feature in almost all languages, providing more phonemes and making the language broader. The absence or 'abnormality' of this function results in 'Speech disorder".

The Voice plays an important role at the semantic level. Use of different pitches with the same string of phonemes would alter the meaning. Speech prosody,intonation, stress, rhythm of language is a function of pitch and loudness as well as phonetic duration.

Perkins (1971) has identified atleast five non-linguistic functions of Voice:

1) Speaker identity
2) Personality
3) Emotion
4) Somatic condition
5) Aesthetic function

Voice provides information regarding sex, age, height and weight of the speaker.

Lass, Brong, Ciccolella, Walters and Maxell (1980) have reported several studies wherein based on Voice, it was possible to identify the speaker's age, sex, socio-economic status, racial features, height and weight. The relationship between Voice and speaker's personality and emotional status have been reported (Starkweather, 1961; Rousey and Mariarty, 1965; Fairbanks, 1966, Huttar, 1967). It is a well known fact that Voice basically reflects the anatomical and physiological conditions of the respiratory, phonatory and resonantory systems. Voice is important for professional speakers and Singers. The basic process of phonation is well established and displays high levels of organisation in many mammals and birds (Kirchener 1988). In man, however these activities have developed into a pattern of movements involving precise co-ordination of reflexive and learned behaviors resulting in accurate, intricate manoevures executed with flexibility and Speed.

The importance of Voice in Speech is dramatically demonstrated in a laryngectomee. Loss of voice has been found to lead to psychological, social and economic problems. These get aggravated if the individual is depending on his voice for his living like in teachers, lawyers, politicians etc. Therefore restoration or providing alternate mode of voice production becomes important.

There are circumstances in which people must produce Speech using a radically altered mechanical system. Patients who have undergone total laryngectomy are in such a situation. Alternate modes of voice production in laryngectomees can be generally classified as oesophageal, artificial laryngeal and prosthetically aided tracheoesophageal. Surgical removal of the larynx is a procedure often performed on patients with latyngeal ratio-)., India figures amongst the countries of the World with a high incidence of laryngeal cancer. Laryngeal cancer is not an uncommon malignancy. Robin and Olofson (1987) reported that there is variation in its incidence across the globe, with India being among the countries with a relatively high incidence of more than 10 per l,00,000 population. Variation in incidence occurs within countries too. According to the Annual report of National cancer registry (1983) published by ICMR (February 1986), the incidence of laryngeal cancer in males per 1,00,000 population in Bombay based cancer registry was 15.2 - 6.94% of all cancers. It was low in South India centres : 5.5 - 4.9% in Madras, 9.7 - 3.8% in Bangalore. The incidence, though expected to be higher is less probably due to under reporting. Statistics from four Indian cancer registries show that the peak incidence is in the fifth and seventh decade of life (Annual report of the National cancer registry, 1983, ICMR).

Voice restoration in laryngectomies has been a challenging problem for both Head and Neck Surgeon and Speech pathologists. Total laryngectomy necessitates removal of the entire larynx.

All structures between and often including the Thyroid bone and the upper tracheal ring are resected. The trachea is rotated forward and sutured to the base of the neck to create a permanent respiratoy stand in the neck wall. Thus the total laryngectomy always results in a sacrifice of tissue essential for normal vocal function and in considerable alteration of the anatomy and physiology of the Speech mechanism. As a result, the normal processes of Speech are modified to such an extent that there is always a complete loss of the ability to produce Voice by conventional means.

Improved surgical techniques and adjunctive therapeutic measures are producing more longterm survivors of laryngeal carcinoma and facilitating voice preservation through the methods of conservation surgery; however when surgery includes total laryngectomy prolonged rehabilitation involving many disciplines may help patients to adjust to many new aspects of their daily lives and to avoid severe depression. Although the time involved in such a program may appear to be excessive, we feel it is justified in terms of improved patient care and the better long term results in terms of total patient satisfaction and rehabilitation.

A cohesive program must be developed, then be applied in a broad pattern, so that all patients who must undergo laryngectomy can afford the optimum opportunity to acheive total rehabilitation and return to their pre-morbid state of productivity (Blom & Singer, 1984).

Laryngectomised patients compensate for this loss by using alternate methods of voicing for Speech production. Compensatory approaches to Speech restoration following total Laryngectomy are:

1) Learning to produce oesphageal Speech
2) Developing Speech that is mediated, in part, on a surgical prosthetic basis and
3) To producing Speech powered by some type of artificial larynx.

OESOPHAGEAL SPEECH

The production of a laryngeal speech necessitates the use of non coventional air stream, phonatory and articulatory mechanism. This notion has implications for diagnosis and management. One of the most important implications is that the Speech reacqiusition and training involves far more than "getting the vioce back" (Weinberg, 1981).

The Laryngectomees can generate sound at three locations:

1) In the oral cavity called "Buccal speech" producing suction noises by trapping air between the tongue and cheek

2) In the pharyngeal cavity termed as "Pharyngeal speech"

3) At the lumen of the oesophagus known as "Oesophageal speech".

Of the various methods of sound production available, Oesophageal speech is the time honoured one.

Aronson (1980) stated that this mode of alaryngeal speech is based on the principle that when the air is taken into the oesophagus, sound is produced on the release of the air by exciting the upper oesophageal tract into vibration, like belching.

The main difference between normal belching and oesophageal speech according to him is that in the latter, the Speaker is higly skilled and can control the initiation and prolong the oesophageal tone. Various percentages of failures have been reported ranging from 43% (King et al, 1968) to 98% (Hunt, 1964). Snidecor (1971) reported an acquisition rate of 60-70% but more objective specific data indicates that approximately only 29% of the laryngectomies really acqiured proficiency in oesophageal communication (Gates, Ryan and Cooper, 1982).

The failures are attributed to:

1) Lack of initiation
2) Old age
3) Hearing loss
4) Dependency on mechanical device for voice productions (artificial larynx)
5) Over protectiveness of the family
6) Damage to the P.E. segment, hypotonicity or hypertonicity of the P.E. segment
7) Structure within the pharynx
8) Lingual and palatal insufficiency
9) Presence of mucosal pouches at the base of tongue and within the pharynx.

ARTIFICAL LARYNX

"An artificial Larynx is a device meant to simulate an approximation to normal laryngeal tones. They have been developed mainly for individuals who have had their larynx surgically removed. The quality of sound, the ease of use and other physical attributes vary greatly from device to device. It is difficult to evaluate these devices. The individuals ability to use a device, the extent of surgery, and the amount of training as well as many other variablers will make the output of the same device different from each patient" (Goldstein, 1982).

Goldstein (1982) categorises these devices into electronic and pnuematic, based on source of energy. The pnuematic prosthesis are of two types, External and Internal. The electronic prosthesis are classified as internal trancervical implantable.

In 1972, Taub and Spiro reported a combination of surgical - prosthetic approach to voice restoration. A fistula found surgically between the oesophagus and skin surface was linked to the tracheostoma by air pass device called 'Voice Bank' prosthesis.

Shedd (1972) developed a reed fistula method of voice restoration. This method required a surgically created fistula leading to the pharynx. An external air bypass and a pseudolarynx mechanism was inserted between the tracheostomy and the fistula.

Recent interest in the internal tracheal shunt was stimualted by the reports of Calcaterra and Jafek (1971). The method of

TRACHEO-OESOPHAGEAL SPEECH

Over the last hundred years, many have attempted voice rehabilitation with a connecting canal between the respiratory tract and the digestive tract. In the last few years, voice prosthesis have been developed to avoid aspiration via the connecting canal between the respiratory tract and the digestive tract. These prothesis allow air to flow into the pharynx and prevent leakage into the trachea. Blom and Singer (1980) gave the fundamental impetus for the development of one such new prosthesis known as Blom and Singer Prosthesis (B.S. Prothesis). The Singer-Blom Tracheoesophageal Puncture (T.E.P.) technique.

The Singer-Blom technique for voice restoration provides pulmonary air for speech by diverting exhaled air from the trachea into the oesophagus (Singer and Blom 1980). According to Blom and Singer (1980), the laryngeal speech mechanism used is conceptually simple. Through the tracheoesophageal tunnel, air flow of 100-150 cc/sec at pressure of 30-40 cm water is diverted when the stoma is covered by finger to produce vibrations in the walls of the nasopharynx producing sound. Sound is emitted from the oral cavity after passing through the articulators of the remaining vocal tract (Singer, 1983). According to Jackson (cited by Singer, 1983) " the requirements (for pseudo voice) are closely approximated membranous surfaces" and a moving column of air that can be set into vibration by the membranous surfaces. This technique utilizes a one-way valved silicone prosthesis designed by Singer, an Otalaryngologist and Blom, a speech pathologist at the Indian University Medical centre and the Veterans Administration in Indianapolis Indiana (Singer and Blom, 1979). The term Tracheoesophageal puncture (T.E.P.)has been commonly used reference to the Singer-Blom technique (Evans/Drummond, 1985).

The T.E.P. procedure as described by Singer and Blom (1980) is an endoscopic procedure where a mid-line puncture is made from the trachea into the oesopahgus. Post operatively, the surgeon and the speech pathologist select the proper prosthesis in terms of length and insert it in the puncture site immediately after removal of the stenting catheter. Voice therapy is initiated with immediate voice obtained by occluding the stoma. The patient is instructed in the care of the stoma and the prosthesis. The speech pathologist demonstrates the significance of controlled respiration, precise articulations, muscle relaxation and daily care involved in using the prosthesis.

General description of the Prosthesis

Nowadays different types of prosthesis are used by T.E.P. Speakers. All of these prosthesis have some common structural part as follows:

A hollow tube (shaft) comes in different length and diameter to allow an exact fit with each type of fistula. Generally there will be two flanges in a prosthesis to hold the device firmly into the fistula i.e. it prevents both prosthesis dislocation and leakage around the tube. Flange on the tracheal side is also called as retention collar which keeps device in close contact

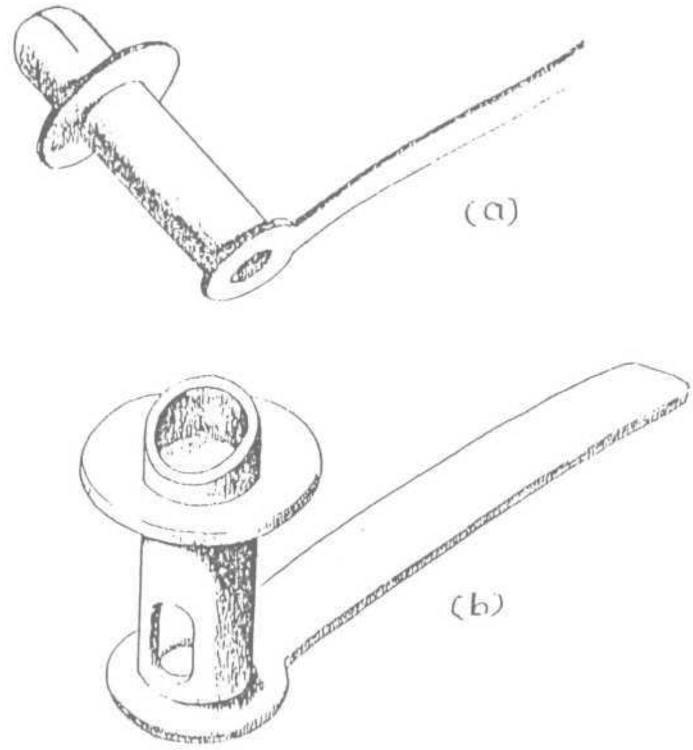


FIGURE-1: Blom-Singer's Prosthesis
(a) Duck-bill prosthesis
(b) Low-pressure prosthesis.

with the tracheal mucosa. Oesophageal side flange helps in holding the device firmly and preventing its falling into the trachea. A slit or valve is present in the flange which acts as a one way valve. It remains closed during swallowing and opens only under low positive endo-tracheal pressure to divert air into the hypopharynx for speech production (See figure]).

Blom-Singer (B.S.) Voice Prosthesis

Singer and Blom (1980) introduced a method of T.E.P. and silicone "Duckbill" voice prosthesis for voice restoration following total larynngectomy. Details of this prosthesis and other prosthesis are gioven in Appendix II. Weinberg and **Moon (1984), Sullivan (1983)** reported that total airway resistance offered by duckbill prosthesis ranged from 106.5 to 117.5 cm of water per litre per second (L.P.S.)

"A Silicone device (Voice button) was developed by **Panje (19810** to prevent aspiration and stenosis and allowing vocalization. The device is 1.5cm long. An insertor must be used which is made of wire and comes in various handle lengths to accomodate patient dexterity in order to place the voice button". Advantages of voice button over B.S Prosthesis is accomplished with an outpatient surgical procedure requiring no special instrument, the prosthesis is self contained with in the tracheostoma, it can't be dislodged unintentionally and no sizing is needed. But the limitation is that the size of the tracheostoma must be atleast 1.5cm in diameter. Voice buttons are of two types:

a) Short type which emanates 6 mm from the inner flange, has a 4 flutter flap, one-way valve used most frequently.

b) Long type is for patients who cannot generate sufficient lung pressure for good long term vocalization and for same patient it is easier to insert than short type.

In 1982, Blom, Singer and Hamakar introduced a prototype low-pressure voice prosthesis especially designed to reduce the airway resistance inherent in the duck-bill prosthesis. A series of **studies (Weinberg and Moon 1982, Smith 1986)** have demonstrated tat low pressure type prosthesis have a lower resistance to air **flow than** the original duck-bill voice prosthesis when listed in vitro.

Nijdam Excajadillo (9184) developed a new prosthesis for vocal rehabilitation after laryngectomy called Groningen Prosthesis. **The prosthesis** is placed inthe T.E. wall as a primary **procedure** during **laryngecotmy** and as a secondary procedure sometime after surgery. The prosthesis is self-retaining and self cleaing. It's replacement is by a simple outpatient procedure **(Mannri, Brock, Groot and Berends, 1984).** Success rate of 73% was reported.

Henly-Cohn (1984) recently described a new prosthetic valve for use in the vocal rehabilitation of laryngectomized patients. The major advantages were:

1) One size of the device fits all patients provided the fistula is properly located.

2) Once inserted, the device can be retained in patients for 2-3 months without cleaning. The feature of the device is attributed to both the material used to make the device (HRT doped silicone which resists crusting and deterioration) and to the design of the device (self cleaning lip and medially placed retention flanges which diminish the extrusive forces associated with the neck rotation and flexion).

3) The device is said to offer less resistance to air flow than either B-S or Panje Voice button prosthesis. The average total resistance of the H-C prosthesis was 68.5 cm water/LPS, 126 cm water/LPS for the B-S prosthesis and 194 cm water/LPS for the Panje Voice button. The lower resistance of the H-C prosthesis was shown to be due to both its large inner cross sectional area and to an improved valve tip design. This should result in more "efficient" production of oesophageal voice than the B-S prosthesis or Panje devices.

T.E. Laryngeal Device Comparison

Table 1: Showing comparison of B.S, Panje and H.C Prosthesis on Different characteristics

{Characteristics	Bivona B.S.	Xomed Panji	Dow Corning H.C.
1) Opening Pressure	Low	High	Very low
2) Air flow	Medium	Low	High
3) Extrusion rate	High	Low	Low
4) Stoma destruction	Yes	No	No
5) Valve crusting	High	High	Low
6) Self care difficulty	Moderate	Moderate	Minimal
7) Post-op visits	Many	Many	Few
8) Patient training	Moderate	Moderate	Minimal
9) Speech fluency	Good	Fair	Very Good
10) Speech volume	Good	Fair	Very Good
11) Speech strain	Some	Moderate	Minimal
12) Device removal	Daily	Daily	2-3 mts

All these prosthesis show several disadvantages like difficulty in routine maintainance and irritability, problems in fitting into the fistula (especially after surgery). Some types are easily ejected from the fistula because the endoesophageal flange is too small and thus, unable to hold the device securely into the fistula. Others with too narrow an endoesphageal retention collar, don't prevent aspiration or leakage along the fistula wall, still others greatly impede speech. It was with this in mind that a new silicone T.E. Voice button was developed by Mario Staffieri and Alberto Staffieri (1986). This new Voice button displays very good aspiration control and very low impedance with no maintenance problem.

Presently many prosthesis for voice rehabilitation, such as the B.S prosthesis, the Panji button and the Groningen Button are available. The major difference between the DS and Panje devices and the Groningen prosthesis, is the patients' role in prosthesis replacement. The BS and Panje devices need to be changed regularly by the patient, whereas the Groningen button is self retaining. This latter feature ensures easier patient instructin and maintenance, because replacement techniques donot have to be practiced. For the above mentioned reasons, the Groningen button is considered a valuable addition to the B.S prosthesis. The major drawback of the Groningen button is its relatively high airflow resistance (Hilgers and Schouwenburg, 1990).

Priorities for further developement of the methods and instruments for prosthesis voice rehabilitation have led to the design of a low resisitance, self retaining voice prosthesis. The results obtained in 79 patients are described by the airflow resistance ranged from 1.6 to 3.8 KPa (mean = 1.9 KPa) and the speech quality was good in 91% of the patients. The self-retaining properties of the prosthesis appeared to be satisfactory. The average device life was more than 5 months.

The new low resistance, self retaining Provox voice prosthesis and the modified repalcement method appeared to further improve the results of prosthetic voice rehabilitation after total laryngectomy.

In 1991, Zijlstra, Mahieir, Van lith,Bigl and Schultz 1991 developed low resistance Croningen button. Previously mentioned standard Croningen button had very high opening pressure, 50 to 150 mm Water. But this low resistance Croningen button needs very low opening pressure,(i.e) 3 to 5 mm Water.

As per review of literature these are the different types of prosthesis used for voice restoration after laryngectomy. Each prosthesis has its own merits and demerits. The disadvantages of prosthesis has led to the developement of new prosthesis. Recently developed like provox, low resistance Groningen button etc. have been found to overcome the drawbacks of many other previously mentioned prosthesis.

Attempts have been made to develop Fingerless Voice Restoration.

Not only voice loss but also the existence of a permanent tracheostomy are severe handicaps of laryngectomy. For that more than 20 years, various surgical techniques for post laryngectomy voice restoration have been described. Main aim has been to achieve:-

1) Intelligible fluent speech with good modulation, no aspiration and without closing the tracheostomy with fingers.

2) The construction of the respiratory tract without a permanent tracheostoma.

The Blom-Singer tracheostomy valve (Blom-Sinqer and Hamaker, 1982) developed to eliminate manual occlusion of the stoma enabling "Hands free speech". It consists of a curved latex diaphragm that is sensitive to variation in air flow. During tidal respiration, it remains fully open; as air flow increases for speech, the diaphragm closes against the inner rim of the valve assembly and occludes the tracheostoma, thus diverting air into the oesophagus. The valve automatically reopens when exhalation decreases at the completion of a single speech utterance.

<u>Hermann tracheostoma valve</u>:- This tracheostoma stent is made up of a cannula part and three different types of outer silicone rings to retain the tracheostoma stent. The stent itself is made of very soft silicon and has no magnet. The cannuala part of the tracheostoma valve is identical in shape to the tracheostoma stent. The flap valve contains a metal piece located off centre and is controlled by a magnet fixed in the cannula part. The sensitivity of the tracheostoma valve can be adjusted to individual needs by turning the flap valve.This valve overcomes the problem seen with the B.S Valve (ie) tracheal secretion occludes the stona valve.

Rubert (1986) reported a case who learned to close his tracheal stoma by the actual contraction of his platysma muscle.

<u>Indian Prosthesis</u>: The first Indian prosthesis was developed by Hazarika, Rajshekar and Ajit (1992) known as HRA Slit-valve voice Prosthesis. It has been designed keeping in mind, the tropical nature of India's climate as well as durability and cost effec-

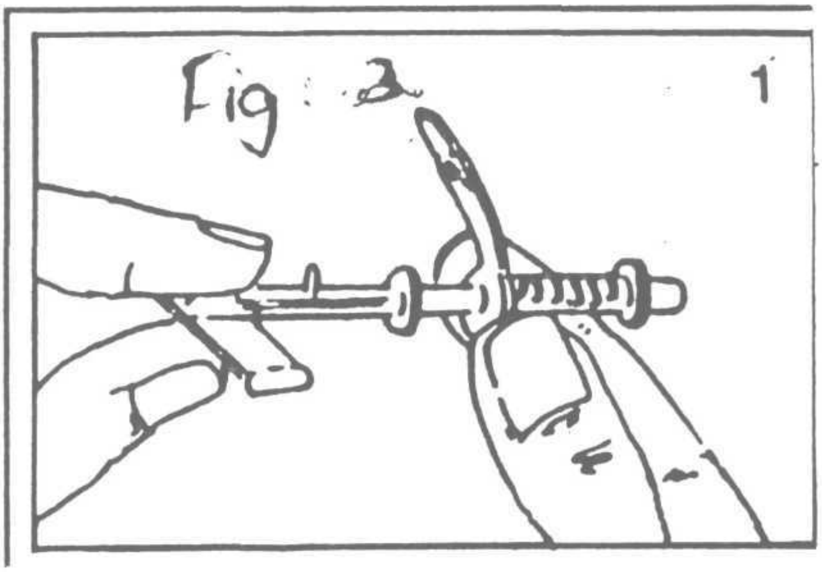


Fig : 2

tiveness. It is a silicon one-way valved device for voice restoration in laryngectomy. The prosthesis is inserted into the puncture between the trachea (Windpipe). Unlike Western Voice restoration devices, the HRA device has bellows on its shaft and special reinforcement for the retention collar. This is to ensure smooth airflow into the oesophagus and avoid prosthesis dislodgement during voilent coughing. Thus the prosthesis is designed to keep the puncture patent (open)', permit air to flow from the windpipe to the foodpipe, thus producing voice and also to prevent oesophageal leak into the trachea (during swallowing) [Figure III].

Primary and secondary Tracheosophageal puncture

Primary T.E.P. is defined as "Voice restoration at the time of laryngectomy" and secondary T.E.P. as "Voice restoration at a time subsequent to total laryngectomy". Singer et al (1983) reported a success rate of 63% and Hamaker, Singer, Blom and Daneils (1985) 69% in their series of Primary T.E.P. cases. The continued use of Primary T.E.P. procedure was limited by the inability of the newly laryngectomized patient to manage a tracheostoma puncture and prosthesis simultaneously.

Perry, Cheesman, McIvar and Chaltan (1987) reported that 94% of their patients who underwent secondary voice restoration were successful by two weeks after surgery but his success rate dropped to 73% by 3 months. The results in the primary series (Perry 1988) were 94% at 3 months after surgery.

tiveness. It is a silicon one-way valved device for voice restoration in laryngectomy. The prosthesis is inserted into the puncture between the trachea (Windpipe). Unlike Western Voice restoration devices, the HRA device has bellows on its shaft and special reinforcement for the retention collar. This is to ensure smooth airflow into the oesophagus and avoid prosthesis dislodgement during voilent coughing. Thus the prosthesis is designed to keep the puncture patent (open), permit air to flow from the windpipe to the foodpipe, thus producing voice and also to prevent oesophageal leak into the trachea (during swallowing) [Figure III].

Primary and secondary Tracheosophaqeal puncture

Primary T.E.P. is defined as "Voice restoration at the time of laryngectomy" and secondary T.E.P. as "Voice restoration at a time subsequent to total laryngectomy". Singer et al (1983) reported a success rate of 63% and Hamaker, Singer, Blom and Daneils (1985) 69% in their series of Primary T.E.P. cases. The continued use of Primary T.E.P. procedure was limited by the inability of the newly laryngectomized patient to manage a tracheostoma puncture and prosthesis simultaneously.

Perry, Cheesman, McIvar and Chaltan (1987) reported that 94% of their patients who underwent secondary voice restoration were successful by two weeks after surgery but his success rate dropped to 73% by 3 months. The results in the primary series (Perry 1988) were 94% at 3 months after surgery.

Wenig, Mulloly, Levy and Abramson (1989) commented that primary and secondary punctures were equally effective in permitting the developement of T.E. speech. They reported that the incidence of complication associated with primary T.E.P. is slightly higher than that seen with the secondary group. Hrizarika, Murthy, Rajashekhar and Kumar (1990) advocated the use of secondary T.E.P. owing to its high success rate (90%) and the time at the disposal of the patient to learn oesophageal mode of laryngeal speech if he is interested.

Pharyngo Esophageal (PE) Segment function assessement

The elements involved in laryngeal speech production are different from the normal laryngeal speech. Table II shows the different elements involved in laryngeal speech (both oesophageal and T.E.P.) compared with laryngeal speech.

Table II: (Adapted from Edels, 1983, Different elements involved in laryngeal speech (both Oesophageal and T.E.P.)

Physical requirements	Laryngeal Voice	Oesophageal voice	T.E. voice
1) Initiator	{Moving column !of air from {lungs	Moving column of air from Oesophagus	Moving column of air from lungs
2) Vibrator	Vocal cords	PE segment	PE segment
3) Resonator	Vocal tract (i.e. Px nose mouth)	Vocal tract	Vocal tract
4) Articulators	Tongue,teeth, lips, soft palate	Tongue,teeth, lips, soft palate	Tongue,teeth, lips, soft palate

The P.E. segment or sphincter is vibrated in both Oesophageal and T.E. speech. Conversely with good P.E. function, the main advantage of the T.E. speech is the increased air reservoir of the lungs allowing louder and more sustained speech.

Seeman (1967) demonstrated that in some patients, air escapes easily through the P.E. sphincter with an audible sound as soon as the pressure is built upto 10-30cm of water. However, in some patients, the sphincter fails to relax even at pressures exceeding 100cm of water. This has been attributed to the presence of functional spasm in the pharyngeal musculature. This spasm directs the built in air towards the stomach instead of pharynx, causing gastric filling and no voice production. This factor has been amply demonstrated in cineflurographic studies(Singer and Blom 1981; Hazarika, Murthy, Rajashekar 1983). It has been demonstrated that laryngectomles with P.E. spasm are at risk for T.E. speech acquisition. Hence its mandatory to establish the presence or absence of the spasm.

Oesophageal Insufflation test

The Oesophageal Insufflation test as described by Blom et al (1985) is performed with a disposable system consisting of a special 50 cm long, No.14, French latex catheter inprinted with a 25 cm marker, a flexible circular tracheostoma housing, adhesives and an insertable stoma adaptor. The patients nostril is sprayed with a toopical anaesthetic and the rubber catheter is transnasally inserted into the oesophagus, until the 25cm marker resides at the nostril. This is to ensure that the tip of the catheter is within the upper thorasic oesophagus. The proximal end of the catheter is then attached to the adaptor which is inserted into the tracheostoma housing. The patient is required to do an inhalation, light stoma occlusion and attmept ! a ! phonatin or exhalation. The patient is trained till he is used to the procedure. If the patient can sustain phonation without interruption for 8 seconds or longer and can count from 1-15, then he is said to have passed the test. The interpretation is that he apparently has no pharyngeal constriction and is considered an ideal canditate for T.E. puncture and B.S prosthesis fitting. If the patient cannot sustain phonation of ! a ! for atleast 8 seconds or phonate at all, then he is said to have failed in the test and needs a pharyngeal myotomy along with puncture for good voice.

Though controversial pharyngeal myotomy is reported to facilitate the developement of voice production (Singer and Blom 1981; Chodosh, Gian Carlo and Goldstein 1984; Henley, Sobera 1986). An assessement protocol to successfully assess the P.E. segment function, using video fluroscopy and radiological techniques in patients undergoing secondary tracheoesophageal puncture has been reported (Cheesman, Knight, Me Ivar and Perry 1985; Perry, Cheesman, Me Ivar and Chalton 1987; Mc Ivar, Evan, Perry and Cheesman 1990).

Aerodynamic and Myoelastic contributions to Alaryngeal Speech

Normal voice production is an aerodynamic - myoelastic event (Van den Berg, 1958). For example, alterations in respiratroy drive and the byproducts there of (Glottal volume flow, Subglottal pressure) mediate sound production at the level of the larynx

(Atkinson, 1978; Collier, 1975; Ohala, Hirano, 1970). According to Moon and Weinberg (1987), Voice source is controlled or mediated solely on the basis of aerodynamic influences could be operationally be described as a "Passive " resonant device. They felt that such a device would not be capable of intrinsic and systematic myoelastic adjustments. Alterations in myoelastic properties of the vocal folds also mediate sound production at the level of the larynx (Atkinson, 1978; Bacr, Gray and Nuini, 1976; Collier, 1975; Hirano, Ohala and Vinnard, 1969; Monscn et al, 1978). A Voice source controlled as a whole, or in part, on the basis of intrinsic and systematic myoelastic adjustments could be described operationally as an "active" voice source. Laryngectomy necessitates the use of alternate structures for voice production. Two major forms of alaryngeal speech, oesophageal and tracheosophageal use the upper oesophageal sphincter as a substitute voice source. The phonatory apparatus used by these speakers is different from that used by normal speakers.

Angermier and Weinberg (1981) have stated that "there is no evidence to support the view that laryngectomized individuals are capable of altering the level of muscular activity within the P.E. (Pharyngoesophageal segment) on a systematic basis to pre-tune control or influence the vibratory rate of this sphincter" (Vanden Berg and Modenar Bizl, 1959).

Snidecor and Isshiki (1965) have suggested that oesophageal voice production is an aerodynamically mediated event. Accurate non-invasive measurement of source driving pressure and trans-source, air flow rate permitting systematic appraisal of physiological mechanisms underlying production and control of oesophageal voice are now feasible.

Moon and Weinberg (1987) carried out a series of phonatory tasks in tracheoesophageal speakers to assess (a) aerodynamic and acoustic properties of tracheoesophageal vioce and (b) aerodynamic and myoelastic contributions to the mediation of fundamental frequency change. Data from their study could be integrated with existing information to highlight some fundamental differences among normal, tracheosophageal and oesophageal voice production. Sustained Vowels by normal speakers at comfortable levels typicaaly are associated with source driving pressures ranging between 5 to 10 cm water, trans-source airflow rates ranging between 100 to 200 cc/s, and airway resistacne ranging from 45cm water/LPS (Litres/seconds). Vowels produced at comfortable levels by tracheoesophageal speakers were typically associated with source driving pressures ranging between 20 and 50 cms. Water, trans-source airflow rates ranging between 110 and 335 cc/s, and airway resistance ranging from about 142 to 383 cm water/LPS. Moor and Weinberg (1987) reported that though directly comparable data during sustained production of vowels by oesophageal speakers were not available, Snidecor and Isshiki (1965) had shown that trans-source air flow rates during oesophageal voicing ranged between 25 and 72 cc/s, while Datnste (195H) had shown that oesophageal source driving pressure typically ranged between 15 and 60 cm water.

Moor and Weinberg (1987) on the basis of these observations reported that tracheoesopahgeal voice production was generally characterized by:

a) Increased trans-source airflow rates, comparable to oesophageal source driving pressure and decreased airway resistances comapred with conventional oesophageal voice production and

b) Comparable to normal trans-source airflow rates, increased source driving pressures and increased airway resistance when compared with normal voice production. These observations according to them, marked fundamental differences that existed between these three forms of voice production. Both normal and tracheoesophageal voice production use pulmopnary airflow, and both are accompanied with a closed tracheal airway. On the other hand, conventional oesophageal voice production doesnot use pulmonary air to move the voicing source and is accomplished with an open tracheal airway.

A major finding in their study was that the tracheoesophageal speakers were capable of varying Fo in association with negatively related variation in trans-source airflow rate. This finding doesnot confirm the views expressed by Vanden Berg, Moolenaasa-Bift, Damste (1958) and Angertneier and Weinberg (1981). Their results, coupled with findings that aerodynamics contributes to TE phoantion, are interpreted to suggest that tracheoesopahgeal voice production should be regarded as an aerodynamic myoelastic event. Similarly, the role and airway resistances in laryngeal voice production has been the area of interest to many investigators and relevant information has accumulated over the recent years.

Analysis of Voice

Numerous studies have been done to understand the mechanism of voice in normal laryngeal speakers. A lot of interest has been shown by researchers to understand the mechanism of alaryngeal voice, the mode of communication for laryngectomees. The mode of alaryngeal voice aided with different prosthesis like B.S prosthesis, Panje button, Groningen prosthesis etc., have been studied by few investigators. The studies have concentrated on speicific areas like paramters of frequency, duration and intensity . Exhaustive studies considering all the relevant parameters and their contribution to intelligibility and acceptability are limited. Hence, there is a need to identify the factors influencing the intelligibility of this mode of alaryngeal speech.

Michel and Windahl (1971) and Hirano (1981) have emphasized the need to use as many parameters of voice as possible in assessing voice and its disorders. Michel and Windahl (1971) considered voice as a multidimensional series of measurable events and suggested 12 parameters for assessing voice. Others (Imaizumi, Hiki, Hirano and Masushita, 1980; Kim, Kakita and Hirano, 1982) have suggested different parameters to study voice and its disorders. Some of the parameters suggested by these have been used by Natraja (1986) to find the possibilities of differential diagnosis of dysphonics. These parameters have been reported to be useful in differentiating different types of Voice. Similar parameters have been used by shipp]' (1967), Rajashekar (1991), Hariprasad (1992), Sanyogeetha (1993) to study oesophageal speakers. Robbins et al (1984), Rajashekar (1991), Hariprasad (1992) have compared the T.E. speakers with oesophageal and laryngeal speakers in frequency, intensity and temporal measures. Santhosh (1993) has compared T.E. speakers with different types of prosthesis in frequency, intensity , temporal and spectral measures.

The parameters considered in the present studies were:

1) Acceptability (ACPTL)

2) Intelligibility (INTL)

Acoustic paramters

Frequency

3) Fundamental frequency (Fo) in Phonation (!a!, !i! & !u!)

4) Extent of fluctuation in Fo in phonation (!a!, !i! & !u!)

5) Speed of fulctuation in Fo (!a!, !i! & !u!)

6) Frequency range (FR) in phonation (!a!, !i! & !u!)

Intensity

7) Intensity range (IR) in phonation (!a!, !i! & !u!)

8) Extent of fluctuation in intensity in phonation (!a!) !i! & !u!

9) Speed of fluctuation in intensity in phonation (!a!, !i!, !u!

Temporal measures

10) Words per minute - Paragraph

11) Syllabus per minute - Paragraph

12) Percentage of pauses - Paragraph

13) Number of Pauses - Paragraph

14) Mean Pause time Paragraph

15) Vowel Duration - Word list

16) Voice Onset time - Word list

These parameters were studied to determine their relationships with aerodynamic and physiological function of the vocal mechanisms and their contribution towards perception of voice/speech. The frequency parameters enable asessement of the contribution of pulmonary source of air in T.E speakers to loudness and its stability. Temporal parameters determine the effect of pulmonary air on the P.E. segment. All these parameters, singly or in interaction with each other are considered to be affecting the intelligibility and acceptability of alaryngeal speech. The effect these of parameters on the intelligibility and acceptability of speech in alaryngeal speakers has not been given much importance. Hence, all these parameters have been considered in this study.

The following review highlights the importance of each parameter in the assessement of speech of the laryngeal speakers.

Acceptability of Alaryngeal speakers

Clinical utility of any alaryngeal voicing technique lies in its intelligibility and acceptability. Many studies have been carried out to find out acceptability ratings for oesophageal speakers, T.E.P. speakers, Speech using artificial larynx. But not many have been carried out to study the acceptability rating of T.E.P. speakers with different prosthesis i.e. comparative study of different prosthesis.

The work of Shjpp (1967) and Honps and Noll (1969) have been shown that variable such as rate of Speech, Phonation time, high mean fundamental frequency and severity of stomal noise ratings are significantly related to judgements of speech acceptability. Rajashekar et al (1990) in a single laryngectomies case found that T.E. Speech was more acceptable than oesophageal because of:

1) Increased intensity and rate
2) Reduced pauses and extraneous noises.
3) Better quality

Hazarika et al (1990) studied the Speech proficiency profile of their T.E.P. patient fitted with B.S. voice prosthesis. The acceptability of their Speech was judged as "fair" and only one as "poor". It was hence decided to identify those factors whcih contributed to the acceptability of alaryngeal Speech. Rajashekar (1991) reported that L.P. aided T.E. speakers were more acceptable to the listeners than oesophageal speakers. Santhosh (1993) reported that no significant difference were observed across different prosthetic condition in T.E. speakers, however, Indian Prosthesis aided T.E. speakers showed better acceptability score than the other two groups (Duck-Bill and Blorn-Singer's low pressure prosthesis.

Intelligibility of Alarynqeal Speech

Comprehensive data about articulatory changes as a result of the removal of the larynx is lacking. There is experimental evidence to support the notion that total laryngectomy does alter articulatory behaviour. Weinberg (1986) opines that total laryngectomy disrupts muscular support for the tongue, brings out major changes in articulatory, aerodynamcis and alter the vocal tract morphology. Singer (1983) noted that T.E. speakers were more intelligible although the differences decreased in quiet listening condtions.

Tardy, Mitzell, Andrews and Bowman (1985) studied the acceptability and intelligibility of T.E. Speech. They observed a mean intelligibility score of 93% in T.E.P. speakers. There was no significant differences among groups (Duck-Bill prosthesis, Blom-Singer's Low pressure prosthesis and HRA prosthesis) except L.P. aided T.E. speakers who differed significantly from D.B. aided T.E. speakers and obtained highest score and D.B. aided obtained least score.

ACOUSTIC MEASURES

Frequency

a) Fundamental frequency (Fo) in phonation

Fo is the lowest frequency that occurs inn the spectrum of a complex tone. In human voice also, the lowest frequency in the voice spectrum is known as the fundamental frequency. "Both quality and loudness of voice are mainly dependent upon the frequency of vibration. Hence it seems apparent that frequency is an important parameter of voice "(Anderson 1961).

"Emrickson (1959) " opines the vocal cords are the ultimate determiners of pitch and that the same general stracture of the cord seem to determine the range of frequencies that one can produce . The perception of pitch and measurement of fundamental frequency are based on the systematic opening and closing of the vocal folds during the production of voiced speech signals. Hence, when fundamental frequency is measured acoustically, the process is actually to count these openings and closing of the vocal folds by some objective methods."

"Evaluation of the fundamental frequency in phonation maynot represent the fundamental frequency used by an individual in Speech. Studies have shown that the Fo in phonation and speech are different (Natraja and Jagadeesha, 1984). Hence determination of fundamental frequency in speech using an adequate speech sample becomes important. Using a reading tasks rather than spontaneous speech has no advantage for comparison between speakers if th

Variation in Fo plays an important role in Speech and has been studied as intonation. The study of Fo has important clinical implications.

Number of studies have been undertaken to specify the Fo characterisitcs in alaryngeal speakers. Fo of oesophageal speakers is too narrow.

Attempts have been made to extract the Fo in T.E.P. Speakersfitted with B.S voice prosthesis as follows:

Table 3: The Mean Fo in T.E.P. speakers reported by different investigators

Investigators	Mean F_o (H_3)
1) Singer (1983)	64 - 81
2) Robbins et al (1984)	82.8
3) Blood (1984)	89.3
4) Mac Curtain & Christopherson (1985)	70 (Mode)
5) Hammarberg & Nord (1989)	84 - 125
6) Zanoff et al (1990)	100
7) Rajashekar et al (1990)	92
8) Rajashekar et al (1991)	110.7

Zanoff, Wold, Montagui, Kruegers and Drummond (1990) analysed T.E.P. Speech with and without the tracheoestoma valve (singer et al, 1982) in nine patients. No statistically significant difference was found between the two speaking conditions.

Santhosh (1993) reported the mean Fo and range in T.E.P. speakers using different types os prosthesis.

Table 4: The mean, S.D. and Range of F_o (HZ) in phonation of

!a! !,! ! i ! and _!u! for normal, Duck-bill, Low-pressure and Indian Prosthesis groups

GROUP	{Mean (HZ)	S.D.	Range (HZ)
Normal:			
: a :	156.4	22.63	128-171
: i :	170.4	31.18	135-200
: u :	166.4	31.15	116-195
Duck-Bill:			
; a :	84.57	30.38	43-125
: i :	98.84	41.98	53-156
: U :	90.05	38.32	46-154
Low Pressure:			
: a :	77.69	26.21	44-123
: i :	81.50	23.33	58-124
: u :	85.45	35.42	45-159
Indian Prosthesis:			
: a :	85.47	35.6	42-127
: i :	93.67	37.32	52-143
: u :	99.27	40.9	55-150

In this study, attmept has once again has been made to study F_o in phonation using different types of prosthesis.

b) Intensity

Loudness, a perceptual co-relate of intensity is essential for speech to be audible and thus be intelligible. Isshiki (1964, 1965) considered vocal intensity to be depoendent ona n interaction of subglottic pressure and the adjustment status and aerodynamic at the level of the vocal folds as well as vocal tract status. The range of intensities at which voice can be produced is a measure of the limits of adjustment of the phonatory system and therefore, has been proposed as a potentially important measure in the assessement of voice (Michel nnd Wertdahl, 1971). The intensity level of connected speech shows large fluctuations over short time intervals, because speech contains period of silence and the intensity is varied for syllable and word stress (Liberman 1960, Fry 1955). Further, different phonemes are characterized by different acoustic power i.e. intensity.

The SPL of connected speech in normals lies in the range of 70dB (Hyman, Laes, Robbins et al 1981) and Singer (1983) reported considerably lower intensity in oesophageal speakers compared to T.E.P. speakers.

Pauloski et al (1989) mean intensity (reading in dBSPL) for those conditions were:

73.19 - Duck-Bill with valve

73.57 - Duck-Bill without valve

73.74 - Low Pressure with valve

73.41 - Low Pressure without valve

These parameters not has been considered in the present study. It is known that intensity in speech is affected by several factors like environmental noise, context of speech, hearing sensitivity of the individual. Further, factors involved in recording like Microphone, Mouth distance, sensitivity of the microphone affect this parameter.

c) Fluctuation in Fundamental Frequency and intensity in Phonation

Presence of small perturbations or irregularities of glottal vibrations in normal voice has long been known through oscilloscope anlaysis of acoustic pressure waves and through laryngoscopic high speed photographic investigations (Moore and Van Leden 1958). In abnormal vocal production, aperiodic laryngeal vibratory patterns have been reported (Carhart, 1938, 1941; Bowler 1964).

Variations in Fo (period) and amplitude of successive glottal pulses, in particular are often referred to as "jitter" and "shimmer" respectively. Because of their minute nature, their measurements were time consuming and difficult. Even with recent research their neurophysiological and perceptual significance are not well understood (Heiberger and Horii, 1982). However, these measures have been useful in describing the voice characteristics of both normnal; and pathological speakers and used for early detection of laryngeal pathology (Koike 1973; Zyski, Bull, McDonald and Johns 1984; Liberman 1963).

Shimmer is defined as "variations of peak amplitude in successive glottal pulses" (Herberger and Horii, 1982). Shimmer, in any given voice is dependent at least upon the modal frequency lvel, the total frequency range and the SPL relative to each individual voice (Michel and Wendahl 1971). During normal voice production, the vocal folds vibrate in a synchronous quasioeriodic manner in which small cycle to cycle variation in frequency and amplitude of vibrations occurs. Non-pathological speakers appear to have an average jitter of approximately 1% or less (Jacob, 1968; Hollein et al 1973; Koike 1973). Likewise overall average shimmer has been found to be 0.39dBSPL for the three vowels :a:, :i: & :u:.

"Studies to investigate the relationship between pitch and amplitude perturbations and pathological conditions in the larynx like recurrent laryngeal nerve palsy advanced carcinoma have been studied and concluded that significant differences were found compared to the normals" (Liberman 1961; Kim et al 1982; Koike 1969; Yoon et al 1984). " Natraja (1986) studied the voices of normals and dysphonics and reported significant differences between normals and dysphonics."

Liberman (1963) prosposed an index which he called the perturbation factor which is the precentage of all perturbations, equal to an greater than a half milli seconds (0.5 ms).

Jitter ratio (JR) a relative measure which takes into account the dependence of absolute jitter size as F level is obtained using a formula, proposed by Smith, Weinberrg, Feth and Horii (1978) a formula, proposed by Smith, Weinberrg, Feth and Horii (1978)

JR = xj /xp x 1000

xj = mean jitter in ms

xp = mean period in ms

Several studies to investigate the pitch and amplitude perturbation in alaryngeal voices have been done. Most of them concludes that jitter ratio is maximum in oesophayeal speakers and minimum in normal laryngeal speakers. The T.E. speakers exhibited intermediate levels.

Robbins et al (1984) obtained the mean jitter ratio and directional jitter during sustained phonation in groups of laryngeal, oesophageal and T.E. speakers..[s]

Table 5: The MJ, JR and DJ in Normal and T.E. speakers

Jilter	Mean (MJ)	JR Jilter (DJ)	Directional
Laryngeal	MJ = .1 SD = .1	JR = 7.7 SD = 5.1	DJ = 54.3 SD = 8.6
T.E.	MJ = .7 SD = .6	JR = 51.4 SD = 46.8	DJ = 63.4 SD = 9.3

Kinishi and Amatsu (1986) measured pitch perturbation of alaryngeal voices after the Amatsu T.E. shunt operation. They reported mean jitter of 0.07, 0.47 and 0.82 ms and Jitter ratio of 10, 30 and 60 for laryngeal, T.E. and oesophageal group respectively.

These studies conclude that T.E. speech using exhaled pulmonary air is more stable than conventional oesophageal speech. According to them, the stable air supply (pulmonary) in T.E.P. contrib-

Pauloski, Fisher, Kempster and Blom (1989) compared T.E. Speech produced under 4 prosthetic / occlusion speaking conditions in 12 males and 12 females subjects. The speaking conditions were:

1) Duck-Bill prosthesis with digital occlusion
2) Duck-Bill prosthesis with tracheostoma valve
3) Low pressure prosthesis with digital occlusion
4) Low pressure prosthesis with tracheostoma valve

The mean directional jitter (%) in these 4 conditions were:

70.79 = Duck-Bill with valve

68.76 = Duck-Bill with digital occlusion

68.57 = Low pressure with valve

68.98 = Low pressure with digital occlusion

Zanoff et al (1990) compared acoustic and temporal measures in 9 male T.E. speakers with and without the valve. The mean pitch perturbation in sustained vowel was 9.44% (SD = 7.20) and with the valve, 8.56% (SD = 3.84).

Trudeau and Qi (1990) reported a mean jitter, jitter ratio and directional jitter of 1.78 msec, 134.8 and 63.2% respectively in 10 female T.E. speakers. Comparing the values with those for male T.E. speakers in the study by Robbins et a] (1984), they stated that the females demonstrated large jitter and jitter ratio, Rajashekar et al (1990) from a study of two modes of alaryngeal speech in a single laryngectomee reported that the extent of fluctuation in Fo was higher in the oesophageal mode

(19 HZ) as compared to the T.E. mode (9.2 HZ). The speed of fluctuation in Fo was 36 in the oesophageal and 14 in T.E. mode. They attributed these higher values in the oesophageal mode to less stability in Fo control during sustained phonation. Rajshekar (1990) from a study of 20 L.P. aided T.E. speaker and 20 oesophageal speaker in Fo was 13.3 HZ in T.E. speaker and 10.4 HZ in oesophageal speakers and speed of fluctuation in Fo was 14.6 HZ in T.E. speakers and 16.5 HZ in oesophageal speakers. The presence of greater values of extent and speed of fluctuations in phonation in both the groups suggested that availability of pulmonary air supply to the T.E. speakers didnot improve the vibratory patterns at the pseudoglottis. Santhosh (1993) from a study of five T.E.P. speakers using different types of T.E. prosthesis (Duck-Bill, Low pressure and HRA prosthesis) reported that there was significant difference in the extent and speed of frequency fluctuation in phonation in all the three vowels but there was no difference within different types of prosthesis. This indicated less stability in the control of fundamental frequency in phonation in T.E. speakers..lsl

Table 6: The mean Speed F.F. in T.E. speakers reported bydifferent investigators

Investigators	Mean Speech F.F. (HZ)
Rajashekar et al (1990)	14 (L.P.)
Rajashekar (1991)	14.6 (L.P.)
Santosh (1993)	19 (D.B.) 18.23 (L.P.) 20.17 (I.P.)

Table 7: The mean Extent F.F. in T.E. speakers reported by different investigators

Investigators	Mean Extent F.F. (H) 3
Rajashekar et al (1990)	9.2 (L.P.)
Rajashekar (1991)	13.3 (L.P.)
Santosh (1993)	19.17 (D.B.) 18.06 (L.P.) 30.82 (I.P.)

d) Intensity perturbation

Robbins (1984) revealed that both the alaryngeal groups demonstrated greater mean shimmer and shimmer SD in their vowel production relative to the laryngeal speakers. The oesophageal group presented the most deviant values. However, directional shimmer values and SD for directional shimmer were higher for the T.E. speakers than normals. Based on the result, they concluded that the difference in anatomic-physiologic mechanisms used by the alaryngeal groups for production of voice were not only different from those employed by laryngeal speakers but were substantially different from those employed by each other. Pauloski et al (1989) reported lower shimmer values in T.E. speakers, who used low pressure prosthesis and spoke by digital occlusion. The directional shimmer (%) in those 4 conditions were:

70.52% - Duck bill with valve

65.14% - Duck bill without valve

67.50% - Low pressure with valve

66.89% - Low pressure without valve

The female T.E. speakers in the study by Tiundean and Qi (1990) indicated greater amplitude perturbations than the male speakers of Robbins study (1984). Rajashekar et al (1990) reported that the extent of fluctuation and speed of fluctuation, a gross measure of the amplitude perturbation were greater in the oesophageal mode than T.E. mode, in a laryngectomee, who proficiently used both these modes. Rajashekar (1991) found extent of fluctuation in intensity in phonation of :a: was 3.3 dB in L.P. aided T.E. speakers and speed of fluctuation of :a: was 6.8 dlB in L.P. aided T.E. speakers and 28.4dB in esophageal speakers.

Santosh (1993) reported that the Speed and extent of fluctuation in intentsity in T.E.P. speakers differed significnatly from the normal group but there was no significant difference across prosthetic conditions.

The speed and extent of fluctuation in intensity and frequencey have been considered to be related to the quality of voice. They are considered to eb useful in assessing the quality of voice in alaryngeal speakers also.

e) Frequency range in Phonation and Speech

The patterned variations of speech over linguistic events of differing length (syllables, words, phrases, clauses, paragraphs), yield the critical prosodic features, namely intonation (Freeman 1982). In other words, during speech the Fo varies with time. The difference between maximum and minimum Fo is called the speech frequency range (Hirano 1981). The mean, S.D. and range of frequency phonation in a study by Natraja (1986) reported a mean frequency range in Speech of 248 HZ Gopal (1986) has reported a mean of 134 HZ (16-25 years) and a mean of 181.49 HZ (36-45 years) in speech.

Murry and Doherty (1980) reported that the variability in SFF, along with directional and magnitudinal perturbation factors enhanced the ability to discriminate between normal and individuals with cancer of larynx.

Snidecor and Curry (1959) reported a mean F range of 13.21 tones in secondary oesophageal speakers. Robbins et al (1984) reported a mean Fo range of 5.8 HZ (SD = 1.8) in normal during sustained phonation, 73.9 HZ (SD = 43.2) in oesophageal speakers and 39.9 HZ (SD = 41.6) in T.E. speakers. The mean Fo range of normal, oesophageal and T.E.P. groups during reading were 85.9 HZ (SD = 18.8), 118.1 (SD = 43.8) and 142.3 HZ (SD = 96.8). They concluded that large Fo range during vowel production was produced by oesophageal speakers, whereas greater Fo range during connected Speech was produced by T.E. speakers. Rajshekar (1991) reported mean Fo range of 45 HZ in Low pressure aided T.E. speakers and 25.7 HZ in oesophageal speakers in phonation of !a! and 111.4 HZ in L.P. and T.E. speakers and 59.6 HZ in oesophageal speakers in Speech. Santosh (1993) reported that there is significant difference in FR in phonation of normal and T.E.P. groups. There is no significant difference in FR in phonation with in the T.E. speakers group across prosthesis whereas in speech, there was no significant difference between normal and Indian prosthesis aided T.E. speaker group. With T.E. speaker group, there was significant difference between the L.P. aided and I.P. aided T.E. speaker and D.B. adided and I.P. aided T.E. speakers but no significant between D.B. aided and L.P. aided T.E. speakers group.

Table 8: The mean FR in T.E. speakers during Phonation as reported by Santhosh (1992)

Type of Prosthesis	Mean FR (HZ)
Duck Bill	65.33
Low pressure	61.2
Indian Prosthesis	98.25

Table 9: The mean FR in T.E. speakers during Phonation as reported by Santosh (1992)

Type of Prosthesis	Mean FR
Duck Bill	1371.07
Low pressure	151.64
Indian Prosthesis	207.25

q) Intensity range in Phonation:

Loudness is in general, the perceptual correlate of intensity. It refers to the "strength of the sensation received through the ear ". Intensity changes are important in everyday verbal behaviour, and the extremes in intensity of vocal tones occupy a considerable range, even during conversational speech. Coleman et al (1977) reported the average intensity range of Phonation (in SPL re:0.0002 dynes/cm^2) at a single Fo as 34.8 dB for males and 51 dB for females.

Measurement of vocal intensity, as a clincial dignostic ans not proved to be as popular as that of Fo in voice clinics.

Natraja (1986) reported small variations in intensity in sustained phonation, in normals.

Singer (1983) reported intensity ranges in four T.E.P. patients extended from 20-29 dB. Pauloski et al (1989) reported intensity range (vowel phonation) in four conditions. They were:

10.54 dB - Duck-Bill with valve
10.05 dB - Duck-Bill without valve
9.67 dB - Low pressure with valve
9.92 dB - Low pressure without valve

Rajshekar (1991) reported a mean intensity range of 13.6 dB in L.P. aided T.E. speakers and 16.4 dB in oesophageal speaker in phonation of !a! and 34.7 dB in L.P. aided T.E. speaker and 39.1 dB in oesophageal speakers in Speech. Santos)) (1993) reported a significant difference between normal and T.E.P. groups. Among T.E.P. groups, differences were seen between all prosthetic groups. L.P. aided T.E.speakers showing highest IR and I.P. aided showing the lowest IR. It suggested that none of the T.E. speakers could maintain the intensity at a steady level as compared to normal.

Information regarding the intensity range in the laryngeal group is scanty. The measurement of this parameter would enable under standing of the alaryngeal speakers ability to maintain the intensity and its contribution to the intelligibility.

TEMPORAL MEASURES

a) Words Per Minute: The rate of speech is usually expressed in terms of words per minute (WPM) during a complete speech performance. (Kelly and Sten 1949). This would include all pauses (intentional and unintentional) and the words spoken in unit elapsed time. Ratna ,Bharadwaj and SubbaRao (1979) reported a rate of speech of 93.68 WPM for normals during pasage reading in Kannada langauage. Venkatesh, Purushottama and Poornima (1983) reported a rate of speech of 282 syllables per minute for normals in Kannada.

Snidecor and Curry (1959,1960) have demonstrated that rate of speech in oesophgeal spekers is markedly reduced. The rate of speech of superior esophegeal speakers in their study ranged from 85 to 129 WPM, with a group average of 113 WPM. The assumption has always been that the decrement in the rate of esopphegeal speech is due to the increasee in amount, time spent in silent pauses. This increase in silent pauses results from the esophageal speaker's limited ability to sustain voice. Hoops and Noll (1969) reported a mean rate of speech of 114.3 WPM in 22 esopheageal speakers. The rate of speech in the 20 esophageal speakers of Filter and Hyman's (1975) study was considerably low (100.1).

Singer (1983) reported the rate of Speech in four T.E.P. subjects to range from 97-136 WPM . This value exceeded the oesophageal groups and it was not suprising, since pulmonary air is used for T.E. speech while oesophageal speakers are dependent on air trapping. Robbins et al (1984) reported that the rate of speech in normals, T.E. and Oesophageal groups was 172.8 (SD = 23.3), 127.5 (SD = 21.1) and 99.1 (SD = 24.8) respectively.

In general, the oesophageal and T.E. speakers, produced speech at a rate slower than the normal speakers, with the oesophageal speakers showing the most extreme rate reduction. According to Robbins et al (1984), the similarity in the rate of speech (WPM) for the laryngeal and T.E. speakers, in contrast to the significantly slower rate of oesophageal speech, reflected the use of the pulmonary system during phonation by the former two groups, while the latter group is restricted by the use of air trapped in the oesophagus. More discrete analysis of this study showed that the T.E. speakers paused much less frequently than the oesophageal speakers indicating that access to large respiratory volumes resulted in less time for "recharging" of air supply.

Blom, Singer and Hamaker (1986) assessed the speech of 47 T.E. speakers to determine the efficacy of their surgical voice restoration method (Singer and Blom 1980). The mean rate of Speech for males was 122.77 WPM (SD = 4.02). Pauloski et al (1989) reported a higher rate of speech in T.E. speakers using Duck-bill and Low pressure prosthesis with and without tracheostoma value. The maximum rate of speech of 160.22 WPM was observed when the patients wore the Low pressure prosthesis with tracheostoma valve.

Pindzola and Cain (1989) found a significant difference in the rate of speech during reading in normal, oesopahgeal and T.E. speakers. Normal speakers (WPM = 158.8) WPM faster than T.E. speakers (WPM = 152.2) which was not significantly different. The oesophageal speakers had a rate of speech of 93.8 WPM and were significantly different from both the laryngeal and T.E. speakers. The rate fo speech in T.E. speakers reported by Zanoff et al (1990) was considerably less when compared to other studies. The rate of speech in their T.E. speakers with and without tracheostomes value was 87.11 and 87.78, respectively. Frudeau and Qi (1990) reported a WPM of 138.03 in female T.E. speakers.

Rajshekar et al (1990) comparing the oesophageal vs T.E. modes in a single laryngectomee reported WPM of 57 in the oesophageal as against 78 in T.E. mode. Rate of speech ranging from 25-150 WPM in 18 T.E.P. speakers fitted with Blom-Singer prosthesis have been reported by Hazarika et al (1990). Rajshekar et al (1991) reported that the rate of speech in T.E.P. and oesophageal groups was less than the values obtained for the normal group. Among the alaryngeal speakers, the oesophageal group acheived low rate.

b) Syllables / minute: This has been an indirect measure of the rate of speech as reported by some investigators. This is reported to be higher in T.E. speakers (Robbins et al, 1984; Sidory et al, 1989). Krishnamurthy et al (1992) reported that the alaryngeal groups (T.E.P. and Oesophageal) had a reduction in the number of syllables/minute relative to the normal laryngeal group. This can largely be attributed to their increased pause time.

c) Pauses:

A pause is marked when there is more than 200ms of continous silence. The criterion used should be in such a way that one Should exclude stop closure durations from being interpeted as pauses (Lisker 1957; Robbins et al 1984).

Robbins et al (1984) reported that both the alaryngeal groups had reduction in reading rate relative to the laryngeal group (as seen in Table No.10.

Variables	Normal	T.E.	Esophagal
Total Pause time (S)	6.3 (3.8)	11.6 (4.0)	22.0 (8.6)
Total No. pauses time (S)	9.7 (3.1)	13.0 (2.8)	35.4 (11.3)
Mean Pause time (S)	624.7 (196.3)	891.2 (213.0)	649.1 (133.2)

Means and standard deviations (in parenthesis) of duration measures for the paragraph reading and phonation of :a: by laryn-geal, T.E. and Oesophageal talkers.

This can largely be attributed to their increased pause time. The large number of pauses and greater amount of total pause time demonstrated buy the oesopahgeal speakers may be explained by that group's limited air resorvior. Dudrich (1968) reported that the fully inflated oesophagus contains only 80cc of air. Thus this group must pause more frequently to inject air for connected speech production. According to Robbins et al

(1984), it was found that oesophageal speakers paused most frequently, their mean pause time values were only slightly higher than normal and much lower than those for the T.E. speakers. There are two reasons for this finding. The first is a function of the way in which pause time was derived. Since a pause was considered to occur when the graphic level recorder tracing returned to baseline atleast for 200 msec, the oesophageal speakers air charges of a latency of 0.2 sec and greater were included in pause time calculations. The probably deflated the mean pause time value for the group. The second reason for the T.E. groups relatively high mean pause time value may be that these talkers necessiate additional pause time for digital opening and closing of the stoma upon inspiration for phonation. According to Sidory et al (1989) the pause time in oesophageal speech is 36.1% pause time and in T.E. Speech it is 24.2% (this study supports findings of Robbnins et al 1984). Thus this study confirmed that the increased frequency of pauses by oesophageal speakers seem to affect the total percentage of pause time and speaking rate, whereas the rate of T.E. speech is more stronly influenced by longer pauses. Krishnamurthy et al (1992) reported that all the pause time measures were longer for the oesophageal speakers than for T.E. speakers with the exception of mean pause time and mean phrase duration.

e) Vowel duration

Speech is a skilled motor performance (Krmt 1976). "Timing may be the most critical factor in skilled Motor performance". Duration of vowels and consonants are the important aspects of

speech. Khozhevinkou and Christovich (1965) considered the durational data as useful in deducing important facts regarding the nature and organization of speech production.
Measurements of vowel durations have been made using oscillograms, spectrograms, electrokymographic tracings and computers.

Review of literature indicates that although vowel duration differences are very reliably produced, their role in perception is not predicatble. This duration of the preceding vowel is often cited as an important cue to the voicing feature of final stop consonants in English. Natraja and Jagdeesha (1984) have shown that the relationship between FF of voice and vowel duration.

Vowel duration has been studied in the oesophageal speakers also (Weinberg 1976,1982; Robbins, Christensen and Kempster, 1986). Compared the vowel duration of 15 T.E. speakers with 15 Oesophageal and 10 normal laryngeal speakers. They reported that the T.E. speakers exhibited the longest durations in producing vowels !i!, !a! & !u!. The normal speakers had the shortest durations while the oesophageal speakers had the intermediate values. The normal speakers did not differ significantly from oesophageal speakers and T.E. speakers didnot differ significantly from oesophageal speakers. When compared across fgroups the vowel :i: and :u: were found to be not significantly differeentg in vowel duration. However, :a: was significantly longer in duration for all the groups than either :i: or :u:. According to Robbins et al (1986) factors influencing vowel duration in T.E.P. speakers are pulmonary air which is used as a voicing source, speakers are pulmonary air which in used as a voicing source, large air supply and the effect fo the interposed prosthesis creating an average airway resistance 3.5 times greater than offered by the normal larynx. This difference in vowel duration in oesophageal and T.E.P. speakers may be due to distinctive aerodynamic components.

Rajshekar (1991) reported from his study that there was no significantly difference in VD in L.P. aided T.E. speakers and oesophageal speakers and also both of these alaryngeal Speakers didnot differ significantly from normal speakers.

Santosh (1993) reported that normal speakers didnot differ significantly from T.E. speakers. Among T.B.P. groups no significant differences were found across prosthetic conditions except in D.B. and L.P. aided T.E. speakers differed significantly in VD of :i: vowel.

Vowels are considered as carriers of speech. Sounds and therefore, the information about the vowel duration in alrayngeal speakers was considered to contribute to the understanding of the influence of pulmonary air as the articulatory behaviour and acceptability and intelligibility of speech in laryngectomee.

f) Voice Onset Time (VOT)

VOT is defined as the difference, interms of time, between the release of a complete articulatory constriction and the onset of phonation (Lisker and Abramson 1967). They state that VOT was ah useful acoustic cue for various phonemic categories such as

"Voiced Stop", "Voiceless Stop", and "Voiceless Aspirated Stop". They further state that the normal speakers of English systematically varied :p: :+: k from :b:, :d: and :g:. Voiced plosives in English normally have a short VOT (less than 20 - 30 msec) and voiceless plosives relatively long VOT (greater than 50 msec).

Lisker and Abramson (1971) state that VOT is the "single most effective measure for classifying stops into different phonetic categories with respect to voicing". Gilbert and Campbell (1978) attributed the increased VOT for voiceless stop consonants to greater intra-oral air pressure resulting in the increase in the air flow rate and at Glottis. This glottal frication inhibits the vocal folds from initiating periodic vibrations during the production of voiceless stop consonants, thereby delaying VOT. It has also been reported that VOT increase as the place of articulation moved backwards in the oral cavity i.e. VOT is greater for velars than the alveolars and alveolars than labials (Borden and Harris, 1980; Lisker and Abramson 1967).

According to Weinberg (1982) it is also now well established that laryngectomised patients using oesophageal speech have difficulty acheiving voicing contrast between homorganic stop consonants". Christensen, Weinberg and Alfonso (1978) studied the VOT associated with production of stops in oesophageal speakers. They reported that oesophageal speakers did effect systematic variation in VOT and that the VOT values associated with pre-vocalic voiceless stops exhibited lag intervals which were significantly shorter than in normal speakers. They further stated that the VOT characteristics of oesophageal speakers were differentially sensitive to place of articulation.

Robbins, Christensen and Kempster (1986) measured the VOT voiceless consonants in T.E. speakers and compared it with oesophageal and normal speakers. The VOT was measured from the broad band spectograms. The VOT results for the laryngeal and the T.E. speakers differentiated front, mid and back vowels. The oesophageal group did not reflect this distinction. The laryngeal speakers had the largest VOT values for :a: production, (:Kap:) followed by the T.E. group. The oesophageal speakers had the shortest VOT. The laryngeal and T.E. speakers systematically varied VOT with the change of stop loci from labial to velar positions. The oesophageal speakers performed only marginally in ths aspect. Based on above mentioned studies, Robbins et al (1984) suggested that the physical characteristics of the neoglottis exert a major influence on VOT production in alaryngeal speakers. Further they attributed different VOT effect in alaryngeal groups to aerodynamic capactiy, myoelastic and motor control properties of the voicing source and consonant - vowel articulatory loci. Thus, the study of VOT may be useful in determining its effect on intelligibility of speech in alaryngeal speakers. Rajshekar et al (1991) reported mean VOT of 27.6 msec for !p!, 24.8 msec for ! + ! and 33.4 msec for !k! in L.P. aided T.E. speaker. Santhosh (1993) reported that there was no significant difference between different prosthetic conditions i.e. type of prosthesis used had no effect on VOT of the T.E. speakers. There was no significant difference between normals and T.E. speakers except for the VOT Of :p: which was significant between D.B. aided T.E. speakers and normal and L.P. aided T.E. speakers and normal.

Computer analysis of Alaryngeal Speech

In recent years, a number of mathematical techniques of speech analysis using computers have been developed and utilized to extract sound source and resonance characteristics of speech. These include the Cepstrum methods. Covariance and autocorrelation methods the PARCOR method, the linear prediction method and the inverse filtering method to name a few (Noll 1964; Markel and Gray 1973). The method permits researchers to extract from the time domain speech waveform, voice Fo , harmonics, amplitudes, formant frequencies and intensity of connected speech. High fidelity of these methods has been demonstrated not only by the close agreements of their results with traditional spectrographic and oscillographic results but also by highly intelligible results.

Review of literature revealed few studies of computer applications for the analysis of alaryngeal speech (Horii 1982; Sedory et al 1989; Pauloski et al 1989; Trudeau and Qi 1990; Rajashekar et al 1990, Rajashekar et al 1991). Horii (1982) advocated the exploration of the feasibility of both computer and analog methods to enhance diagnostic, rehabilitative and evaluative procedures for laryngectomees.

The review of literature, thus shows that acoustic ,and few temporal parameters have been studied in T.E. speakers. Further studies of acceptability and intelligibility has been done using different types of prosthesis.

Since the study has been carried out in Kannada speakers, the present study is carried out in Malayalam speakers to see if there is any difference across languages and also to study the various other temporal parameters along with acceptability and intelligibility ratings.

METHODOLOGY

METHODOLOGY

The aim of this study was to:

1) Determine the acceptability and intelligibility of speech in Malayalam speakers with different types of prosthesis i.e. B.S Duck-Bill, B.S. Low pressure and Indian (HRA) prosthesis.

2) Temporal analysis of the T.E. Speech with different types of prosthesis.

3) Acoustic analysis of the T.E. Speech with different types of prosthesis.

Subjects: Five subjects who had secondary T.E.P. having undergone laryngectomy earlier were selected for the study. All of them were serened for hearing ability and neurological conditions. Their pure tone thresholds in the speech frequencies were within normal limits. They had no other speech problem. Details about each case is shown in Table 11.

Table 11: Showing the details of the subjects used for the study

sl. No.	Age/Sex	Surgical Procedure	Type of prothosis used after operation	Time of post T.E.P (mts)
	66 / M	' Laryngectomy +2^{o} T.E.P.	Duck-bill prosthesis	56
2)	75 / M	Laryngectomy +2^{o} T.E.P.	Duck-bill prosthesis	34
3)	61 / M	Laryngectomy +2^{o} T.E.P.	Duck-bill prosthesis	37
4)	66 / M	Laryngectomy +2^{o} T.E.P.	Duck-bill prosthesis	37

All of them has T.E prosthesis fitting and speech services at the same centre (K.M.C. Hospital, Manipal). The selection of the prosthesis and speech services were provided by a speech pathologist. All the subjects were using (finger) occlusion for T.E. Speech production.

Material

1) Word list: 38 Malayalam words (list presented in Appendix) were selected. Most of these words were used in the Sentences of the passage eg. "Onam".These words were selected with due attention to their frequency of accurence in Malayalam i.e., the frequency of occurence of these words arc high in Malayalam.

2) Passage: A passage consisting of 60 words was specially constructed using the above mentioned most fimiliar words in Malayalam. In the passage, non-emotional sentences were used. The wrods included in the passage tried to accomodate most of vowels and consonants in Malayalam.

Data Collection

All the subjets were first familiarized with the material, i.e. both word list and the passage. The subjets were asked to read the word list and the passage, the subject read the material, in a sound treated chamber using a high bias mnetal cassettes and Philips tape recorder with Eletric microphone. The microphone to mouth distance was approximately 10cm for all the subjets. Recording was done under three conditions for each laryngectomee. All the patients were made to use:

1) B.S. Duck-Bill prosthesis

2) B.S. Low pressure prosthesis

3) Indian (HRA) prosthesis

No patient complained of any discomfort with prosthesis that he was made to use during recording. All the subjects were required to perform the following tasks which were recorded for further analysis.

1) Phonation of vowels: The T.E. speakers were instructed to 'inhale deeply' close the puncture with the finger and then say :a: as long as possible without removing the finger. This was demonstrated. Three trials of :a: was recorded. Similarly three trial of :i: and :u: were recorded for all the subjects. This is used for measuring:

a) Fundamental frequency

b) Frequency range

c) Fluctuation (extent and speed) in Fundamental frequency

d) Intensity range

e) Fluctuation (extent and speed) in intensity in phonation.

2) Words: The words were visually presented (in written form) and the subjects were instructed to utter them. The words beginning with the vowels were used to measure

a) The vowel duration and within these words those which consisted of the consonants were used for measuring the

b) voice onset time. Nearly 3 lists which consisted of 15 words each (selected from the 38 words) were prepared at: a random order

3) Recordings: Recordings were also obtained of each subject reading the passage at his comfortable loudness and rate. These recordings were used for the measurement of :

a) Words per minute
b) Syllables per minute
c) Total number of pauses
d) Mean pause time
e) Percentage of pause time
f) Acceptability of speech

ANALYSIS OF SPEECH AND VOICE

The analysis involved the following equipment:

1) Tape deck to play the rcorded speech samples.
2) Antialiasing filter (Low pass filter having cut off frequency at 3.5/7.5 K).
3) A-D/D-A converter (sampling frequency of 16Khz, 12 bit).
4) Personal Computer - AT Intel 80386 microprocessor with 80387 Numerical Data processor.
5) Software developed by voice and speech systems, Bangalore
6) Amplifier and speakers

Procedure for analysis of different parameters

The recorded phonations and speech samples of each subject were digitized at the rate fo 16 KHz using 12 bit VSS data input and output card by feeding the signal from the tape deck to the speech interface unit through live feeding. The digitized sampies were stored on hard disk for a further analsysis.

The following parameters were obtained from the analysis of digitized samples of vowels :a:, :i: and :u: using FoA off-programme.

Fundamental frequency in Phonation

The Fo of three trials of :a: was averaged and then considered as the mean Fo in phonation for :a:. Similarly the mean F_o in phonation for the vowel :i: and :u: were obtained for all the subjects of the three groups.

Extent and Speed of fluctuation in Fo in Phonation

The fluctuation in frequency was defined as the variations +/- 3 Hz and beyond in Fo. The extent of fluctuations in frequency was defined as the means of fluctuations in Fo in phonation of one second. The speed of fluctuation in frequency was defined as the number of fluctuation in Fo in a phonation of one second. The extent and speed of fluctuations for all the 3 trials of :a: were averaged and the value considered as the extent and speed of fluctuations for :a:. The extent and speed of fluctuation in Fo for the vowels :a:, :i: and :u: for subjects of all the 3 groups were thus obtained.

Extent and Speed of fluctuation in intensity of in Phonation:

Fluctuation in intensity was defined as the variations +/- 3 dB and beyond in intensity. The extent of fluctuation in intensity was defined as the means of fluctuations in intensity in phonation of one second. This was caluculated for vowels :a:, :i: and :u: for all the subjects of all the 3 groups.

Intensity range in Phonation: The difference between the maximum and minimum intensity in phonation. The maximum of the 3 trials of :a: was considered as the intensity range of :a:. Similarly the intensity range for :a:, :i: and ,:u: for each subject were obtained.

The programme Fo - Ao off line provided the above parameter (Ref: Figure 1 - Picture)

The following parameters were obtained from the words which were digitized using dB CRT programme. The spectographic display of each of the digitized signals of each word were obtained on the screen of the monitor (Figure 2 - Picture).

The vowel duration (msec) for each vowel ,:a:, :i: and :u: were measured from the spectrographic display. Measurement criterial for vowel duration were based on suggestions by Peterson and Lelusk (1960) i.e. the vowels were identified on the spectrogram and duration from the onset of phonation indicated by the initial periodic striations of the first formatn to the last vertical striation associated with the second formatn were considered as duration for each vowel.

Voice onset time

VOT (msec) of :P:, :t: and :K: from :ilanjipoovu:, :inthapa-zam: and :aikaisham: were measured using the defintion given by

Liskneh and Abramson (1967) i.e., the time interval between the burst (a breif interval of high intensity noise) that marks release of the stop closure and the onset of quasi-periodic pulsing that reflected laryngeal vibration was the VOT.

The following parameters were obtained from the analysis of speech sample digitised and displayed waveform on the screen of the Computer.

Pauses: From the display pauses were identified as a silence of greater than 200 msec as indiicated at the baseline of waveform. The total number of such pauses were computed.

Mean Pause time: Further ther mean pause time was obtained by dividing the total pause timne by the total number of pauses.

Percentage pause time: This was computed using the formula :

Summed duration of pauses x 100 / Total
(Duration of first pause + Duration / reading
of 2nd pause + ... / duration
duration of nth pause duration /

The other paramters were measured as follows:

Syllable per minute: The number of syllables uttered per minute was measured for each subjet using different types of prosthesis words per minute. The number of words uttered per minute uwas measured for each subject using different types of prosthesis.

Intelligibility: Five speech and !a! hearing Post graduates who were proficient in Malayalam served as Judges. The test was played to them from a tape recorder.

The judges were instructed "to write down the words on a sheet of paper, as you hear them". You can adjust the volume of the tape recorder to your comfortable loudness level. The intelligibility score was computed as percentage:

$$\frac{[\text{No. of words correctly identified} \times 100]}{15}$$

Intelligibility score by all the five judges were averaged that was considered as the score for each subject. Similarly intelligibility score of all the subjects of the 3 groups were determined.

Acceptability: The five judges who had provided the intelligibility scoring all rated speech for acceptability. The recorded material was played through a tape recorder and the acceptability rated on a five point scale were (1 being the least acceptable and 5, the most). The judges were instructed to rate the speech of the samples that they heard using 5 point scale. The ratings made by all the five judges were cosnidered and the judgement taken as the acceptability socre for all subject. Thus scores of all the three grouyps were deetremined.

Thus values for all sixteen parameters for all the subjects of all the 3 groups were obtained. This was subjected to statistical analysis using Ness programmer to obtain descriptive statistical information of inferential information.

RESULTS & DISCUSSION

RESULTS AND DISCUSSIONS

The purpose of the present study was to

1) Determine the acceptability and intelligibility of T.E. sppech with different types of Prosthesis i.e. Duck-bi]l, B.S. prosthesis, Low pressure B.S. prosthesis and an Indian prosthesis.

2) Temporal analysis of T.E. speech with different types of prosthesis.

3) Acoustic analysis of T.E. speech with different types of prosthesis.

As stated earlier, seven temporal parameters and seven acoustic parameters and two Pyschoacoustic parameters were studied.

The results regarding each parameter studied are presented here with discussion.

ACOUSTIC PARAMETERS

1. Fundamental frequency in Phonation:-

Fo in Phonation of !a!, !i! and !u! for T.E.P. Malayalam speakers with Duckbill prosthesis (D.B), low pressure prosthesis (L.P.), and an Indian Prosthesis (HRA) are presented in Table:-1 and the same is depicted in graph 5.

Graph 6: Mean F_0 In Phonation Of /a/, /i/ /a/ /u/ In D.B, L.P And I.P Groups.

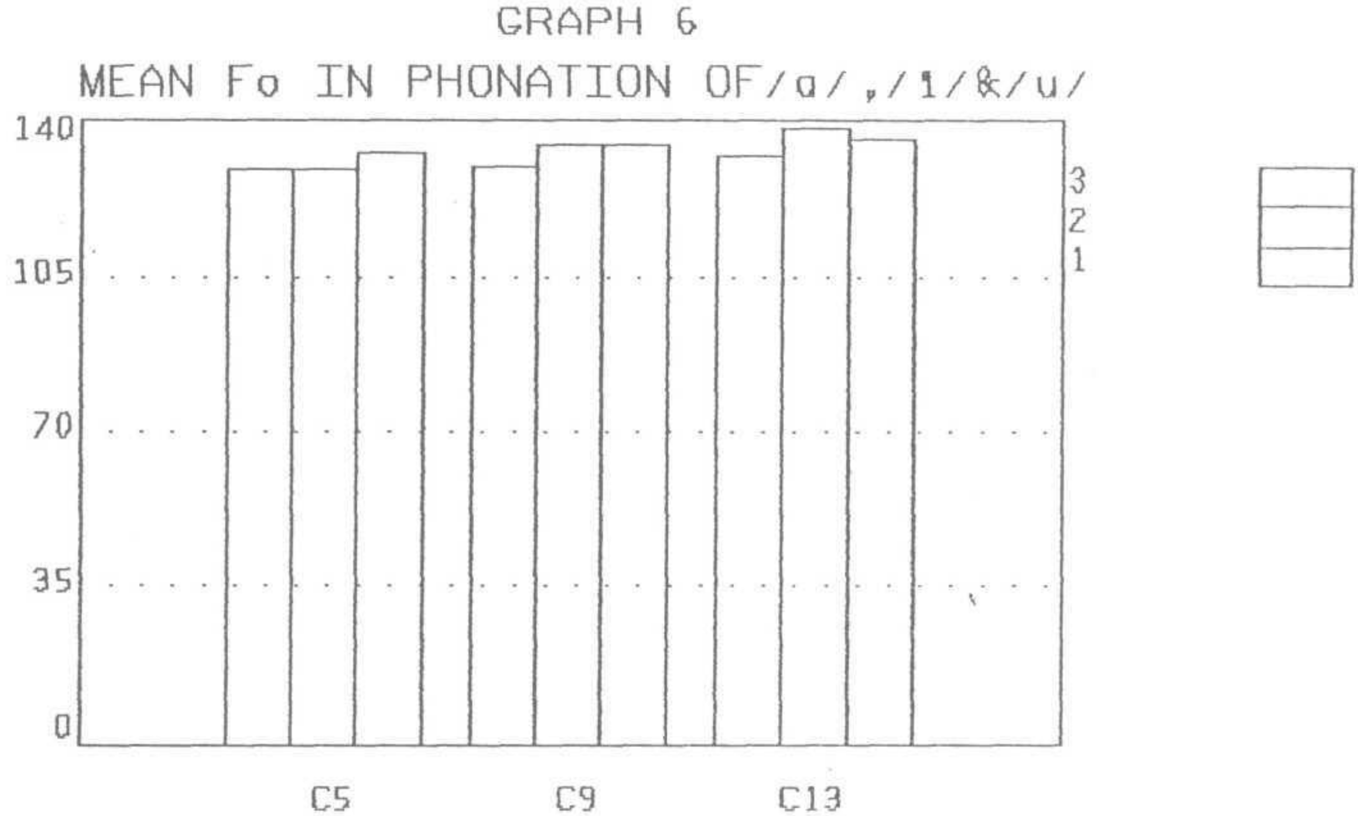


Table-1.

GROUP	Mean (H 3)	!S.D.	R<inge (H 3)
D.B. :			
:a:	128.79	12.47	117.20-139.83
: i :	129.45	21.20	102.85-147.89
:u:	131.64	22.10	105.98-155.38
L.P. :			
:a:	128.81	25.91	101.25-162.75
: i :	134.62	30.15	102.85-175.56
: u :	138.04	25.59	105.56-161.02
I.P.			
: a	132.622	28.39	98.94-162.98
:i:	134.59	24.13	102.60-160.38
:u :	135.725	23.73	105.08-162.29

TABLE I :. MEAN F_0, S.D AND RANGE OF /a/ /i/ & /u/ IN D.B, L.P & I.P GROUPS.

The mean, S.D and range of Fo(Hz) in phonation of :a: :i: and :u: in D.B, L.P and I.P. groups. The range in Fo to the T.E.P. groups Mere range for the I.P. (H.R.A.) group than D.B. and S.L.P. group. The mean Fo in phonation was slightly higher for :u: followed by :i: and :a:. Mann whitury's test for unmatched: pairs was used to determine the significance of difference between the vowels.

Fo (Table.26) No significant difference was observed between D.B. Vs L.P. Vs IP and DB Vs IP.

Thus the hypothesis stating that "there is no significant difference in terms of Fo in Phonation between

1) D.B. aided and L.P. aided T.E. speech accepted.
2) B.S. aided and 1.P. aided T.E. speech accepteed.
3) L.P. aided and T.P. aided speech accepted.

2. <u>Extent of fluctuation in Fo (ex. F.F.)</u>

Ex: F.F. phonation of :a:, :i: and :u: for T.E speakers with D.B., L.P. aND 1.P. prosthesis are presented in Table II and the same is depicted in graph:9.

GRAPH 9: EXTENT OF FLUCTUATION IN F_0 OF /a/, /i/ & /u/ IN D.B, L.P & I.P GROUPS.

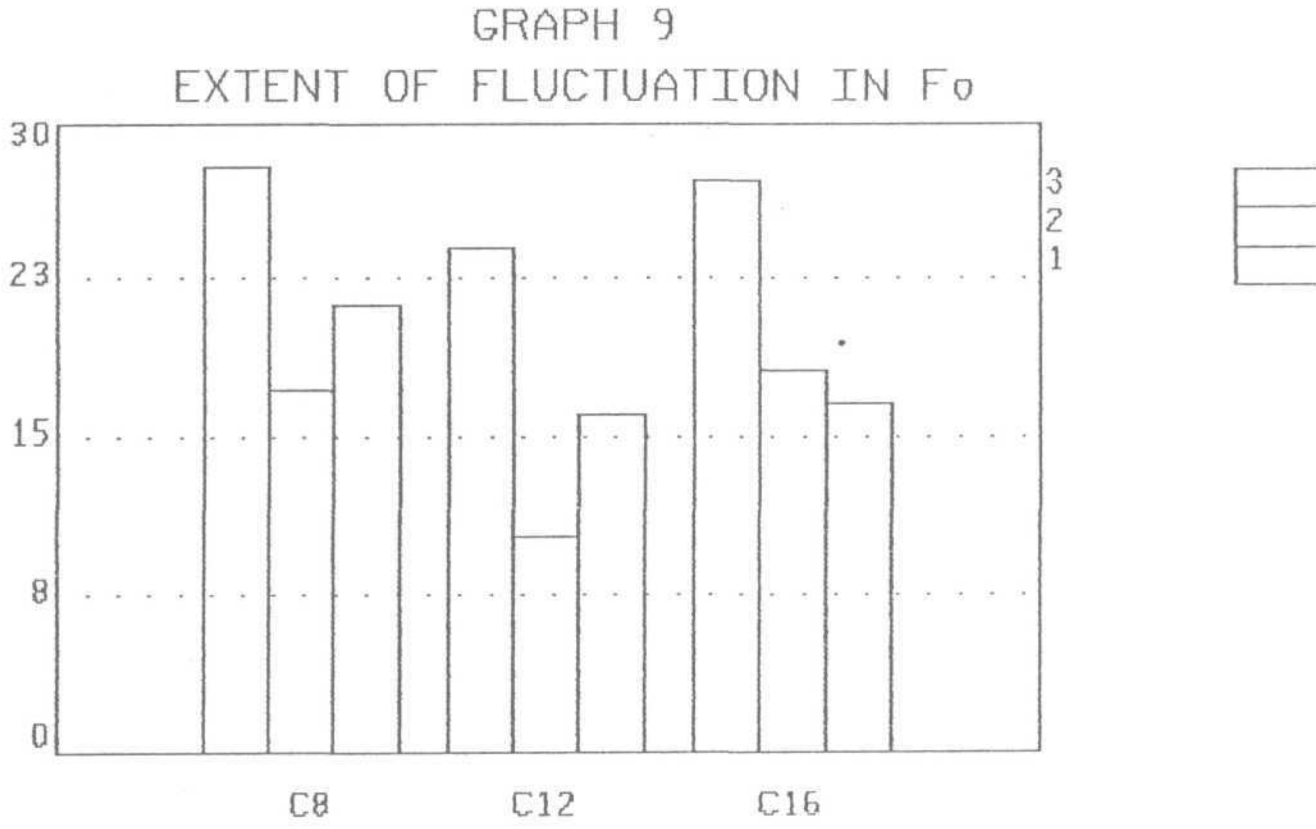


TABLE II:

GROUP	{Mean (Hz) : 8	S.D.	Range (Hz) 3
D.B. :			
: a :	' 27.84	24.69	12.23-64.47
: i :	23.99	21.89	6.84-55.94
: u :	27.17	23.36	4.61-57.21
L.P. :			
: a :	17.18	11.13	6.32-29.35
: ı :	10.31	7.63	3.96-21.30
: u :	18.14	14.87	4.18-38.69
i.p.			
: a :	21.24	12.20	4.63-31.18
: i :	15.98	7.67	6.35-25.05
: u :	16.49	9.00	4.55-25.05

Table II: The mean S.D. a Range of EX. F.F.( ) in phonation of !a!, !i! and !u! for D.B., L.P. and I.P. groups.

Among T.E.P. . . . . Ex. F.F. seen in D.B. aided T.E. speakers than in LP and I.P aided speakers. All the three groups showed lesser extent of fluctuation in frequency in phonation of :i:.

The mean Ex. F.F. in phonation of !a! for T.E. speakers of this study were higher compared to previous studies. Except in the study done by Santosh (1993) where the Ex. F.F. of :a: using T.P. is greater compared to the previous study.

TABLE III:

Investigators	Mean Extent F.F. (Hz.) §
Rajashekar et al (1990)	9.2 (L.P.)
Rajashekar (1991)	
Santhosh (1993)	19.17 (O.n.) 18.06 (L.P.) 30.82 (I.P.)
Present study (1994)	27.84 (H.B.) 17.18 (L.P.) 21.24 (I.P.)

Table III:- The mean Ex. F.F. in T.E. speakers reported by different investigators.

Results of Mann Whistney V test for unmatched pairs are shown (Table-26) within the T.E.P. groups in a significant difference were observed across prosthesis.

The hyphothesis stating that there is no significant difference in terms of Ex. F.F. between.

1. D.B. aided and C.P. aided T.E. speakers accepted.

2) D.B. aided and I.P. aided T.E. speakers accepted.

3) L.P. aided and I.P. aided T.E. speakers accepted.

Hence the results of the present study showed that the Ex. F.F. in phonation of all the three vowels were greater in T.E.P group, but there was no difference within different types of prosthesis. This indicated less stability in the control of fundamental frequency in phonation in T.E. speakers.

3. Speed of Fluctuation in Frequency (SP. F.F.)

The results obtained for the following three groups with respect to these paramators are provided in table 4 and the same is depicted in graph 11.

TABLE IV:

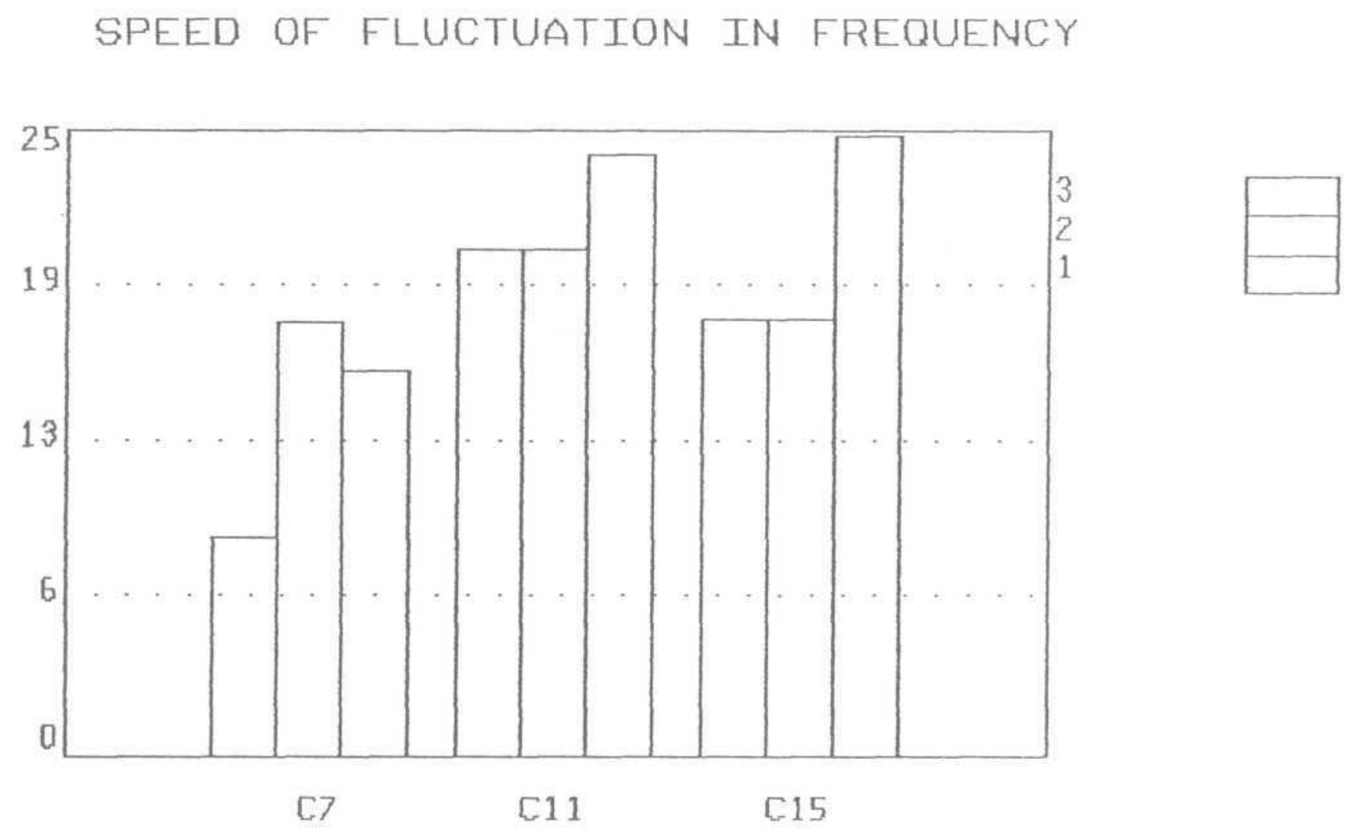
{GROUP	Mean (Hz) 3	S.D.	{Range (Hz-) 3
D.B. :			
: a :	8.53	11.82	1.64-26.20
: i :	20.15	18.78	3.01-37.60
: u :	17.33	19.29	1.39-42.09
L.P. :			
: a :	17.30	13.32	4.66-30.33
: i :	20.15	16.80	0.93-37.60
: u :	17.42	12.05	1.28-29.72
I.p.			
: a :	15.32	14.82	1.44-29.19
: i :	24.03	14.50	5.86-38.00
: u :	24.69	11.66	14.04-40.94

Table IV:- The mean, S.D. and Range of Sp. F.F. in phonation of !a{ !i! and !u! for D.B., L.P. and I.I groups.

In the T.E.P group D.B. aided group had greater variability than L.P. aided and I.P. aided group.

The mean Sp. F.F. in phonation of !a! for T.E speakers of this study was greater when compared to results (14.46) reported

GRAPH 8: SPEED OF FLUCTUATION IN INTE FREQUENCY IN PHONATION OF /a/, /i/ & /u/ IN D.B, L.P & I.P GROUPS.



by Rajashekar Et.al (1990) and Rajashekar (1991) and less when compared to the study done by Santosh (1993).

TABLE V:

Investigators	Mean Sp F.F. (Hz.) 3
Rajashekar et al (1990)	14.0 (L.P.)
Rajashekar (1991)	14.6 (L.P.)
Santhosh (1993)	19.0 (D.B.) 18.23 (L.P.) 20.17 (I.P.)

Table V:- The mean Sp: F.F. in T.E. speakers reported by diferent investigators.

Mann Whistney U test for unmatched pairs (Table:26) launched that there Mas no significant difference in T.E. speakers across prosthesis' group.

The hypothesis stating that there is no significant difference in terms of Sp. F.E. between:

1) D.B. aided and L.P aided T.E. speakers accepted.

2) d.b. AIDED AND i.p. AIDED t.e. speakers accepted.

3) L.P. aided and I.P. aided T.E. speakers accepted.

This suggests that availability of priliminary air, supply to the T.E. speakers and type of prosthesis used did not improve the vibratory pattern at the pseudoglottis.

4) Frequency range in phonation(FR)

TABLE VI:

GROUP	Mean (Hz.) 3	S.D.	{Range (Hz) 3
D.B. :			
: a :	55.11	35.01	28.33-106.60
: i :	43.065	34.11	5.73- 84.08
: u :	47.72	26.84	13.51- 74.50
L.P. :			
: a :	60.68	25.09	33.62- 89.43
: i :	64.92	39.59	26.95-116.96
: u :	71.70	40.52	11.84- 99.46
I.P.			
: a :	55.78	39.37	13.20- 92.87
: i :	85.98	36.62	36.85-121.29
: u :	85.41	52.38	13.08-128.11

Table 6 shows the results with respect to frequency range in phonation of :a:, :i: and depicted in Graph:7.

Table:6: The mean, S.D and range of FR in phonation of :a: :i: and !u! for D.B., L.P. and I.P. groups.

I.P. aided group showed greater FR in phonation for !i! and !u! than D.B. and L.P. aided whereas L.P. showed in :a:.

The mean F.R. in phonation for !a! for T.E. speakers of this study was higher compared to the study done by Rajashekar Et.al (1991) but was less when compared to the study done by Santosh(1993).

Graph: 7

FREQ RANGE IN PHONATION OF /a/, /i/ &

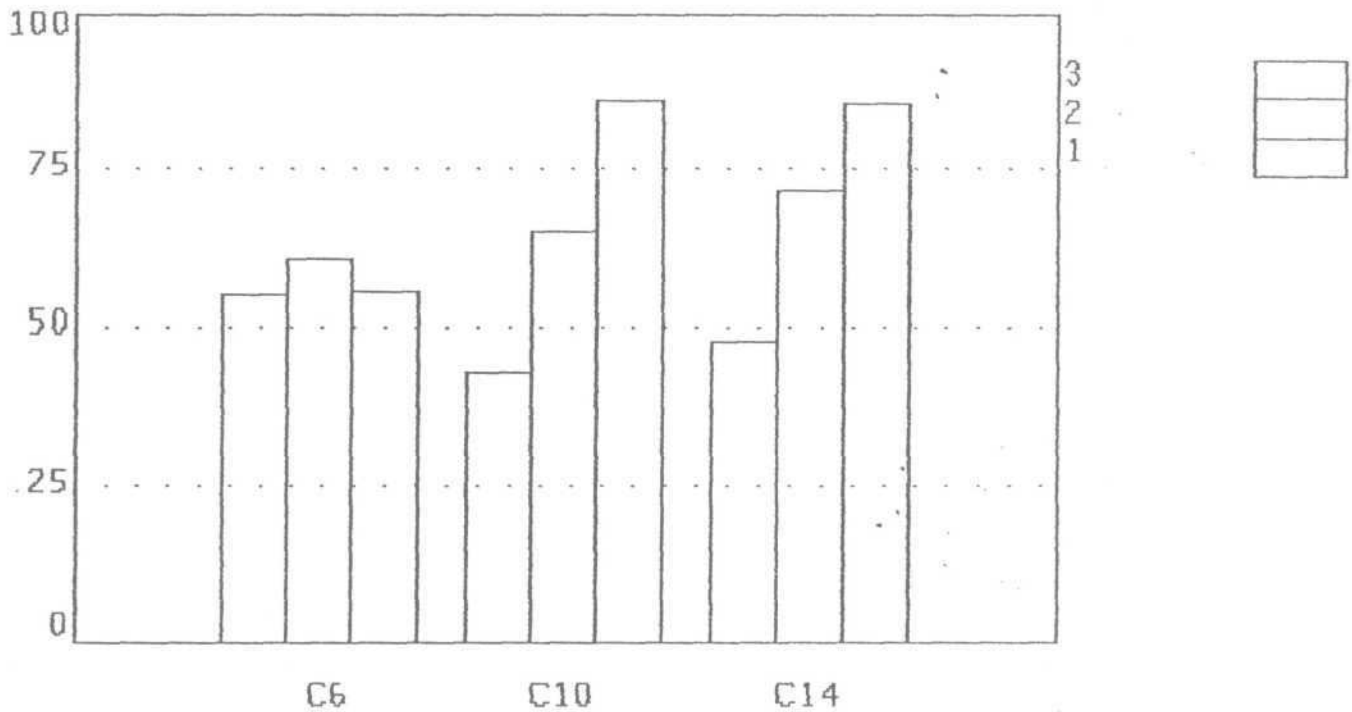


TABLE VII:

Investigators	Mean (HZ) 3.
Rajashekar et al (1991)	45.0 (L.P.)
Santhosh (1993)	65.33 (D.B.) 61.2 (L.P.) 98.25 (T.P.)
Present study (1994)	55.11 (D.B.) 60.68 (L.P.) 55.78 (I.P.)

Table 7:- The mean FR in T.E speakers reported by different investigators for :a:.

Result of Mann Whistney U test for unmatched pairs (Table 6) shows that there is no significant difference in FR in phonation within T.E speakers groups across prosthesis.

The hypothesis dating that "there is no significant difference in terms of FR in Phonation between:

1) D.B. aided and L.P. aided T.E. speaker accepted.
2) D.B. aided and I.P. aided and T.E. speaker accepted.
3) L.P. aided and T.P. aided T.E. speaker accepted.

Thus it was concluded that there was no difference in FR in phonation across prosthesis.9

5. <u>Extent</u> of <u>Fluctuation in Intensity (Ex. F.I)</u>:-

Ex: F.I. in phonation of :a: /e/ and :u: for T.E speakers with D.B.L.P. and I.P. prosthesis are present in Table:-8 and saw depicted in Graph 10.

GRAPH 10:- EXTENT OF FLUCTUATION IN INTENSITY IN D.B, L.P & I.P GROUP.

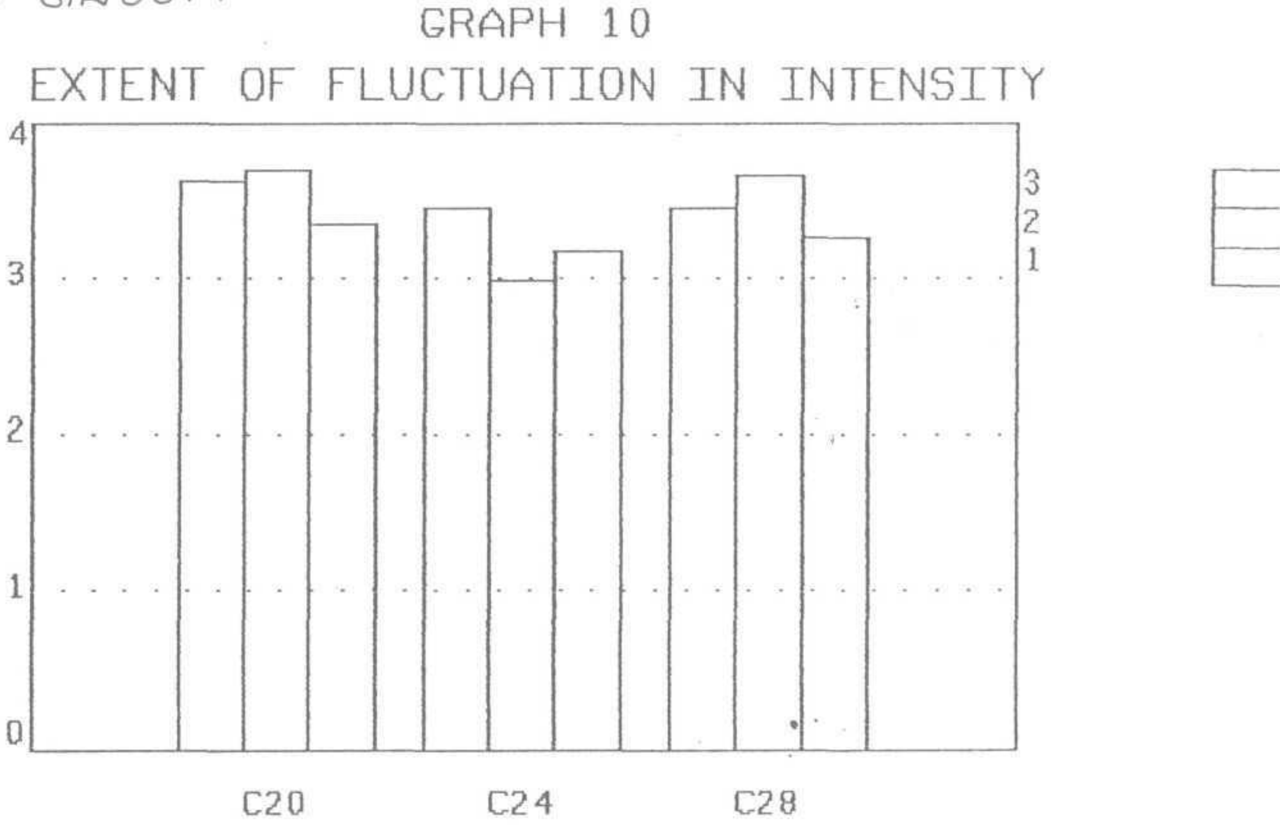


TABLE VIII:

GROUP	Mean	S.D.	Range
D.B. :			
: a :	3.63	.150	3.46-3.78
: i :	3.44	.67	2.50-4.09
: u :	3.46	.92	2.20-4.40
L.P. :			
: a :	3.69	2.29	1.02-6.62
: i :	2.98	1.32	1.05-3.95
: u :	3.66	.101	3.53-3.76
I.P.			
: a :	3.34	1.64	1.04-4.92
: i :	3.17	0.74	2.11-3.80
:u:	13.27	0.74	2.19-3.81

Table 8:- The mean, S.D and Range of Ex.F.I. in phonation of :a:, :i: and :u: for D,B, L.P. AND I.P. groups.

There was no difference between different prosthetic conditions.

Table 7:- Presents result of Man Whitney U test for unmatched pairs of the three groups.

Table 26:- Among the T.E.P. groups no significant differences were found across the prosthetic conditions.

The hypothesis stating that there is no significant difference in terms of Ex: F.I. between:

1. D.B. Aided and L.P aIDED T.\e speakers accepted.

2. D.B. aided and I.P. aided T.E. speakers accepted.

3. L.P. aided and I.P. aided T.E. speakers accepted.

6.Speed of Fluctuation in Intensity (Sp: F.I)

The results obtained for the following three groups with respect to this parameter are given in Table 9. The Sp. F.I in phonation of I.P. aided and same depicted in graph:]1.

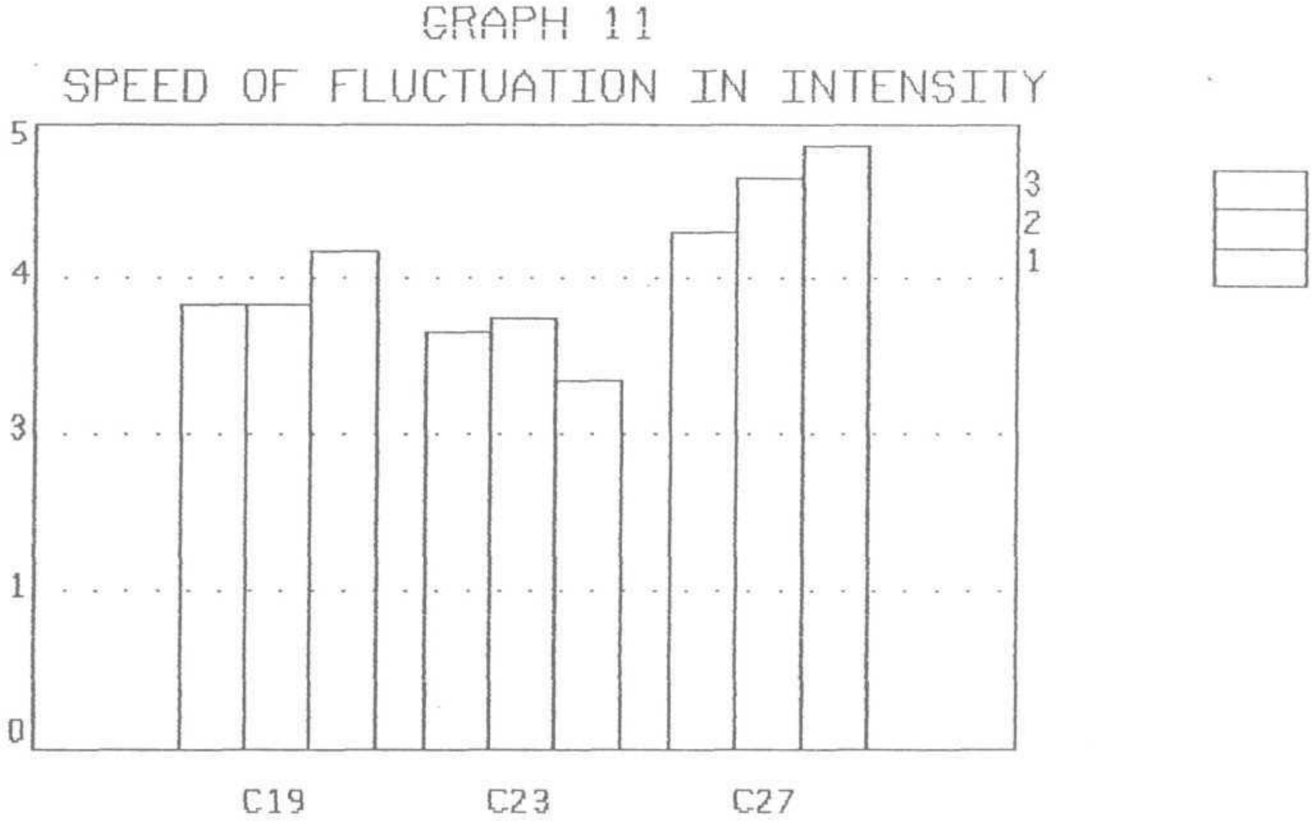
TABLE IX:

GROUP	Mean	S.D.	Range
D.B. :			
: a :	3.54	1.21	1.93- 4.87
:i :	3.32	2.06	1.46- 6.11
:u :	4.13	2.17	1.40- 6.51
L.P. :			
: a :	3.53	2.84	.24- 6.92
: i :	3.43	3.07	.48- 6.36
: u :	3.66	.101	3.53- 3.76
i.p.			
:a :	3.96	2.66	.24- 6.37
: i :	2.92	2.09	1.11- 5.27
: u :	4.81	4.84	.72-10.87

Table 9:- The mean, S.D and Range of Sp: F.I. in phonation of :a:, :i: and :u: for D.B.L.P.and I.P. groups.

In I.P. aided groups the value was greater for :a: (3.96) and :u: (4.81) only. The L.P aided T.E speakers showed more Sp.

GRAPH 11: SPEED OF FLUCTUATION IN INTENSITY IN PHONATION OF /a/, /i/ & /u/ FOR D.B, L.P AND I.P GROUPS.



F.I. in phonation of :i: (3.43) than L.P. aided and I.P. aided T.E. speakers.

The mean Sp. F.I. in phonation for the T.E. speakers of this study and other studies are shown in Table 10.

TABLE X:

Investigators	Mean (H_3)
Rajashekar et al (1991)	13.60 (L.P.)
Santhosh (1993)	14.37 (D.B.) 7.78 (L.P.) 9.19 (I.P.)
Present study (1994)	3.54 (D.B.) 3.53 (L.P.) 3.96 (I.P.)

Table 10:- The mean Sp. F.I. in phonation for T.E. speakers as reported by different investigators.

The mean Sp. F.I. was less as compared to the reports made by Rajashekar (1991) and Santosh (1993).

Mann/whitney 'u' test for unmatched pairs (Table:26) . The test indicated there was no significant difference across the prosthetic conditions (Table.10) Thus the results suggest the type of prosthesis used did not improve the type of prosthesis of the psendoglotis.

The hypothesis stating that there is no significant difference in terms of Sp: F.I. between

1) D.B. aided and L.P.aided T.E. speaker accepted.
2) D.B. aided and I.P. aided T.E. speaker accepted.
3) L.P. aided and I.P. aided T.E. speaker accepted.

7. Intensity Range in Phonation (IR):

The results obtained for the following three groups with respect to this parameter are provided in Table 11 and same depicted in Graph 12.

GRAPH 12 :- INTENSITY RANGE IN PHONATION OF /a/, /i/ & /u/ IN D.B, L.P & I.P GROUPS.

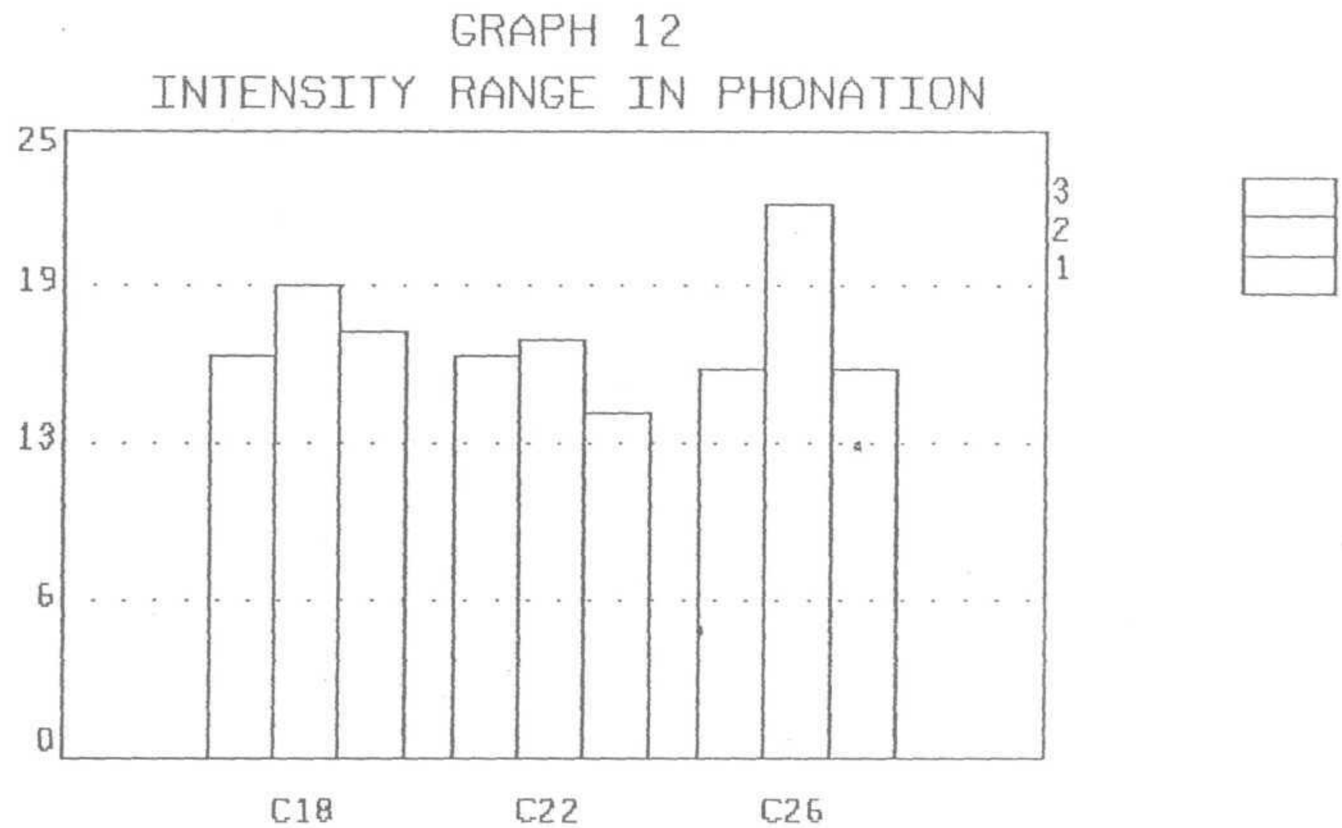


TABLE XI:

GROUP	Mean	S.D.	Range
D.B. :			
: a :	15.94	2.33	14.15-19.32
: i :	15.98	6.74	7.99-22.78
: u :	15.37	7.20	7.81-22.41
L.P. :			
: a :	18.74	11.00	3.16-28.84
:i:	16.58	14.04	3.56-32.37
: u :	22.05	9.75	13.30-33.76
I.p.			
: a :	16.94	9.66	3.06-24.96
: i :	13.71	9.79	4.37-24.90
: u :	15.40	11.01	5.05-25.79

Table 11:- The mean, S.D and Range IR in phonation of :a:, :i: and !u! for D.B.,L.P.and I.P. groups.

L.P. aided T.E. speakers had greater IR than D.B. and I.P. aided for all the vowels.

The mean IR in phonation for !a! for T.E speakers of this study and other studies are shown in Table 12.

TABLE XII:

Investigators	Mean (H_3)
Rajashekar et al (1991)	13.60 (L.P.)
Santhosh (1993)	30.60 (D.B.) 42.60 (L.P.) 25.83 (I.P.)
Present study (1994)	15.94 (D.B.) 18.07 (L.P.) 16.94 (I.P.)

Table 12:- The mean I.R. in phonation in T.E speakers reported by different investigators.

The mean I.R was high as compared to the study done by Rajashekar (1991) and less when compared to the study done by Santosh (1993).

The Statistical analysis using Mann. Whitney U' test for unmatched pairs (Table 26) among T.E.P. groups showed that there is no significant difference between the prosthetic conditions. Thus the hypothesis stating that there is no significant difference in terms of IR in phonation between:

1) D.B. aided and L.P. aided T.E speaker accepted.
2) D.B. aided and I.P aided T.E speaker accepted and
3) L.P aided and I.P. aided T.E speaker accepted.

TEMPORAL MEASURES

1. Words per minute:- The rate of speech was expressed in terms of words per minute in the present study. The results obtained for the following three groups with respect to this parameter is provided in Table:13 and same depicted in Graph 1.

GRAPH 1: WORDS PER MINUTE IN SPEECH IN D.B, L.P & I.P GROUPS

GRAPH 1

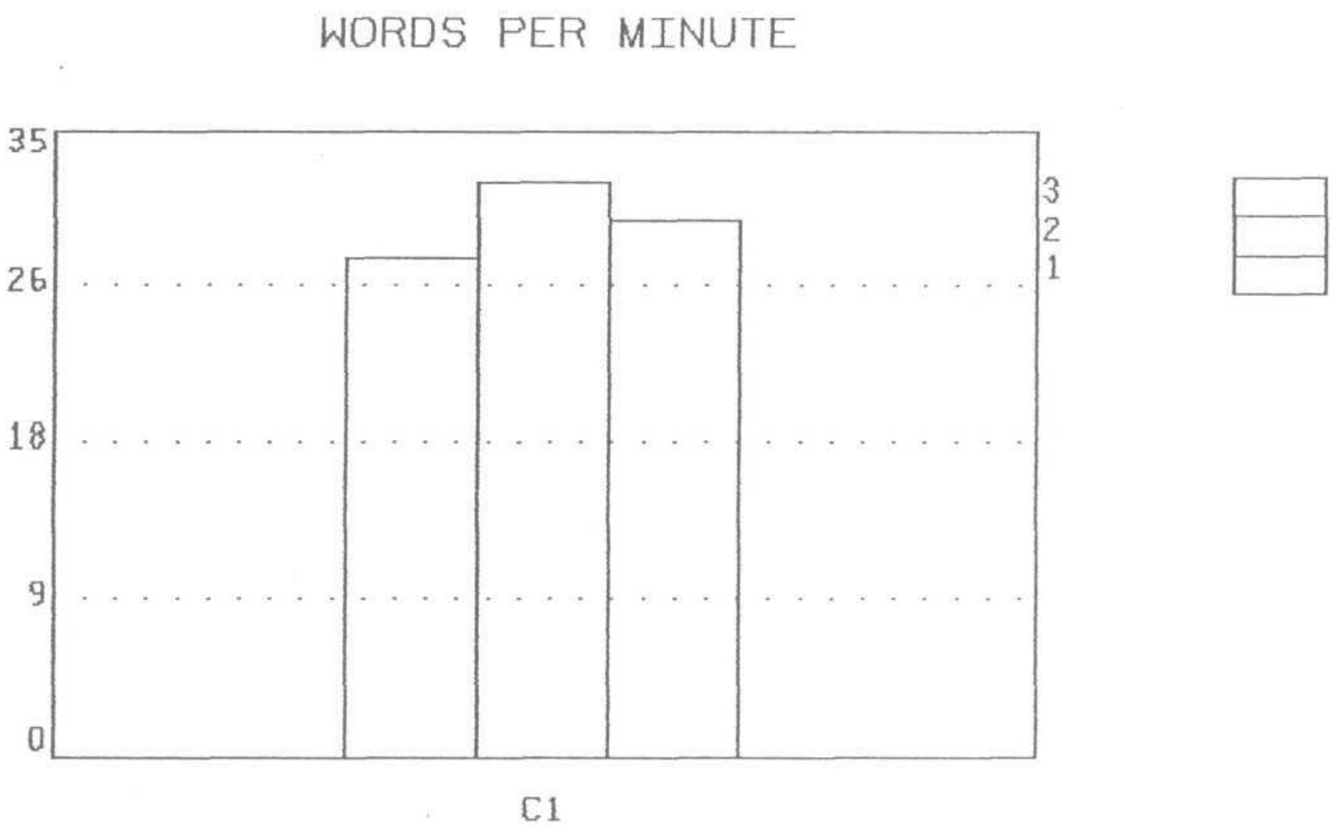


TABLE XIII:

Group	Mean	S.D.	Range
D.B.	27	6.05	19 - 33
L.P.	32	6.97	24 - 40
I.P.	30	3.46	27 - 35

Table 13:- The Mean, S.D, Range of Rate of speech (WPM) for D.B., L.P. and I.P group, were among the T.E speakers the L.P. aided group uttered more number of words followed by I.P and then D.B. aided group.

The mean W.P.M. is compared with studies done by others investigators as shown in Table.

It was found that the W.P.M. in the present study was less when compared to

TABLE XIV:

Investigators	Mean W.P.M.
Rajashekar (1991)	83.7 (L.P.)
Present study (1994)	27.0 (D.B.) 32.0 (L.P.) 30.0 (I.P.)

Table 14:-The mean WPM in speech in T.E speakers reported by different investigators the study done by Rajashekar (1991).

MaNN, WHISTNEY, 'u' TEST FOR UNMATCHED PAIRS (TABLE 27) SHOWED THAT THERE was no significant difference in W.P.M. across T.E. speaker groups with different prosthesis. The hypothesis stating that there is no significant difference in terms of WPM in speech between:-

1) D.B. Aided and L.P. Aided T.E speaker accepted,

2) D.B. aided and I.P. aIDED t.e SPEAKER ACCEPTED AND

3) L.P aided and 1.P. aided T.E. speaker accepted.

Thus it was concluded that there was no difference in W.P.M. in speech acorss prosthesis.

2. Syllables per minute:- The table shows the results with reference to syllables per minute in speech in T.E.P group with D.B. L.P and I.P. prosthesis (Table 15) and same depicted in Graph 2.

TABLE XV:

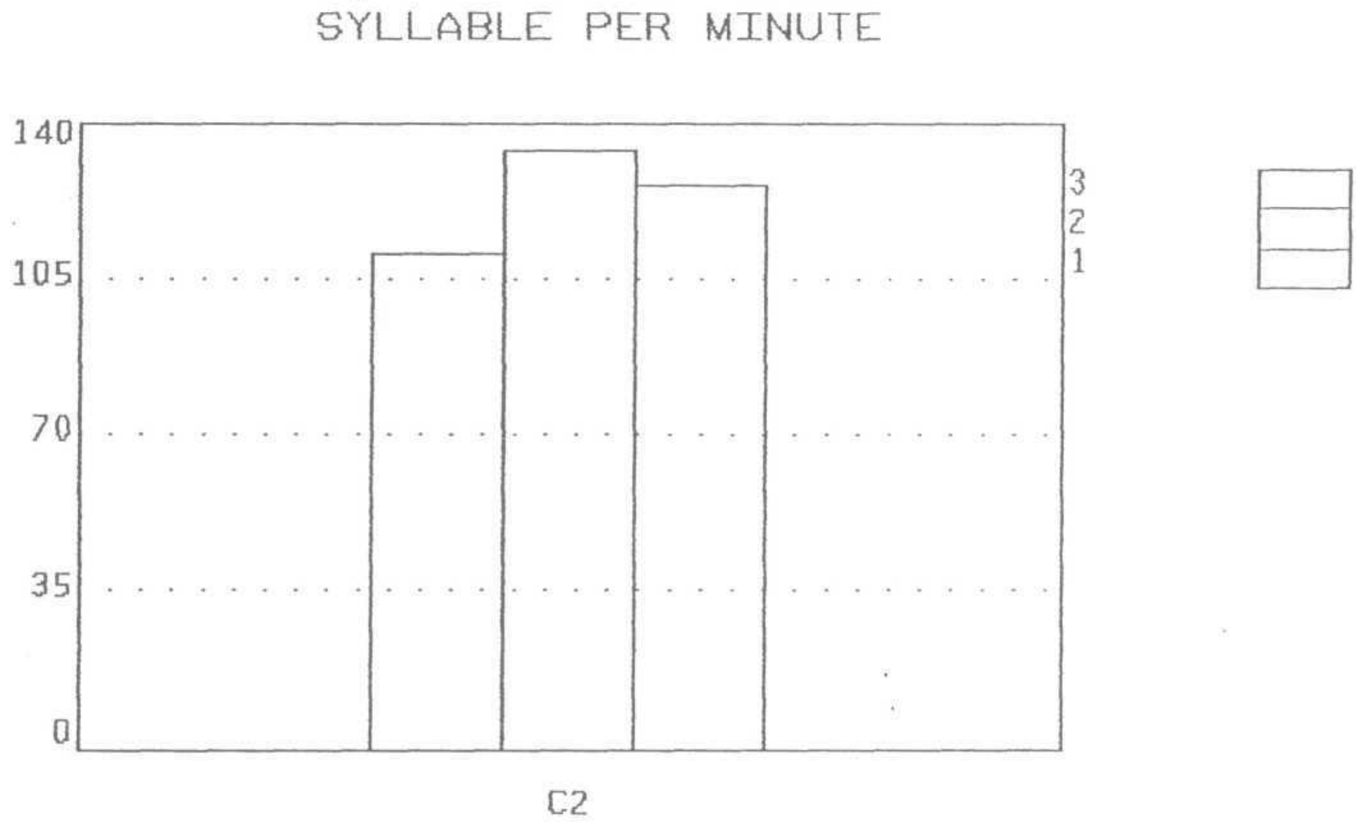
Group	Mean	S.D.	Range
D.B.	110.5	26.23	75 134
L.P.	3.5	31.85	97 169
I.P.	125.75	18.30	107 150

Table 15:- The mean, S.D and range of syllables per minute is speech in D.B. L.P. and I.P. groups.

Within the T.E.P. group the C.P aided T.E speaker showed greater syllable per minute (133.5 PM) followed by the I.P aided T.E speaker (125.75 SPM) and then the D.B. aided speakers.

Mann whistney 'U' test for unmatched pairs (Table:27) revealed that there was no significant difference among the prosthetic condition.

GRAPH 2 :- SYLLABLES PER MINUTE IN D.B, L.P & I.P GROUPS



Thus the hypothesis stating that there is no significant difference in terms of syllables per minute between:

1) D.B. aided and L.P aided T.E. speakers accepted.

2) D.B. aided and I.P. aided T.E speakers accepted.

3. Number of Pauses:- Table shows the numbers of pauses in speech for T.E.P group with D.B, L.P. and I.P prosthesis (Table 6) and same depicted in graph 3.

TABLE XVI:

Group	Mean	S.D.	Range
D.B.	116.5	25.49	80 - 139
L.P.	100.0	22.23	74 - 125
I.P.	86.5	22.95	54 - 108

Table 16:- The Mean, S.D and Range of number of pause in speech for D.B. L.P. and I.P. groups.

The I.P aided T.E.P speaker showed lesser number of pauses (86.5) compared to L.P and D.B. group and L.P. aided showed lesser number of pauses (100) compared to D.B. group.

The mean number of panses when compared with reports by other investigators as shown in Table 17.

TABLE XVII:

Investigators	Mean No. of Pauses
Rajashekar et al (1991)	15.5 (L.P.)
Present study (1994)	116.5 (D.B.) 100.0 (L.P.) 86.5 (I.P.)

GRAPH 3: PAUSES IN SPEECH IN D.B, L.P AND I.P GROUPS

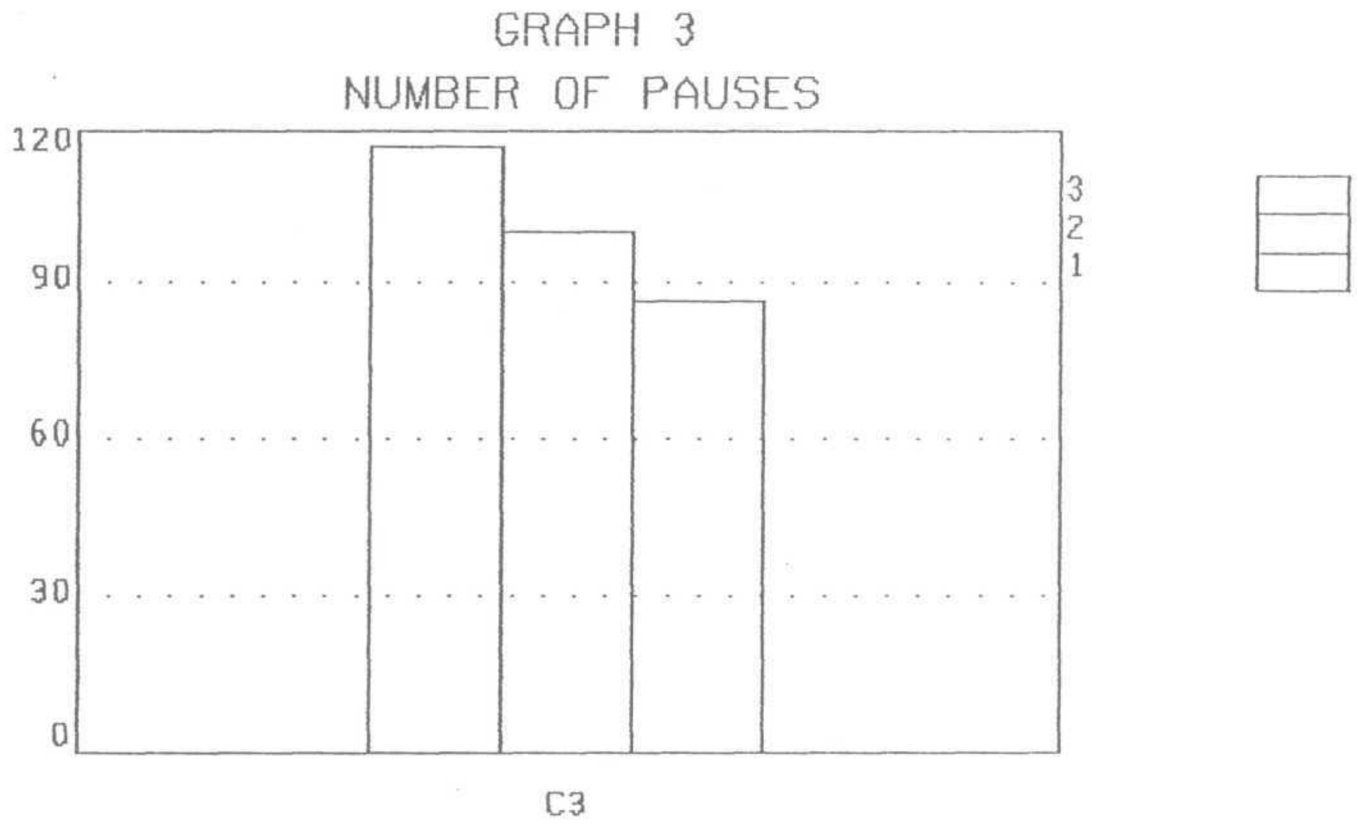


Table 17: The mean number of pauses in speech jn T.E. speakers reported by different investigators.

The number of pauses is greater in the present study when compared to the study done by Rajashekar Et.nl(1992).

Mann Whitney 'U'; test for unmatched pairs (Table 27) revealed there is no significant difference among the T.E.P groups. Thus the hypothesis stating that there js no significant difference in terms of number of pauses between:

1) D.B.aided and L.P. aided T.S speakers accepted.

2) D.B. aided and I.P. aided T.E speakers accepted.

3) L.P. aided and I.P aided T.E speakears accepted.

4) Mean pause time: Table 18 shows the mean pause time in T.E.P. with D.B. L.P. and I.P prosthesis(as depicted in Graph 4)

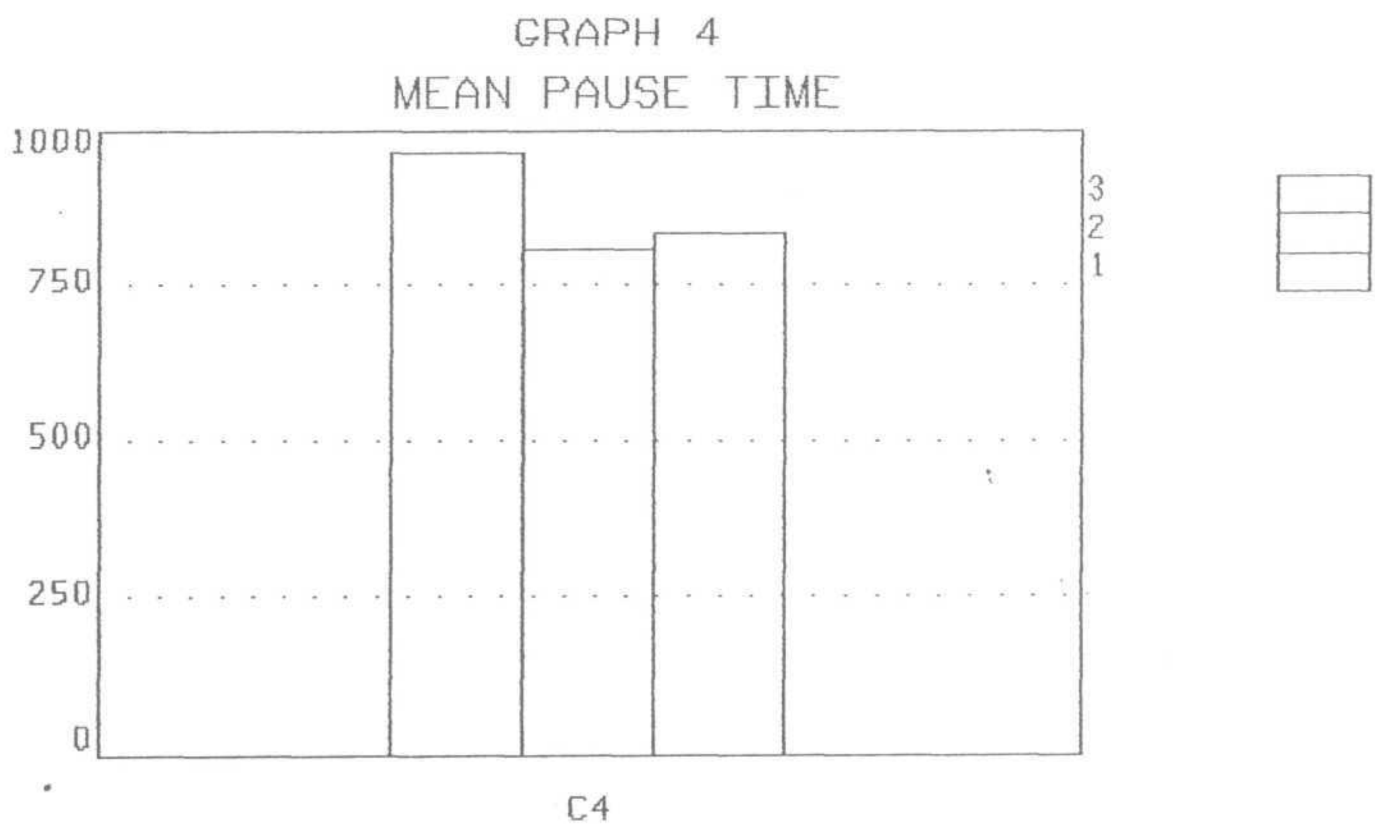
TABLE XVIII:

Group	Mean (msec)	S.D.	Range (msec)
D.B.	962.53	358.990	80.00-139.00
L.P.	808.95	113.475	705.09-933.88
I.P.	832.59	169.400	675.00-989.52

Table 18: The mean, S.D and Range of Mean pause time in speech in D.B., L.P and I.P. groups.

Here the L.P aided group had lesser mean pause time (808.95 m/sec) than the D.B. and I.P. aided groups. And among them the I.P. aided group had lesser value (832.59 m/sec) compared to D.B. aided.

GRAPH 4: MEAN PAUSE TIME IN SPEECH IN D.B, L.P & T.P GROUPS



The mean pause time when compared with studies done by other investigators as shown in Table 19..

TABLE XIX:

Investigators	Mean No. of Pauses
Rajashekar et al (1992)	869.56 (L.P.)
Present study (1994)	962.53 (n.n.) 808.95 (L.P.) 832.59 (I.P.)

Table 19: The Mean pause Time of speech in T.E speakers reported by different investigators.

The mean pause time was less in the present study as compared to the study done by Rajashekar Et al (1992)

Mann Whitney 'u' test for unmatched pairs (Table 27) revealed there is no significant difference among T.E.P groups. Thus the hypothesis stating that there is no significant difference in terms of mean pause time between:

1. D.B. aided and L.P. aided T.E speakers accepted.
2) D.B. aided and I.P. aided T.E speakers accepted.
3) L.P. aided and I.P. aided T.E speakers accepted.

5) % Pause Time:- Table 20 shows the % pause time in T.E.P. group and with D.B. L.P. and I.P. prosthesjs as depicted in Graph:5.

TABLE XX:

Group	Mean	S.D.	Range
D.B.	49.55	15.58	36.97-69.25
L.P.	43.68	18.51	27.34-64.85
* I.P.	39.09	9.53	29.05-51.51

GRAPH 5: % OF PAUSE TIME IN SPEECH IN D.B, L.P & I.P GROUPS.

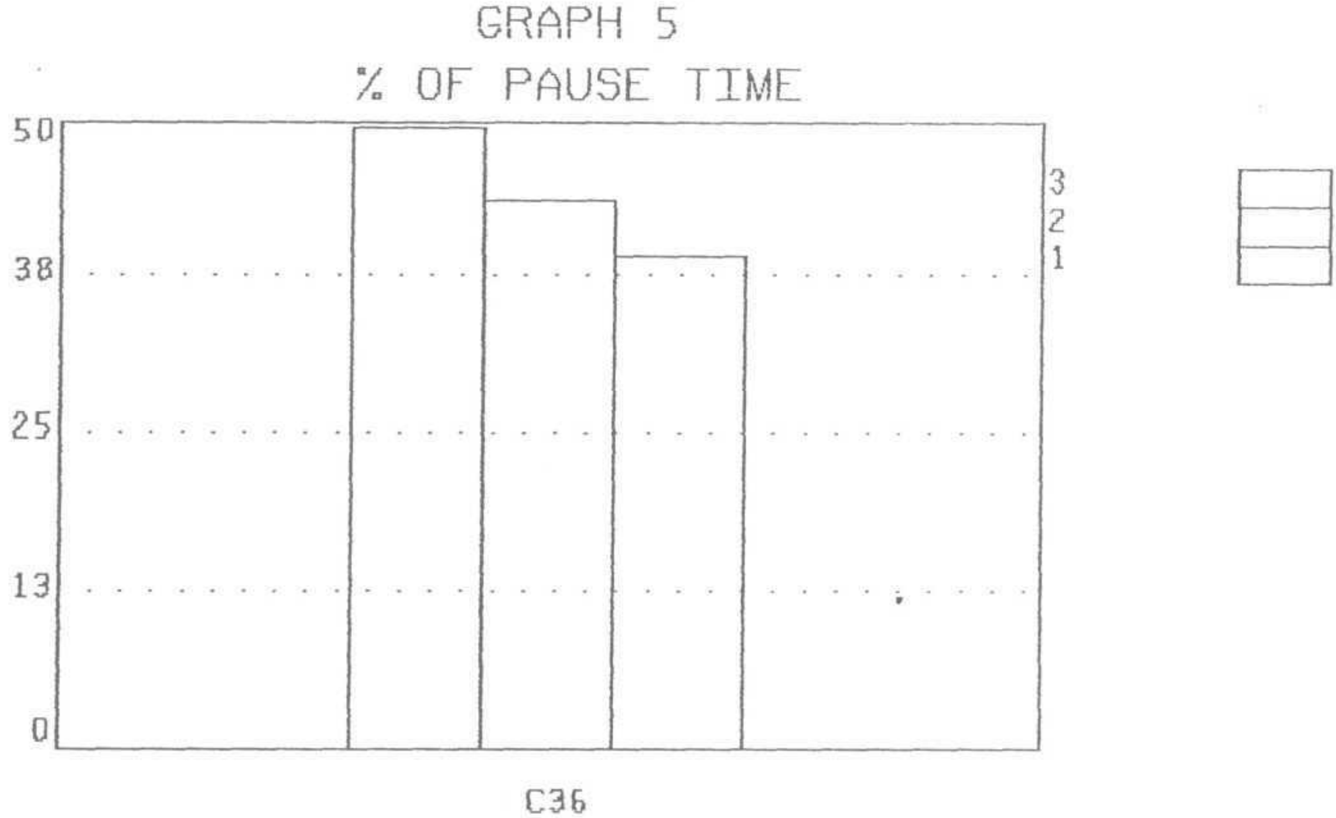


Table 20: The mean, S.D and range of % of pauses in speech in D.B. L.P. and I.P groups.

The I.P aided group showed lesser % of pauses (39.09) compared to L.P. and D.B aided group and L.P. aided showed lesser % of pauses (43.68) compared to D.B groups.

The % of pauses when compared with studies done by other investigators as shown in Table 21.

TABLE XXI:

Investigators	Mean % of Pauses
Rajashekar et al (1992)	34.28 (L.P.)
Present study (1994)	49.55 (D.n.) 43.68 (L.P.) 39.09 (I.P.)

Table 21: The mean % of pauses in speech in T.E speakers reported by different investigators.

The % of pauses is higher in the present study when compared to the study done by Rajashekar et.al(1992).

Mann Whitney 'U' test to unmatched pairs (Table 27) revealed that there was no significant difference among the T.E.P groups. Thus the hypothesis stating that there is no significant difference in terms of number of pauses between:

1) D.B. aided and L.P. aided T.E speakers accepted.
2) D.B. aided and I.P. aided T.E speakers accepted
3) L.P. aided and I.P. aided T.E speakers accepted.

6. Vowel Duration(V.D):- The V.D for T.E speakers with D.B, L.P. and I.P. prosthesis are presented in Table 22 as depicted in Graph 13.

TABLE XXII:

Vowel	D.B.		L.P.		I.P.	
	Mean	Range	Mean	Range	Mean	Range
:a:	264.78 (15.52)	243.75 277.88	250.19 (29.58)	212.50 (282.00)	240.62 (30.83)	200.00 275.00
:i:	108.06 (23.13)	76.00 131.25	113.94 26.25	87.5- 150.00	117.18 (25.70)	93.75 150.00
:u:	140.625 (35.90)	112.5- 187.50	130.75 40.51	75- 168.75	120.31 (32.02)	75- 150.00
:e:	128.78 (43.61)	84.38- 187.50	147.75 (30.94)	112.5- 187.5	179.69 (32.02)	150- 225.00
:o:	134.44 (41.00)	93.75- 187.50	145.56 (53.76)	82.25 206.25	154.70 (40.03)	100- 1875.00

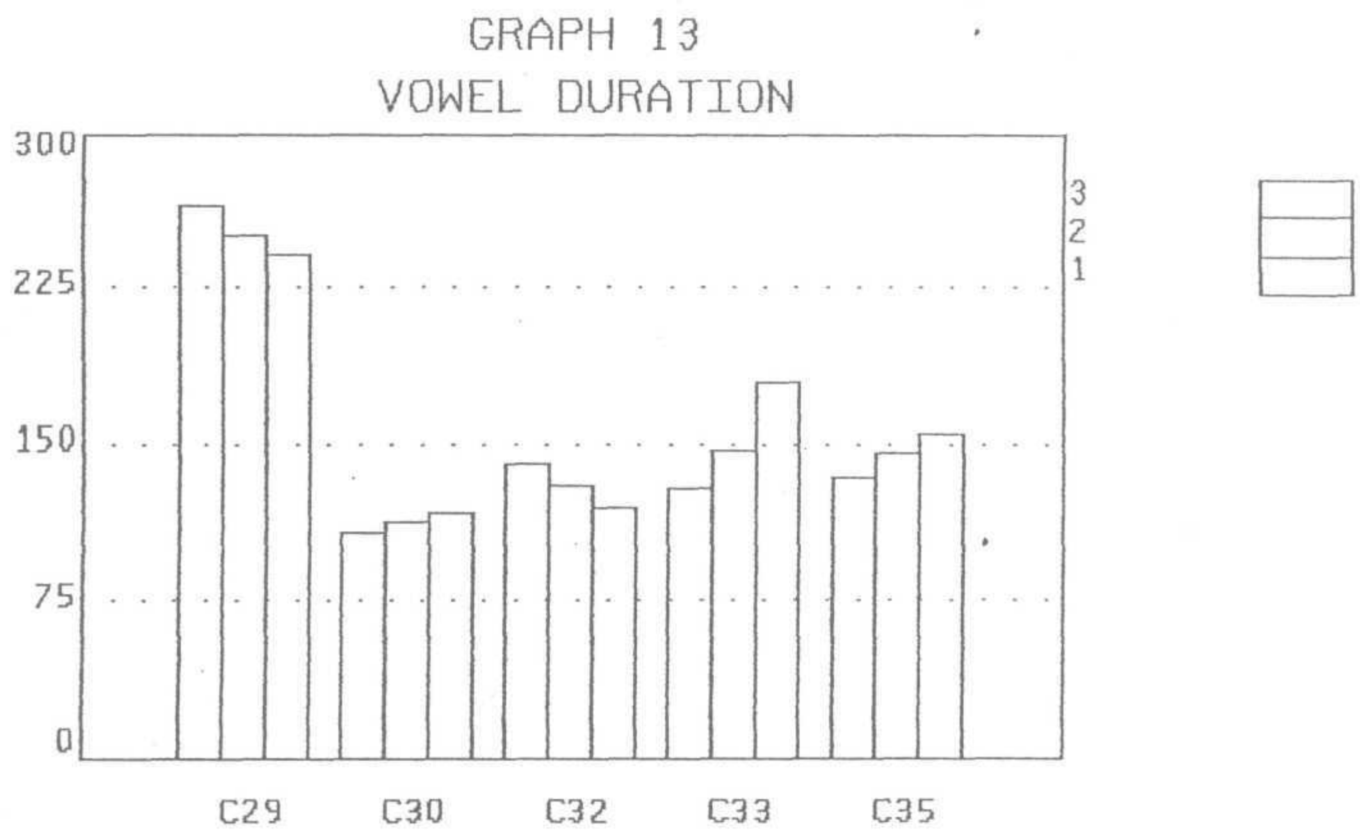
Table 22:- The mean, S.D and range of vowel duration of :a:, /e/, :u:, /e/ and /o/ for D.B. L.P. I.P. groups.

Among T.E speakers the D.B aided T.E speakers and longest V.D in two vowels (:a: and :u: (264.78 and 140.65) out of 5 vowels studied. The I.P. aided T.E speaker had longer U.D for the vowels (!ii /e/ and /o/) (117.18,179.69 and 154.7).

The vowel duration in the present study was greater for :a: and /e/ when compared to the study done by Rajashekar et.al (1992) and lesser for :i:, :u: and /o/.

Mann Whitney 'U' test for unmatched pairs (Table 27) revealed that there was no significant difference among the T.E.P. groups. Thus the hypothesis stating that there is no significant

GRAPH 13: VOWEL DURATION OF /a/, /i/, /u/, /e/ & /o/ IN PHONATION IN D.B, L.P & I.P GROUPS.



difference in terms of vowel duration between:

1) D.B. Aided and L.P. aided T.E speakers accepted.

2) D.B. aided and 1.P. aided T.E speakers accepted and

3) L.P. aided and I.P. aided T.E. speakers accepted.

7. Voice onset Time: Voice onset time for /P/ /t/ and /k/ (unaspirated vowel stops) was analysed using spectroqraphic display. It was found that for all the three groups the burst could not bo identified easily and VOT could not be measured. It may be duo to inability of the T.E.P speakers to build and maintain air pressure.

PSYCHOACOUSTIC MEASURES

Acceptability:- A five point scale with one being the "most acceptable" and five being the "least acceptable" was used to rate the acceptability of speech of all the three groups. Five judges rated the acceptability for each speaker individually. The inter and intrajudge reliability test showed no significant difference between the judges.

Table:, ...23...depicts the judgement on the acceptability ratings of the four groups. It is seen that no significant difference was observed across different prosthetic condition in T.E speakers.

TABLE XXIII:

Group	Mean	S.D.	Range
D.B.	3.87	0.95	2 - 5
L.P.	3.56	0.96	2 - 5
I.P.	3.50	0.63	2 - 4

Table:23:- The mean, S.D and range of acceptability rating for D.B. L.P. and I.P. groups.

For T.E speakers acceptability rating score of this study was higher than as observed by Rajashekar (1991) (2.7) Santosh (D.B.2.5, L.p.2.65, i.p. 2.41).

Mann Whitney U test indicated no (Table 28) significant differences across prosthetic groups.

The hypothesis stating that " There is no significant difference in terms of acceptability across".

1) D.B. aided and L.P. aided T.E speakers accepted
2) D.B. aided and I.P. aided T.E speakers accepted.
3) L.P. aided and I.P. aided T.E speakers accepted.

INTELLIGIBILITY: Table 24-present the mean intelligibility scores (percentage) computed from the scores of five judges for three groups. The inter and intra judge reliability tests showed no significant difference between the judges.

TABLE XXIV:

Group	Mean	S.D.	Range
D.B.	79.36	13.43	60.0 - 100
L.P.	71.76	24.46	13.3 - 100
I.P.	76.64	17.68	46.6 - 100

Table 24:- The mean, S.D. and range of intelligibility (%) for D.B. L.P. and I.P. groups.

When compares with the study done by Santosh the scores of the Investigator:

TABLE XXV:

Investigators	Mean % of Pauses
Santhosh (1993)	76.33 (D.B.) 83.79 (L.P.) 80.10 (I.P.)

Table 25:- The mean intelligibility scores in T.E. speakers reported by Santhosh (1973).

The present dtudy was slightly lower than the scores reported by him.

Mann Whitney U test for unmatched pairs revealed no significant differences(Table 25) among T.E speakers in all the three prosthesis conditions. But when compared individually between subjects it was found that the seconds third subject performed better using low pressure prosthesis.

The hypothesis stating that 'There is no significant difference in terms of intelligibility between:

1) D.B. aided and L.P. aided T.E speakers accepted.
2) D.B. aided and I.P. aided T.E. speakers accepted and
3) L.P. aided and I.P. aided T.E speakers accepted.

TABLE XXVI summarizes the significant difference between the groups in terms of acoustic parameters studied:

Parameter		D.B. vs L.P.	D.B. vs I.P.	L.P. vs I.P.
1) Fo in Phonation				
	:a:	NS	NS	NS
	:!i:	NS	NS	NS
	:u:	NS	NS	NS
2) Ex F.F.				
	:a:	NS	NS	NS
		NS	NS	NS
	:u:	NS	NS	NS
3) Sp F.F.				
	:a:	NS	NS	NS
	:i:	NS	NS	NS
	:u:	NS	NS	NS
4) FR in Phonation				
	:a:	NS	NS	NM
	:i:	NS	NS	NS
	:u:	NS	NS	NS

5) Ex F.I.				
	:a:	NS	NS	NS
		NS	NS	NS
	:u:	NS	NS	NS
6) Sp F.I.				
	:a:	NS	NS	NS
	:i:	NS	NS	NS
	:u:	NS	NS	NS
7) IR in Phonation				
	:a:	NS	NS	NS
	:i:	NS	NS	NS
	:u:	NS	NS	NS

[Note : S = Significant, NS - Non-significant]

TABLE XXVII summarizes the significant difference between the groups in terms of Temporal parameters studied

Parameter	D.B. vs L.P.	D.B. vs I.P.	L.P. vs I.P.
Words per minute	NS	NS	NS
Syllables per minute	NS	NS	NS
Numbers of Pauses	NS	NS	NS
Mean Pause time	NS	NS	NS
% of Pauses	NS	NS	NS
V.D.	NS	NS	NS

Parameter	D.B. vs L.P.	D.B. vs I.P.	L.P. vs I.P.
Acceptability	NS	NS	NS
Intelligibility	NS	NS	NS

[Note : S = Significant, NS = Non-significant]

Thus it was found that among T.F.P. groups there were no significant difference between the prosthetic conditions in all parameters that were studies. But when compared with normals (study done by Santosh (1993) the Fo in phonation produced by the speakers with the I.P. prosthesis was more similar to the normals for all the three vowels than the Fo in phonation of vowels by speakers with the prosthesis. Ex: F.F. Sp: F.F, F.R in phonation were greater in all the prosthetic conditions than in normals. It was found that Sp. F.I. Ex: F.I. and IR in phonation were higher in all three groups when compared with normals. When compared with study done by Rajashekar et.al (1992) it was found that the number of syllables per minute was lesser in all the three groups when compared with normals. Words per minute was less when compared with normals. Number of pauses, Moan pause time, % pause time were greater than in normals. V.O.T as shown by speakers with Duck-Bill, L.P and I.P. the vowels !a! and /e/ was greater and the duration for /o/ was similar to the normal.

Thus the results revealed several interesting facts. It was seen that the greater number of pauses, mean pause time and % of pauses was seen in all the three groups. This was similar to the study done by Robbins Et.nl (1984). Similarly the reduction in reading rate could be done to the increased pause time. Thus it was found that the alaryngeal speakers were different from the laryngeal speakers in terms of several parameters (Accountic and Temporal).

Thus based on the results of the present study it may be concluded that there is no significant difference between :

1) Duck-Bill Vs Low pressure prosthesis

2) Duck-Bill Vs Indian prosthesis

3) Low-pressure Vs Indian Prosthesis in terms of the following acountic, temporal and psycho acoustic parameters.

a) Fo in phonation

b) Extent of fluctuation in frequency

c) speed of fluctuation in frequency

d) Frequency range in phonation

e) Extent of fluctuation in Intensity.

f) Speed of fluctuation in Intensity.

g) Intensity range in phonation

h) Words per minute

i) Syllabus per minute

j) Number of pauses.

k) Mean pause time

1) % of pauses

m) Vowel duration

n) Acceptability

o) Intelligibility

As the three prosthesis mentioned above do not differ in their efficiency in producing voice in laryngeotomees, the Indian prosthesis is recommended as it is less expensive and easily available in India that the prosthesis developed in India is equally efficient and at the same time it is economical and easily available. Therefore it is recommended that the Indian prosthesis could used for laryngectomees.

On the basis of these results it has been suggested that voice restoration in laryngecttomees must emphasise on working with the above mentioned parameters especially the number of pauses, the mean pause time and % of pauses which would bring about an increase in the rate of speech thus contributing to better acceptability and intelligibility of alaryngeal speakers.

SUMMARY AND CONCLUSION

Rehabilitation of a laryngectomee aims at restoring the pre-operative condition of the patient as far as possible in terms of psychological, physiological, social and economic status i.e. basically by restoring voice. This is achieved by the efficiency of the patient in making use of his remaining structures for speaking.

Different methods for the restoration of voice following laryngectomy have been developed such as Oesophageal speech, electronic artificial larynx. But with the development of T.E.A technique (singer and Blom) 1980), T.E speech has become widely accepted method of alaryngeal speech. T.E. speech is achieved when pulmonary air is directed through the prosthesis to vibrate the P.E segment and produce voice. Blom singers duck bill prosthesis was developed first. Later many other prosthesis were developed in different parts of the world to overcome the drawback of existing prosthesis. So there was a need for studying the different prosthesis in terms of temporals acoustic and perceptual parameters. In this study it was possible to study B.S Duck Bill prosthesis, B.S low pressure prosthesis and Indian prosthesis all being used by the same subject and they were compared with each other. The voice and speech sample from 4 T.E.speakers under three conditions(i.e. 3 types of prosthesis) were collected. There were analysed using computer programmes and judges to obtain 16 parameters (acoustic, temporal and psychoacoustic)

ACOUSTIC PARAMETERS

1. Fundamental frequency in phonation.

2. Extent of fluctuation in Fo (ex.F.F)

3. Speed of fluctuation in frequency (Sp. F.F)

4. Frequency range in phonation (F.R)

5. Extent of fluctuation in Intensity(Ex.F.I)

6. Speed of fluctuation in Intensity (Ex.F.I)

7. Intensity range in phonation (IR)

TEMPORAL PARAMETERS

1) Words per minute

2) Syllable per minute

3) Number of pauses

4) % of pause time

5) Mean pause time

6) Vowel duration.

PSYCHOACOUSTTIC MEASURES

1) Intelligibility

2) Acceptability.

CONCLUSION

There was no difference between the different types of prosthesis.(Duck Bill, Low Pressure and HRA) on the following parameters studies. It may be concluded that there is no significant difference between:-

1) Duck Bill Vs Low pressure prosthesis
2) Duck Bill Vs Indian Prosthesis
3) Low pressure Vs Indian Prostheisis in terms of the following acoustic, temporal and psychoacoustic parameters i.e.

a) There is no significant difference in Fo in Phonation
b) There is no significant difference in Extent of fluctuation in frequency
c) There is no significant difference in Speed of fluctuation in frequency.
d) There is no significant difference in Frequency range in phonation
e) There is no significant difference in Extent of fluctuation in Intensity
f) There is no significant difference in Speed of fluctuation in Intensity
g) There is no significant difference in Intensity range in phonation
h) There is no significant difference in Words per minute
i) There is no significant difference in Syllables per minute

j) There is no significant difference in Number of pauses

k) There is no significant difference in Mean pause time

l) There is no significant difference in % of pauses

m) There is no significant difference in Vowel duration

n) There is no significant difference in Acceptability

o) There is no significant difference in Intelligibility.

LIMITATIONS OF THE STUDY

Adaptation effect could have constributed to the better acceptability of the I.P. prosthesis. The subjects were made to send the same passage first using D.B, L.P. and I.P. prosthesis.

The subjects should get familiarity with the each type of prosthesis and then the sample should be recorded. This could not be done due to time limitation.

RECOMMENDATIONS

1. Other parameters may be studied with larger group.

2. Studies on synthesis may be carried out to confirm the role of spacing between the formant frequency in improving the speech in laryngent speaker.

3. Studies related to the articulatory aspects along with these parameters and their influence on acceptability and intelligibility in T.E speakers would help in determining the importance of the parameters considered in the present study.

REFERENCES

BIBLIOGRAPHY

Anderson. V. (1961) - Training the speaking voice. Oxford University, N.Y.

Angelocci. A.A., Kopp, C.A., & Holbrook, A (1964) - The vowel formants of deaf and normal hearing 11 to 14 year old boys J.S.H.D., 29, 156-170.

Angermuci C.B., and Weinberg B. (1981) - Some aspects of fundamental frequency control by esophogial speakes. J.S.H.D. 24,85-91.

Arnold (1955) cited in Gordon, M.T., Morton, F.M., and Simpeson, I.C. - Air flow measurements in diagnosis, assessment and treatment of mechanical dipphonics. Folio phoniatrica, 30,1978,161-164.

Arnold (1959) cited in Michel, J.Fand Wendahl.R. Correlates of voice production in Travis, E.L.(Ed) (1971) - Handbook of speech Pathology and Audiology, Prentice Hall, Inc, Englwood Cliffs, N.J.1971.

Araonson, A.E.(1980). Clinical voice Disorder - An interdisciplinary approach. Brain C. Dicker, a div.of Thims-Stratton, Inc: New York.

Atkinson, J.E.(1973). Aspects of intonation in speech; Implications from an experimental study of fundamental frequency. Ph.D. Diss, Univ. of Connecticut (Unpublished).

Atkinson, J.C1978). corelation Analysis of phisiological factors controlling fundamental voice frequenbey. J.A.S.A., 63,211-222.

Baer T. (1980) - Vocal Jitter-A neuromuscular explanation. Trauscription of the Eighth Synposium of the care of the rpofessional voice, voice foundation-New York,19-22.

Bau, T, Gay, T. a Nimi , J.(1976), Control of fundamental frequency, intensity and register of phonation. Haskins.

Baggs, T.W., a Pine, S,J.(1983) Acoustic characteristics: Tracheoesophagial speech. J.C.D., 16,299-307.

Baken, R.J.(1987). Vocal fundamental frequency, Ch.5., in clinical measurement of speech and voice. College Hill press, A division of Little, Brown and company (Inc), Boston, Massachusetts.

Balaji 0. (1988) - Long term Average spectrum and Electroglottography in Dipphonics. Unpublished Master's Dissertation, Univ. of Mysore.

Benson, R. and Hersh, I (1953). Some variables in audio spectrometry. J.A.S.A.25, variables in audio spectrometry. J.A.S.A.25, 499-505.

Blom E.D., Singer M.J. & Hamaku, R.C(1982) - Tracheostoma value for postlayngectomy voice rehabilitation. Aunals of Otology, Rhinology and Layngology,91,576 -578.

Blom E.D., Singer, M.T., & Hamaker,R.C. (1986) A prospective study of tracheoesophagial speech. Arch. Octolaryngol, Head Neck Surg. 112, 440-447.

Blood, G.W.(1984). Fundamental frequency and intensity measurements in lauryngeal and alaryngeal speakers, J.C.D. 17,319-324.

Border G.J. & Harris, K.S.(1980) speech science primer. Baltimore,USA.

Calcaterna, T.C. and Jafek, D.W.(1971) - Tracheoesophageal shunt for speech rehabilitation after total laryngectomy. Arch Otolaryngeal 94: 124-128.

Carhart, R.(1938) Infraglattal resonance and a casluion pipe. Speech manograph,5,65-90.

Carhart, R.(1941). The spectra of model larynx tones, Speech Manograph,8,76/84.

Cheesman, A.D.,Knight, J,,McIvor, J., and pery A(1965) Assessment pror for post-laryngectomy patients who desire surgical voice reestoration. J. Laryngology and otology, 100,191-199.

Chodosh, P.L. Cian Carlo H.R., Goldstein ..J.(1984). Pharyngeal myotomy, Laryngoscope,94,52-57.

Chistensen, J., & Wenburg, B.(1976) vowel duration characteristics of esophageal speakes, J.S.H.R. 19,678-689.

Coleman, R.F., MaLIS, J.H., and Hinson, J.K., (1977)-Fundamental frequency - sound pressure level profiles ofr adult male and female voices. J.S.H.R., 20,197-204.

Colheri, R.(1975) Phisiological correlates of intoration patterns, J.A.S.A. 58,249-255.

Damste, P.H.(1958). Oesophageal speech after laryngectomy., Cyumigem,Netherlands;creler,moistema . . . .

Dejoncbene, P.H. (1986. Acousticsal Characteristics of voice in nodule carrier investigated by long-time average spectra. (Abstract), Folia Phoniatrica, 38 No.(5-6) .

Denes, P.B., Pnser.E.N. (1963),The speech Chain. Bill telephone laboratories. Inc.

Diedrich, W.M.(1968). The mechanism of esophagial speech. Amals of the New York Academy of Sciences,155,303-317.

Diedrich W.M. and Youngstrom (1977) - Alaryngeal speech. Charles C. Thomas, Springfeild, Illinos.

Edels Y., (1983) - Pseudo-voice its theory and practice. In Edels Y. (Ed) - Laryngectomy: Diagnosis to rehabilatation, London, Groom Helm.

Emrickson C.I. (1959) - The basic factors in the human voice. Psy. Monogrpahs, Univ. of Iowa studies in Psychology, 10, 86-112.

Evans B.S., Drummond S.S. (1985) - Surgical voice restoration procedures for laryngectomees : A review. Folia Phoniatrica, 37, 163-194.

Ewan W.A. (1979a) - Laryngeal behaviour in Speech. Rep. Phonolgy Laboratory, Univ. of California, Berkely, 3.

Ewan W.G. (1979b) - Can intrinsic vowel be explained by Source tract coupling? J.A.S.A., 66, 358-362.

Fairbanks G. (1960) - Voice and Articulation. Dull book. New York, hayer and Row publishers

Fant G. (1957) - Modern instruments and methods for acoustic studies of Speech. RIT Stockholm, Technical Report No.8, (19--).

Formly C. and Monsen R.B. (1982) - Long Term Average spectra for normal and hearing - impaired adolescents. J.A.S.A 71, 196-206.

Fritzell G., Hallen 0., Sundberg J. (1974) - Evaluation of teflon injection procedures for paralytic dysphonia. Folia phoni at., 26, 414-421.

Frokjau-Jensen B., Prytz S. (1976) - registration of voice quali-ty. Bruel and Kjau, Technical Review, No.3 , 3-17.

Fry D.B. (1985) - Duration and intensity as physical correlates of linguistic stress. J.A.S.A., 27, 765-768.

Gandou J. & Madduson I. (1976) - Measuring larynx movement in standard Thai using the Cricothyrometer, Phonetica 33, 241-267.

Gauffin J, & Sundberg J (1977) - Clinical applicatoin of acoustic voice anlaysis - acoustical analysis, results and discussion. I.L.A.P. Congress Proc. 1, 489-502.

Gilbert H.R. & Campbell M.I. (1978) - Voice onset time in the speech of hearing impaired individuals. Folia phoniat, 30, 67-81.

Goldstein L.P. (1982) - History and developement of laryngeal prosthetic devices. In A. Sekey and R. Hanson (Eds), Electroacoustic analysis and enhancement of alaryngeal speech: Springfeild:Charles C. Thomas.

Gopal N.K. (1986) - Acoustic analysis of the speech in normal adults. Unpublished Masters Dissertation, Univ. of Mysore

Gouldd W.J. (1975) - Quantitative assessement of vocie function in mycrolaryngectomy. Folia phoniat, 27 (3), 190-200.

Hamaku R.C., Singer M.I., Blom E.D. & Daniel H.A. (1985) - Primary restoration at laryngectomy. Archives of Otolaryngeal, III, 182-186.

HAMMARBERG B., Fritzell S. Schiratzki H. (1984) - Teflon paste injection in 16 patients with paralytic dysphonia:Perceptional acoustic evaluation J.S.H.D. 49, 72-82.

Hammarberg B. & Nord L. (1989) - Tracheo-Oesophageal speech, oesophageal speech and artificial larynx speech - acoustic and perceptional aspects XXI St. Congress I.A.L.P., Prague, 426-428.

Hariprasad G.U.M. (1992) - Spectrographic Analysis of T.E. speech. Unpublished Masters Dissertation submitted by Univ. of Mysore.

Hazarika P., Murthy P.S. & Rajshekar B. (1983) - Ciniflurographic studies os post laryngectomized patients. Paper presented at the 35th Annual Conference of AOI, Trivandrum.

Hazarika P., Murthy P.S., Rajashekar B. and Kumar A. (1990) Surgical voice restoration in alaryngeal patients. Ind J. Otolaryngol, 42, 107-111.

Heiberger V.L. & Horri Y. (1982) - Jitter and Shimmer in sustained phonation. In Lass, N.J. (Ed) Speech and Language, Vol. 7, Academic Puss, New York.

Herby-Cohn N.J., Hausfeld N.J., Jakuliazak (1984) - "Artificial Larynx Prosthesis" : Comparitive Clinical Evaluation. Laryngoscope, Jan 1984, Vol 94, No. 1, 43-45.

Herby J., Souline C. Jr (1986) - Tracheosophageal speech failure in the laryngectomee: The role of constructor myotomy. Laryngoscope, 96, 1016-1020.

Hilges J.M., Schouwenberg F.P. (1990) - "A New Low Pressure, Self sustaining Prosthesis (Provox) for Voice rehabilitation after total laryngectomy". Laryngosscope, Nov. 1990, Vol. 100, No. 11, 1202-1207.

Hirano M. (1981) - Clinical Exantiantion of Voice Disorders of human communication, 5, Springer, Wien.

Hirano M., Koiki Y.J. & Von Lidten H. (1968) - Maximum phonation time and air usage during phonation: A Clinical study, Folia phoniat, 20, 1895-201.

Hirano M., Ohala J. & Vennard W. (1969) - The function of laryngeal muscles in regulating Fo and intensity of phonation J.S.H.R. 12, 618-628.

Hollien H. & Ship. T. (1972) - Speaking fundamental frequency and Chronological age in Males. J.S.H.R. 15 (1), 155-159.

Hollien H., Michel J. & Doherty E.T. (1973) - A method for anlaysing vocal jitter in sustained phonation. J of phonetics 1, 85-91.

Hoops H.R. & Noll J.D. (1969) - Relationships of selected acoustic variables to judgements of speech proficiency H. Comm. Disord, 2, 1-13.

Hudson A.I. & Halbrook A. (1981) - A study of the readiong fundamental vocal frequency of Young Black adults J.S.H.R. 24 (2), 197-201.

Hunt R.B. (1964) - Rehabilitation of the laryngecomee. Laryngoscope, 74, 382-395.

Hyman M. (1955) - An experimental study of artificial larynx and oesophageal speech J.S.H.D., 20, 291-299.

Imaizumi S., Hiki S., Hirano M & Masushita H. (1980) - Analysis of pathological voices with a sound spectrograph. J. Acoust Soc. Japan, 36, 9-16.

Isshiki N. (1964) - Regulatory mechanism of Voice intensity variation. J.S.H.R., 7, 17-29.

Isshiki N. (1965) - Vocal intensity and air flow rate. Folia phoniatrica, 17, 92-104.

Isshiki N., Okamura H. & Horimoto M. (1967) - Maximum phontion, time and air flow rate during phonation: Simple clinical tests for vocal function. Am. Otol., 76, 998-1007.

Jacob (L) (1968) - A Normative study of laryngeal jitter, Unpublished Masters Thesis, Univ. of Kansas.

Jayaram K. (1968) - An attempt at differential diagnosis of Dysphonia. Master's Dissertation, Univ. of Mysore (Unpublished).

Kent R.D. (1976) - Anatomical and Nuero-muscular maturation of speech mechanism: Evidence from acoustic studies. J.S..H.R. 18, 421-447.

Khozhwnikou V.A. & Christovich L.A. (1965) - Speech: Articulation and perception, Washington D.C., Joint publications Research Service.

Kum K.M., Kakita Y. & Hirano M. (1982) - Sound Spectrographic analysis of the Voice patients with recurrent laryngeal Nerve paralysis. Folia phoniat, 34, 124-133.

King P.S, Fowlks E.W. & Pierson G.A. (1965) - Rehabilitation and adaptation of laryngectomy patients. Am. J. physical Medicine, 47, 192-203.

Kinishi M. & Amatsu M. (1986) - Pitch perterbation measures of alaryngeal voice after the Amastu T.E. Shunt operation. Abstract of XXth Cong, of IALP, as appeared in Folia phonation 38/5-6/1986 (317).

Kitzing P. (1986) - LTAS criteria pirlivent to the measurement of voice quality J. OF pHONETICS 14, 477-482.

Koiki Y. & Von Liden (1969) - Vowel amplitude modulations in patients with laryngeal diseases. J. Acoust. Soc. Amer., 45, 839-844.

Krishnamurthy B.N. (1986) - "The measurement of mean airflow rate in normals".

Krishnamurthy B.N., Rajshekar B., Venkatesh C.S. & Natraja N.P. - Some temporal aspects of alaryngeal speech. Journal of the Indian Speech and Hearing Association, 4, 1992.

Ladifoged P. (1968) - A phonetic study of West African languages, 2nd edition, New York: Cambridge Univ. Press.

Lass N.J., Brong G.W., Ciccolella S.A., Walters S.C. & Maxwell F.I. (1980) - An investigation of speakers height and weight discriminications by means of paired comparison judgements J. of Phonetics, 8.

Lass N. & Michel J. (1969) - The effects of frequency, intensity and voice type on the maximum duration of phonation. Univ. of Kan; Unpublished Manuscript cited in Rajshekar (1991) :Acoustic anlaysis of Alaryngeal speech. Unpublished thesis submitted to Univ. of Mysore

Launer P.G. (1971) - Maximum phonation in children. Unpublished thesis, State Univ. of New York, Buffalo.

Lehisle J. (1970) - Suprasegmentals, Cambridge MA: MIT Press

Lwilt H. (1978) - "The acoustic of Speech production": Auditory management of hearing impaired children (Eds) T. Giolds and M. Ross, Baltimore, Univ. Pack Press, 45-115.

Lewis K., Castul R. & Mc Mohan J. (1982) - Durartion of sustained !a! related to the number of trials, Folia phoniat, 34 (1), 41-48.

Luberman P. (1960) - Some acoustic cor-relate of word stress in American English. J.A.S.A., 32, 451-454.

Luberman P. (1961) - Perturbation in vocal pitch. J.A.S.A., 3, 597-603.

Luberman P. (1970) - A study of prosodic features. Haskins Lab Status Res Speech Re, 23, 179-208, New Haven: Haskins Laboratories.

Liski L. & Abramson A.S. (1967) - Some effects of context on voice onset time in ENglish stops. Language and Speech, 19, 1-28 cited in Rajshekar (1991) : Acustic analysis of Alaryngeal speech. Unpublished thesis submitted to Univ. of Mysore.

Liski L. & Abramson A.S. (1971) - Distinctive features and Laryngeal control - Language, 47, 770.

Lofquist A & Mandsson B. (1987) - Long time average spectrum of speech analysis. Folia Phoniat, 39, 221-229.

Luschsinger R. & Arnold G.E. (1965) - Voice-Speech-Language. Clinical communicology:Its physiology and pathology. Constable and Co. Ltd.

Mac Curtain F. & Christopherson A. (1985) - Aspects of vocal efficiecny in laryngectomyu procedures - A pilot study CST Bulletin.

Mahieu H.F., Schutte H.K. & Annyas A.A. (1986) - "Intelligibility, vocal intensity and Long time average spectrum of Groningen button. Oesophageal speech". In Heerman, I.F. (Ed), Speech restoration via voice prosthesis, Springer Vulag Berlin, Heidelberg.

Markel J.D. & Gray A.H. Jr. (1983) - On autocor-relation equations as applied to speech analysis. IEEE Trans Audio and Electroacoustics, Av-20, 69-79, cited in Rajshekar (1991): Acoustic analysis of alaryngeal speech. Unpublished thesis subnmitted to the Univ. of Mysore.

Mc Ivan J., Evans P.F., Perry A. & Cheesman A.D. (1990) - Radiological assessement of post laryngectomy speech. Clinical Radiology 41, 312-316 cited in Rajshekar (1991): Acoustic analysis of alaryngeal speech. Unpublished thesis subnmitted to the Univ. of Mysore.

Michel J.F., Hollien H. & Moon P. (1965) - Speaking fundamental frequency characteristics of 15,16 and 17 year old girls. Long, Speech 9, 46-51, cited in Rajshekar (1991): Acoustic analysis of alaryngeal speech. Unpublished thesis subnmitted to the Univ. of Mysore.

Mitzell S., Andrews M.L. & Bourman S.A. (1985) - Acceptability and intelligibility of tracheosophageal speech. Arch. Otolaryngeal Head Neck Surg. 1ll, 213-215.

Mohr B. (1971) - Intrinsic variations in the speech signal. Phonetica, 23, 65-93.

Monsen R., Engebretson A. & Vemula N. (1978) - Indirect assessement of the contribution of sub-glottal air pressure and vocal tension to changes of fundamental frequency in ENglish J.A.S.A,., 64, 65-80.

Moon J.B. & Weinberg B. (1987) - Aerodynamic and Myoelastic contributions to tracheoesophageal voice production J.S.H.R. , 30, 387-395.

Moore P. & Von Liden H. (1958) - Dynamic variations of vibratory pattern in the normal larynx. Folia phoniat, 10, 205-238.

Murry T. (1978) - Speaking fundamental frequency characteristics associted with voice pathologies J.S.H.D. 43 (3), 374-379.

Murry T. & Doherty E.T. (1980) - Selected acoustic characteristics of patholgic and normal speakers. J.S.H.R. , 23 (2), 361-369.

Natraja N.P. (1986) - Differential diagnosis of dysphonias, Unpublished Doctoral Dissertation, Univ. of Mysore.

Natraja N.P. & Jagadeesha A. (1984) - Vowel duration and fundamental frequency. J.A.I.I.S.H. 15.

Neuman G.S. & Edison B. (1981) - Procedural aspects of eliciting maximum phonation time Folia phoniat, 33 (5), 285-293.

Neimoller A. et al (1974) - On the spectrum of Spoken ENglish J. Acoust. Sec. Am. , 55, 461.

Nydam A.A., Escajadillo H.F. et al (1984) - Groningen prosthesis for voice rehabilitation after laryngectomy. Clinical Otolaryngology, 9, 51-54, 1984.

Noll M.A. (1964) - Short time spectrum and "Cepstrum" technique for vocal pitch detection. J. Acoust. Soc. Am. 36, 296-302.

Ohala J. & Eukel B.W. (1978) - Explaining the intrinsic pitch of vowels. Rep. phonology Laboratory (Berkely: Univ. of California) 2, 118-125.

Ohala J. & Hirano M. (1970) - Studies of pilrh change in speech. UCLA Working papers in Phonetics 15, 1-92.

Omori K., Shoji K., Fukushima H. & Hojuiua H. (19R9) - Fvaluaiton of trcheoesopahgeal voice with voice prosthesis comapred with oesophageal voice XXst Congress of the TALP, proceedings (432-434) cited in Rajshekar (1991): Acoustic analysis of alaryngeal speech. Unpublished thesis subnmitted to the Univ. of Mysore.

Panje W.R. (1981) - "Prosthetic voice Rehabilitation follwoing laryngectomy - The voice Button". Animals of Otology, Rhinolgoy and Laryngology, Vol. 90, No.2, 116-121.

Pauloski BR., Fisher H.B., Kempstu G.B. & Blom F,.D. (19R9) Statistical differentiation of tracheoesophngeal speech produced under four prosthetic / occlusion speaking conditions. J.S.H.R. ,32, 591-599.

Pukins W.H. (1971) - Speech pathology: An apptied behavioural science. The C.V. Mosby Co., St. Louis.

Perry A. (1988) - Surgical voice restoration following laryngeto-my: The tracheo-oesophageal Fistula technique (Singer-Blom), B.J.D.C., 23, 23-30.

Perry A. (1989) - Vocal rehabilitation after total laryngcctomy. Unpublished Ph.d., Thesis, Univ. of Leicestu, cited in Rajshekar (1991): Acoustic analysis of alaryngeal speech. Unpublished thesis subnmitted to the Univ. of Mysore.

Perry A., Cheesman A.D., Mc Ivan J. & Chalton R. (198 7) - A British experience of Surgical voice restoration as a secondary procedure following total laryngectomy. J. Laryngology & Otology, 101, 155-163.

Pindzola R.H. & Cain B.H. (1989) - Duration and frequency charac-teristics of tracheosophageal speech. Am. Otol. Rhenol, Laryngol, 98, 960-964.

Ptacek P.H. & Sander E.R. (1963) - Maximum duratoin of phonation, J.S.H.D., 28, 171-182.

Qi Y. & Weinberg B. (1991) - Spectral of vowels by Tracheosopha-geal speakers J.S.H.R., 34, 243-247.

Rajshekar B., Hazarika P., Natraja N.P., Jagadeesh)a A., Murthy P.S. (1989) - Acoustic ANlaysis of Gastric speech. Paper presented at the 21st Annual conference of Indian Speech and Hearing Association, Madras.

Rajshekar B., Natraja N.P., Rajan R., Hazarika P., Murthy P..!. & Venkatesh C.S. (1990) - Comparison of oesophageal and T.E.P. mode of alaryngeal speech in a single laryngectomee. The Journal of Indian speech and Hearing Association, 71, 43-46.

Rajshekar B. (1991) - Acoustic analysis of alatyngeal speech (T.E.P. with B.S. prostheis and Oesophagela modes). Unpublished thesis subnmitted to the Univ. of Mysore.

Rashmi M. (1985) - Acoustic aspects of the speech of children. Unpublished Master's Dissertation, Univ. of Mysore.

Robbins J. (1984) - Acoustic differentiation of laryngoal, Oesophageal and tracheoesophageal speech J.S.H.R. , 27, 577-585.

Robbins J. (1984) - Acoustic differentiation of laryngeal oesophageal and tracheosophageal speech. J.S.H.R. , 29, 577-585.

Robbins J., Christensen J. & Kempstu G. (1986) - Charactersitics of production after tracheosophageal puncture: Voice onset time and vowel duration. J.S.H.R. 29, 577-585.

Robbins J., Fisher H., Blom E. & Singer M.I. (1984) - A comparative acoustic study of normal, oesophageal and tracheosophageal speech production. J.SH.D. , 49, 202-210.

Robbins J., Fisher H.B., Blom E.D & Singer M.I. (1984) - Selected acoustic features of tracheosophageal, Oesophageal and laryngeal speech. Archives of Otol. 110, 670-672.

Robert M. Deupre - The muscles of voice and speech in Travis, 1971, Ed. Handbook of speech pathology and Audio]ogy, Prentice Hall-Inc., Englwood Cliff, New Jersey.

Robin P.E. & Olofsson J. (1987) - Tumor - the llarynx in Scott-Brown's Otolaryngology (Ed.5) Still, P.M. (Fd), Butterworth and Co. , London.

Robbins W.J. (1962) - A comparative study of vowel formants of oesophageal and normal speaking adults. Doctoral Dissertation, Wayne state Univ. cited in Rajshekar (1911): Acoustic analysis of alaryngeal speech. Unpublished thesis subnmitted to the Univ. of Mysore.

Saivashima (1966) - Measurement of maximum phonation time. J. Logoped, Phoniat., 7, 23-28.

Santhosh (1992) - Acoustic and Perceptual analysis of the T.E.P. Speech. With different types of Prosthesis. Unpublished Master's Dissertation, Univ. of Mysore.

Sidory S.E., Hamlet S.L. & Cotnmor N.P. 91989) - Comparisons of perceptual and acoustic characteristics of tracheosopahgegoal and excellent oesophageal speech j.s.h.d., 54, 209-214.

Suman M. (1967) - Rehabilitation of larygectomized subjets. Act a Otolaryngeal 64, 235-241.

Shashikala H.R. (1979) - Economy at optimum frequency Unpublished Master's Dissertation, Univ. of Mysore.

Sheela E.V. (1974) - A comparitive study of vocal parameters of trained and untrained Surg., Master's degree Dissertation. , Univ. of Mysore.

Shipp T. (1967) - Frequency, duration and perceptual measures in relation to Judgements of alaryngeal speech intelligibility. J.S.H.R., 10, 417-427.

Singer M.I. (1983) - Tracheoesopahgeal speech: Vocakl rehabilitation after laryngectomy, Laryngoscope, 93, 1454-1465.

Singer M.I. & BNlom E.D. (1980) - An Endoscopic technique for restoration of voice after laryngectomy. Annals of Otology, Rhinology and Laryngology, 89, 529-533.

Singer M.I. & Blom E.D. (1981) - Selective myotomy for voice restoration after total laryngectomy. Arch. Otolaryngeal, 107, 670-673.

Singer M.I., Blom E.D. & Hazarika R.C (1981) - Further experience with voice restoration after total laryngectomy. Ann, Otol, Rhinol and Laryngol. 91, 576-578.

Singer M.I., Blom E.D. & Haamku R.C. (1983) - Voice rehabilitation after total laryngectomy J. Otolaryngol 12, 329-334.

Smith B.S, Weinberg B., Feth E.C, & Hori Y. (1978) - Vocal roughness and jitter characteristics of vowels produced by Oesopahgeal speakers J.S.H.R. , 21, 240-249.

Snidicor J.C & Curry E.T. (1959) - Temporal and pitch aspects of superior oesophageal speech,. Ann. Otol. Rhinol., Laryngol, 68, 1-14.

Snidicor J.C. & Isshiki N. (1965) - Air volume and airflow relationships of sex male oesopahgeal speakers. J.S.H.D., 30, 205-216.

Spofford B., Jafele Bruce, Barcz Dennis - "An improved method for Blom-Singer or Panje voice prosthesis". Larynoscope, 1984, Vol. 94, No. 2, 257-258.

Stevens S., Egan J. & Miller G. (1947) - Methods of measureing spoeech spectra J. Acous. Soc. of America 10=9, 771-780.

Suzuki (1944) - Cited by Hiranon M., Kakita V., Ohmaru K. & Kurita S. (1982) - Structure and mechanciall properties fo the vocal field . In las, New Jersey (Ed), Speech and language: Advances in basic research and practice. Vol. 7, Academic Press. Inc. New Jersey.

Frudeau M.D. & Qi Y. (1990) - Acoustic characteristics of female tracheosophageal speech. J.SH.D., 55, 244-250.

Vanaja C.S. (1986) - "Acoustic parameters of normal voice". Unpublished Master's Dissertation., Univ. of Mysore.

Van Der Berg J.W. (1958) - Myoelastic aerodynamic theory of voice production J.S.H.R. 1, 227-244.

Van Der Berg J. & Moolenaar - Biji, Biji A.J. & Dasmste P.M. (1958) - Oesophageal Speech Folia Phoniatric , 10, 65-84.

Van Riper,C,and Irwin, J.V. (1958) - Voice and articulation. Prentice Hall Inc., Ner Jercy, (Englewood Cliffs).

Weinberg B. (1981) - Speech alternatives following laryugectomy. In Holm K. Dailey. Jr. Green and Straton, Inc (eds), Speech evaluation in Medicine.

Weinberg, B (1982) - Speech after laryngecomee: AN overview and review of acoustic and temporal characteristics of oesophgeal Speech., In a Sikey and R. Hanson (Eds), Elctroacoustic analysis and enhancement of alaryngeal speech, Springfield, Charles C. Thomas.

Weinberg B. (1986) - Acoustical properties of Desophageal and tracheoesophageal speech. In R. Kuth and T. Darley (Eds) Laryn-gectomee Rehabilitation (22nd Ed), San Deigo: College Hill Press.

Windier J., Doherty E.T., & Hollier H. (1980) - Voice classifica-tion by means of Long term speech spectra. Folia phonatrica, 32, 51-60.

Wenig B.C., Mulloly V., Levy J. & Abramsson A.C. (1989) - Voice restoration following Laryngectomy: The role of primary vs. Secondary tracheosophageal puncture. Ann. Otol. Rhinol. Laryngol. 98, 70-73.

Watimore S.J., Kruegu K., Wesson K. & Blessing M.C. (1985) - long term results of Blom-Sinbger speech rehabilitation procedure. Archives of Otolaryngology, 111, 106-109.

Williams E.3., Scenic S.T., Rittertman L.S. (1989) - "Temproal] and perceptual characteristics of T.E. Voice.-". Laryngoscope Aug. 1989, Vol. 99, No., 8, 846-850.

Yangihara N. & Koiki Y. (1967) - The regulation of sustained phonation. Folia Phoniat 19, 1-18.

Yangihara N. & Von Liden H. (1966) - The cricothyroid Muscle during phoantion. Ann. Otol. Rhinol. and Laryngology, 75, 987-1005.

Yangihara N. & Von Liden H. (1966) - Phonation and Respiration. Function study in normal subjets. Folia phoniat, 18, 323-340.

Yoonb M.K. , Kakita Y. & Hirano M. (198 1) - Sound spectrographic analysis of the voice patients with glottic carcinomas. Folia Phoniat, 36, 24-30.

Zanoff D.J., Wold D., Montagu J.C., Kenegu K. & Drummond S. (1990) - Tracheoesophageal speech with and without tracheostoma value. Laryngoscope, 100, 498-502.

Zys B.J., Bull G.C, Mc Donald W.E. & Johns M.E. (1984) - Perturbation analysis of normal and patholigic larynges. Folia Phoniat, 36, 190-198.

APPENDIX

APPENDIX - I

1) Tracheo-Oesophageal Puncture [T.E.P.] :
The surgical voice restoration method introduced by Blom and Singer (1980) wherein a midline puncture or fistula between the posterior wall of the trachea and the upper oesophagus is created endoscopically and into which the Blom-Singer's voice Prosthesis.

2) Tracheo-Oesophageal Puncture [T.E.Speech] :
Speech produced by laryngectomees who have undergone T.E.P. and Blom-Singer voice prosthesis fitting. Speech is produced when pulmonary air is directed through the prosthesis into the oesophagus to vibrate the pseudoglottis.[Pharyngoesophageal segment]

3) Fundamental frequency in Phonation (Fo):
The mean frequency (HZ) of the steady portion of Phonation.

4) Extent of fluctuation in Fundamental frequency in Phonation.
The extent of fluctuation in frequency (H2) was defined as the means of fluctuations in fundamental frequency inn a phonation of one second.

Fluctation in frequency was defined variations +/- 3 Hz and beyond in fundamental frequency.

5) Speed of fluctuation in fundamental frequency in Phonation (Sp. F.F.) -

The speed of fluctuation in frequency was defined as the number of fluctuation in fundamental frequency in a phonation of one second.

6) Extent of fluctuation in intensity in Phonation (Ex. F.I.) -
The extent of fluctuation in intensity (dB) was defined as the means of fluctuations in intensity in a phonation of one second.

Fluctuation in intensity was defined as variations +/- 3 dB and beyond intensity.

7) The Speed of fluctuation in intensity in Phonation (Sp. F.I.)

The speed of fluctuation in intensity was defined as the number of fluctuations in intensity in a phonation of one second.

8) Frequency Range in Phonation (FR)

The frequency range in Phonation (HZ) was defined as the difference between the maximum and minimum fundamental frequency in phonation.

9) Intensity Range in Phonation (IR)

The intensity range in Phonation (dB) was defined as the difference between the maximum and minimum intensities in phonation.

10) Words per minute: This was got by measuring the numnber of words per minute during speech.

11) Syllables per minute: This was got by measuring the number of syllables per minute during speech.

12) Number of Pause: A pause was identified as a silence of greater than 200msec as indicated by the signal at the baseline of the waveform. The total number of such pauses were computed.

13) Mean pause time: This was computed by dividing the total pause time by total number of pauses.

14) % pause time: was computed using the formula

$$= \frac{\text{Summed duration of Pauses}}{\text{Total reading duration}} \times 100$$

15) Vowel duration (VD): This was defined as the duration (msec) between the onset as indicated by the initial periodic striations of the first formant to the last vertical striations.

16) Voice Onset time (VOT): Voice onset time (msec) was defined as the time interval between the burst that marks release of the stop closure and that reflected vibration for the following vowel (as defined by Lisker and Abramson, 1967).

17) Intelligibility (INTL): Intelligibility (%) was defined as the words intelligible to the listener (i.e.)

$$\text{Intelligibility} = \frac{\text{Number of words identified}}{\text{Total number of words}} \times 100$$

18) Acceptability (ACPTL): Acceptability was defined as the rating on a 1-5 point scale, where 5 was the least acceptable and 1 was the most acceptable.

APPENDIX : 2

Name of the Prosthesis	Inventor	Made of	Tube	Flange of the Proximal end (i.e. Oeso. end)	Flange of the Distal end (i.e. Tracheal end)	Slit or valve	Duration (Life)	Device removal
Blom-Singer's "Duckbill" Voice Prosthesis	Blom and Singer (1982)	Silicone	16 F diameter tube. 3cm long	5.4mm in diameter (French No. 16)	Has a port on the inferior surface measuring 3.5 x 7mm for exhaled air entry	An 8mm slit in the proximal end of the device act as one way valve		Daily removal for cleaning
Blom-Singer's Low-pressure Prosthesis	Blom, Singers & Hanaker (1982)	Silicone	20 F diameter tube			2mm slit hinged type circular valve in the proximal end		
Pange Voice Button	William R. Pange (1981)	Silicone	Biflanged 7mm and 12mm	10mm in diameter	13mm in diameter	Flutter valve located at the proximal end	Several weeks to 8 months	Daily removal for cleaning
Indian (HRA) Prosthesis	Hazarika Rajashekar & Ajith	Silicone	Same as B.S. D.B. but reinforced with armour for better retention & Bellows	Same as B.S. D.B. Prosthesis	Airflow port similar to B.S. D.B. prosthesis for air entry	Slit valve	Yet to be assessed	Atleast once a week/whenever there is an obstruction due to secretion

APPENDIX - 3

Word list in Malayalam

അ : അനുഭവം

ആ : ആകാശം

ഇ : ഇലഞ്ഞിപ്പൂവ്

ഈ : ഈന്തപ്പഴം

ഉ : ഉത്സവം

ഊ : ഊഞ്ഞാൽ

ഋ : ഋഷി

എ : എളിമ

ഏ : ഏത്തപ്പഴം

ഐ : ഐരാവതം

ഒ : ഒരുമ

ഓ : ഓണം

ഔ : ഔഷധം

അം : അംബരം

ക : കാട്

ഖ : ഖഗം

ഗ : ഗ്രാമം

ഘ : ഘടികാരം

ച : ചെടി

ഛ : ഛായ

ജ : ജലം

ത : തെയ്യം

ദ : ദാനം

ധ : ധനം

ന · നിറ
പ · പർവ്വതം
ബ · ബഹളം
ദ · ദൂമി
മ · മഴ
യ · യാമം
ര · രമണീയം
ല · ലാളിത്യം
വ · വിദേശി
ശ · ശൈലം
ഷ · ഷഢ്പദം
സ · സമുദ്രം
ഹ · ഹിമം
ഫ · ഫലം

കേരളം പർവ്വതനിരക-
ളുടേയും സമുദ്രത്തിന്റേയും സാ-
മീപ്യമനുഭവിക്കുന്ന ഒരു കൊച്ചു
ദ്രാവിഡ സംസ്ഥാനമാണ്. വൃക്ഷ-
ങ്ങളുടെ ഛായ നിറഞ്ഞ കേര-
ളം ഒരു ചെറിയ കാടിനെ അനു-
സ്മരിപ്പിക്കുന്നു. വഗങ്ങൾ പ-
രക്കുന്ന ആകാശവും മഴമേഘ-
ങ്ങളുടെ നൃത്തവും ഇലഞ്ഞി-
പ്പൂക്കളും ഈന്തപ്പഴമില്ലാത്ത
ഈന്തകളും ഔഷധച്ചെടികൾ നി-
റഞ്ഞ ശൈലങ്ങളും പ്രശസ്-
മാണ്. ആനകളും കാവടികളും
തെയ്യങ്ങളും കഥകളിയും നിറ-
ഞ്ഞ ബഹുപുരിതമായ ഉത്സവ-
പരമ്പരകൾ വിദേശീയരേപ്പോലും
ആകർഷിക്കുന്നു. ഓണമാണ്
കേരളീയരുടെ പ്രധാന ഉത്സവം.
ജലകണികകളുമായ് എത്തുന്ന
തെക്കൻ കാറ്റ് കേരളത്തിനു
കൂടുതൽ മഴ നൽകി ഇവിടു-
ത്തെ ഭൂമി ഫലഭൂയിഷ്ഠമാക്കു-
ന്നു. ഋഷികളേപ്പോലെ തപസ്സു

ചെയ്യുന്ന ഗ്രാമങ്ങൾ ഗ്രാമീണ-
സൗന്ദര്യത്തിന് മറ്റൊരു സം
സ്ഥാനത്തേക്കാളും മുന്നിലാണ്.