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Original Research Article

Motor integrated Electro larynx; a novel, less expensive Electro larynx.

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Abstract

Introduction
Total laryngectomy results in a muted person. Electro larynx is one method of sound production for speech in such patients. We introduce a novel, less expensive electro larynx.

Objectives
To assess the usability of the novel electro larynx.

Methods
A new electro larynx was developed. Imbalanced motor was used as the vibrator and hence it could be operated with a 3V battery. It is made as a rechargeable device using a mobile phone charger. Fifty Sinhala and English words and 20 numbers were read by a researcher. It was listened and recorded by 5 listeners and documented. Correctly identified words and numbers were analyzed. Test was done both with and without lip reading.

Results
The new device could generate sound for speech. Eighty-eight percent of English and 89.2% of Sinhala words could be identified with lip reading. For numbers it was 97.6%.

Conclusions
Novel electro larynx could be used for effective communication in post laryngectomy patients.

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Introduction.

One of the main functions of the human larynx is producing sound, and hence aiding speech, which is a unique development in humans. Air flow coming through the trachea is directed to vibrate the mucosal membranes of vocal cords by approximating. It generates sound after which articulation and modulation is done by the tongue, lips and palate.

Most laryngeal cancers are caused by tobacco and 20 % of head and neck cancers are laryngeal[1]. Amongst laryngeal cancers glottic cancers show lower levels of lymphatic spread and therefore have a good prognosis[2].

Total laryngectomy is a treatment option in advanced laryngeal cancer. It is the 'en-bloc' removal of the larynx with hyoid bone, epiglottis and upper trachea. It results in a totally muted person who's breathing through a permanent tracheostomy but, still the articulating part of speech remains intact[3].

Electro larynxes were first introduced in the 1940s[4]. In that period, oesophageal speech was being promoted as the best option in speech. The technique in oesophageal voice was difficult and hence the electro larynx became popular.

The conventional type of electro larynx uses a magnet and a coil to generate vibrations [5]. It needs a different circuit to generate direct current (DC) into alternative current (AC). In newer varieties there is a signal generator circuit. To get a good vibration power it uses a 9 Volts battery.

Currently available devices are expensive. The aim of our study was to assess the usability of an electro larynx which has a novel vibration technology.

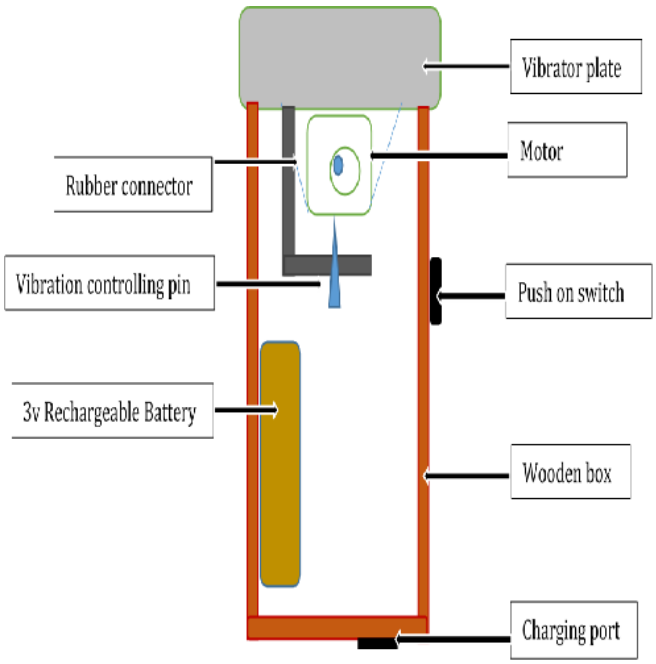
Material and Methods.

The novel motor vibrator electro larynx

A 3V 1cm*1cm*the 1.5cm electric motor is modified as the vibrator. The armature shaft of the motor is imbalanced, by attaching an uneven weight to it. (A metal nut is attached to the armature shaft to make an uneven weight). Due to the imbalance, the motor vibrates with rotation. The motor is attached to a plastic block loosely with a rubber strip. Another 'L' shaped plastic part is attached to the same plastic block. An adjustable pin is attached to the L shaped part in such a way to push the motor against the vibrating plate. The vibratory force of the motor can be controlled by altering the force over the motor by the adjustable pin. (Refer Picture 1)

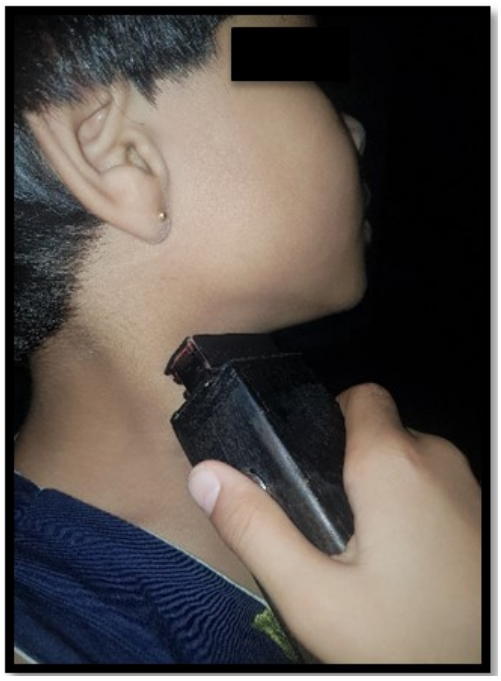
The vibrator part is put in a wooden box in such a way that the plastic part protrudes from a side. The vibrator is attached with a rubber to the wooden box. The power supply to the motor is by a 3V rechargeable Li-ion battery. It is connected through a push to an 'on' switch which is placed on a side. A charger circuit is also included so that it can be charged with a micro USB mobile phone charger.

All the assembly is limited to a 4cm x 2cm x 1.5 cm box, hence the patient can carry it easily as a small mobile phone. (Refer Picture 2 & Picture 3)



Picture 1 – Line diagram of the ‘Novel motor vibrator electro larynx’

Picture 2 – Assembled ‘Novel motor vibrator electro larynx’



Picture 3 – A Patient using the ‘Novel motor vibrator electro larynx’

Testing

The new electro larynx was tested using both English and Sinhala languages. Selected 2 dialogs with 50 words and 20 numbers were read through the electro larynx by a researcher. Five subjects (Listeners) with normal hearing were asked to document the words and numbers. Distance between the reader and listener was kept at 2.5m.

The reading of the words was done only once with only three words read continuously together at a time. The test was performed in a normal environment with an ambient noise of 50dB. The words and numbers were changed each time. Test was done with and without lip reading.

The count of correctly identified words and numbers by each listener was documented and analysed.

Results.

Listener	Words without lip reading		Words with lip-reading		Numbers without lip reading	Numbers with lip reading
	English	Sinhala	English	Sinhala		
A (34y)	21	25	46	47	18	20
B (37y)	23	28	47	46	17	19
C (40y)	17	23	42	45	15	20
D (40y)	24	29	43	41	14	19
E (32y)	30	27	44	44	16	19
Average %	46%	52%	88.80%	89.20%	80%	97.60%

The novel instrument could be used to produce sound. Average standby battery time was 1 week. Average using time per single charge was 24-48 hours. There was no heating problem noticed during charging or using. No skin contact reaction was noticed with the contact plates. The average age of listeners was 36.6 years.

Discussion.

The first electro larynx was developed in the late 1920 s. An electrically powered vibrator was attached to a diaphragm and was placed on the neck. It was named as Western Electric 5A. The diaphragm design is still being used in currently available devices.

After the electric revolution during World War II, more developed devices were made. In the USA the Aurex Neovox M-20 T was developed which is smaller than the Western Electric 5A but, in both devices the patient has to be with the machine. It was not a portable. With the invention of the transistor, the size of the devices became smaller. In 1959 Bell Laboratories developed the first portable electro larynx. In 1980 the Cooper - Rand Electro larynx which was an intraoral device was introduced. The newest advancement of the electro larynx is pitch controlling device which gives variable pitch in voice. US patent US10154899 explains the frequency variable electro larynx, which is the newest technology [6,7].

Contrary to available devices, the novel electro larynx has a simple design. The main modification is the vibrator. The vibrator should deliver adequate energy to the pharyngeal muscle to vibrate and generate sound. In conventional models, this energy is delivered through a vibrating plate attached to a diaphragm. The diaphragm is attached to a coil which gets alternative current (AC) vibrating signals. It is held on a circular powerful magnet which allows the coil to move up and down. When the coil gets a current it moves. When the current is an alternative (signal) it vibrates. The vibratory frequency can be adjusted, either adjusting the signal or through controlling the vibratory force mechanically. With this type of mechanism, it is difficult to get a good vibratory force without a high amperes and voltage, hence in most of the devices a 9 Volt battery is used.

In the novel electro larynx, we introduce a device with a motor vibrator. In this device the vibratory force is generated through an imbalanced motor. The rotatory force is converted to vibratory force. Through this mechanism, adequate sound can be generated with a 3 Volts battery. It's the main advantage of the new device. It can be recharged with a micro USB phone charger.

The vibrator is placed in a wooden box which minimizes the sound transmitting to outside. This outer cover can be further improved with rubbery, sound absorbing material. The vibrator material is plastic in both novel and conventional models. It is lite and vibration is transmitted with less energy loss. When developing the equipment, we tested the vibration with various types of material such as wood, rubber, Rigifoam and metal. Amongst those, plastic was the best vibration transmitter. The vibration is controlled in the novel device in a range which generates a good sound. The vibrating frequency can be controlled with the speed of the motor. Through that the frequency of the sound could be changed. That necessitates a controller circuit. We hope to add that facility in the near future.

In the literature survey, many similar studies have been done around the world regarding electro larynx.

Jack J et al has done a study on the effectiveness of electro larynx on tracheostomy patients after a short training. They found that 14/22 patients showed good communication skills with electro larynx and they suggested that it can be used in patients with a tracheostomy. There was no difference between the different age groups or between gender[8]. We think that if we can produce a low cost device it can be used with tracheostomy patients as well.

In Japan, Hirokazu Takahashi et al has done a study on intraoral electro larynx devices. They have recently developed an intra-oral vibrator with an intra-oral pressure sensor. The sensor detects the utterance of voiceless phonemes during the intra-oral speech (With electro larynx). They have concluded and demonstrated that an intra-oral pressure–based voicing control could improve the intelligibility and quality of the speech [9].

Speech therapy is essential in electro larynx speech as the patient needs to be trained to use the device synchronously with speech and proper placement. There are few other basic requirements.

Proper placement of the device over the neck is necessary for a good vibration. This is interfered by scars and radiotherapy fibrosis. The entire vibration plate should touch the skin. Also, the patient should train to apply proper pressure to gain the optimum vibration.

Not as in normal speech, the use of a 'slowed rate' is important. It helps the listener to differentiate words. In this study we tested the device with a normal rate speech. Even with that speed, listeners could identify a significant amount of words and numbers.

Electro larynx users should be trained for over articulation. It improves the quality of the words. Also help to follow the speech through lip-reading. In our study we tested with and without lip reading. When the listening is combined with lip-reading, it is more efficient in communicating. In our study, it improved from 46% to 88.8% for English and 52% to 89.2% for Sinhala.

The patient should be trained to synchronize the switch with speech. It reduces noise and also improves the battery life of the device. As in a conventional device, this contains a push on switch. Battery life is 1 week on standby. Working time is 24 to 48 hours for a normal person. In this study the machine was used by a researcher. It should be tested with patients for further evaluation.

Natural mannerisms as “um” “hm”, head nodding in appropriate situations, facial expressions, eye contacts and hand gestures should be used with the device to improve the outcome. Distracting behaviours as noise of stoma, excessive muscle tensions should be avoided[10].

There are some drawbacks in electro larynx. Using it has some social issues. It can’t be used in a noisy environment as markets and in public transport services in Sri Lankan setup. In telephone conversations, the other party might misunderstand as talking to a robot or a computer due to its robotic sound. Those are the same to the novel device. Also when the sound is received to a microphone, the background noise is more. It might affect telephone conversations.

In the Sri Lankan market, the cost is around Rs 200000/= for a conventional electro larynx. Therefore, most of the patients are unable to afford this by themselves. This novel instrument is a less expensive device which costs about 5000 LKR. It will reduce the extra burden on the national health system.

Further evaluation on the novel device is necessary. Due to the Covid -19 outbreak, we were able to test the device, only with one patient. We hope to test the device with more patients in the near future.

Key Messages /Conclusion

The novel motor integrated electro larynx can be used as an aid in communication. It is less expensive. With combining lip reading it can be used for effective speech in laryngectomy patients.

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