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Residual speech impairment in patients with traumatic brain injury

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Abstract: Rehabilitation of patients with traumatic brain injury is a challenge for whole rehabilitation team (especially for speech and language pathologist). There is a general agreement that individual who suffer head injury may exhibit communication deficit either in the form of speech disorders (dysarthria) or language disorders (subclinical aphasia). Although head injured patients recover basic language skill within the first six months post-injury, they continue to show deficits in the analysis and synthesis of expressive and receptive language. Acoustical correlates of speech in patients with traumatic brain injury have received minimal attention in research literature. We examined the residual speech impairment in patients with traumatic brain injury even after 3 yrs post trauma, using ten simple sentences in Marathi. Subjects were asked to read the sentences, which were recorded digitally. Acoustical as well as perceptual analysis was carried out. The scores were compared with healthy controls. Patients showed deviated results compared to healthy controls except intensity parameters. Duration of word was lengthened in the patients with traumatic brain injury. Vowel quadrangle was shrunken as compared to healthy controls. Though the difference was not statistically significant, the milder deviations in speech of patients with TBI were affecting the results in perceptual evaluation. Patient with traumatic brain injury need long term therapy in terms of their speech and language is concerned. The study concludes that TBI patients continued to have prosodic as well as articulatory deviations (compared to healthy controls) even after 3 years after trauma.

Keywords: frequency, intensity, duration, traumatic brain injury (TBI), vowel quadrangle.

INTRODUCTION

Head injury can be divided into two major types, open head injuries and closed head injuries. In an open head injury the brain or meninges are exposed. A closed head injury differs from open head wound in that the meninges remain intact even though the skull may be fractured. Following head injury a patient may suffer from a number of complications which include: concussion, contusion, laceration and skull fracture; vascular lesion, infections, increased intra-cranial pressure; rhinorhea and otorrhea; cranial nerve lesion; focal brain lesions; post-traumatic epilepsy; and post-traumatic vertigo[1].

Traumatic brain injury (TBI) can cause a variety of communication problems. Depending on the location of damage in the nervous system, head injury may be associated with speech disorders, language disorders or both[1]. There is some controversy regarding the terminology applied to speech and language deficit in concern with presence or absence of aphasia in closed head injury[1]. Although head injured patients recover basic language skill within the first 6 months post-injury, they continue to show deficits in the analysis and synthesis of expressive and receptive language[2]. The language disorders are likely to be outcome of more general and more pervasive memory and cognitive deficits[3]. Researchers has found severity continuum ranging from aphasia, the most severely impaired group, to the least impaired group, the subclinical aphasia group[4]. Neurologic speech disorders are known to be frequent sequelae after severe closed head injury[5]. Over 75% of adults with speaking difficulties report difficulty being understood by people outside their immediate family context[6]. A number of researchers have reported the occurrence of dysarthria following TBI[7]. TBI subjects exhibit deficit in the prosodic, resonatory, articulatory, respiratory, and phonatory aspects of speech production[8]. There are very few attempts to study speech parameters in patients with TBI, and there is much more to explore in field of speech therapy aspects for the CHI patients. Hence the present study aims at determine residual speech impairment in TBI even after average of 3 years after trauma.

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MATERIAL AND METHOD

Sentences used for study are given in Table 1.

Methodology adopted was as follows:

Sample: 3 subjects (2 males, 1 female) with traumatic brain injury having mixed type of dysarthria were taken for study. Details of patients are given in Table 2.

Procedure: Subjects were asked to read 10 Marathi sentences with emphatic stress. The sample was recorded digitally with a digital recorder with constant speaker to mic distance. Acoustical analysis was done by using PRAAT software (version 4.2.1).

Acoustical analysis: Speech analysis as carried out using following parameters. For stress F0, F0 range, I0 and D0 were selected. These parameters were extracted from each word with emphatic stress by using PRAAT software.

F0: The fundamental frequency refers to the first harmonic of the voice.

I0: Intensity refers to amplitude of the sound.

Table 1: Marathi sentences

Sr.no.	Sentences
1	/ hi ek bIlViKg ahe /
2	/ t*i nImi pæn^ ahe /
3	/ t*aikYde tsTkle^ ahe /
4	/ lai^ tsalU ahe /
5	/ pavsat* ts°Yt*ri vapYrt*at* /
6	/ khIVki UghVi ahe /
7	/ ba^lit* d*ud*± ahe /
8	/ mi famet* d'at*o /
9	/ tfYha goV ahe /
10	/ popY^ hIrva ahe /

Table 2: Details of patients

Age	Sex	Period after TBI	MRI Findings	Type of Dysarthria	Therapy taken
24yr	M	3yr	Hemorrhagic contusion involving dorsal mid-brain, pons, and body /splenium of corpus callosum	Mixed	More than 10 sessions average
27yr	M	4yr	Bilateral thalamic, basal ganglionic and temporo-parietal cortical altered signal. Possibility of extra pontine myelinosis.	Mixed	More than 10 sessions average
60yr	F	3yr	Left basal ganglionic / internal capsular acute infarct without any mass effect	Mixed	More than 10 average

Duration: total time taken by patient to produce the stressed word.

Vowel quadrangle: First formant (F1), second formant (F2) of (/a/, /i/, /u/ and / æ/) were measured.

Perceptual analysis: The perceptual analysis was done by three professionals. Samples were rated for voice, articulation, prosody and intelligibility of speech.

Results were compared with healthy matched controls.

RESULTS

1. **Duration parameters:** Refer Table 3, 4 and Fig 1, 2
2. **Frequency parameters:** Refer Fig 3 and 4
3. **Intensity parameters:** Refer Fig 5 and 6
4. **Vowel quadrangle:** Refer Table 5 and Fig 7 and 8
5. **Perceptual parameters:** Refer Table 6

Table 3: Voice analysis in males with traumatic brain injury and Healthy control

Subject	F0	F0 RANGE	I0	D0	t-value
TBI (Male)	171.88	69.26	76.7	0.52	0.65* (not significant statistically)
Healthy controls	121.41	27.95	84.61	0.34	

Table 4: Voice analysis in females with traumatic brain injury and Healthy controls

	F0	F0 RANGE	I0	D0	t-value
TBI (Female)	209.87	63.73	75.22	0.52	0.95* (not significant statistically)
Healthy controls	225.12	55.11	82.64	0.42	

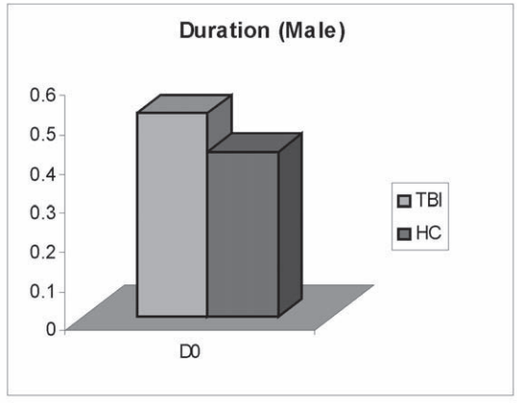

Fig 1 : Duration parameter in males

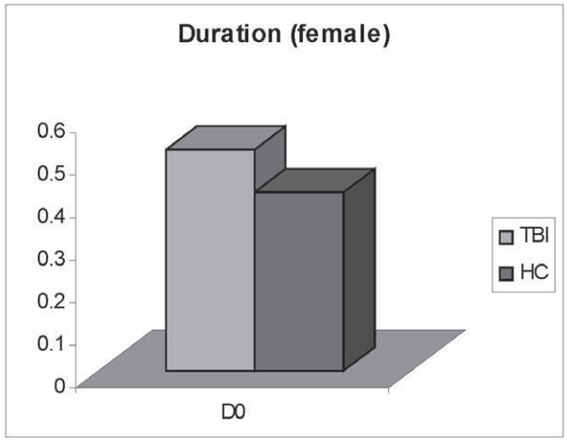

Fig 2 : Duration parameter in females

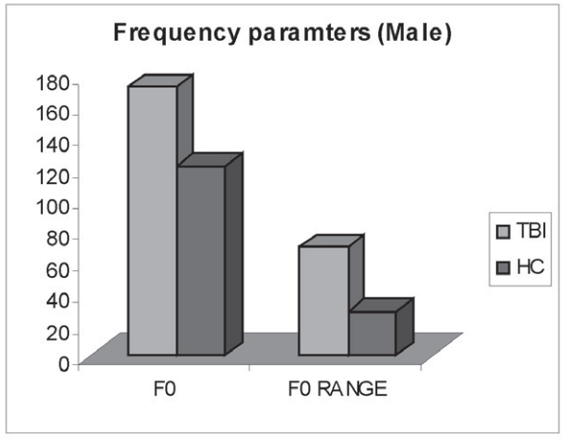

Fig 3 : Frequency parameter in males

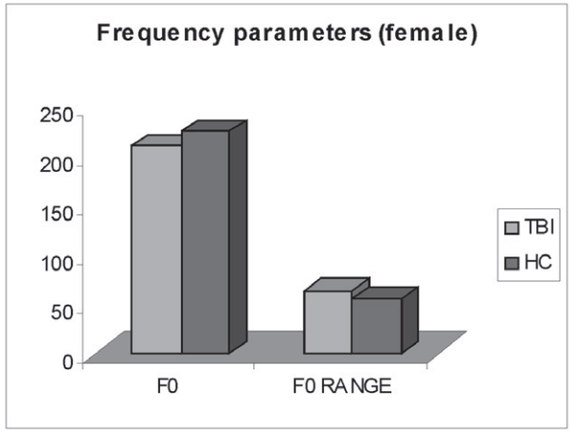

Fig 4 : Frequency parameter in females

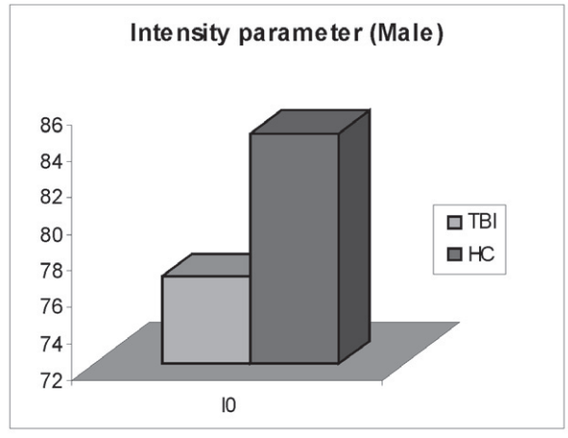

Fig 5 : Intensity parameters in males

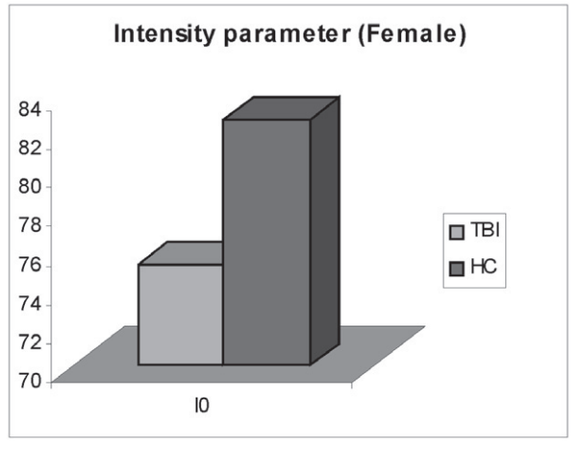

Fig 6 : Intensity parameters in females

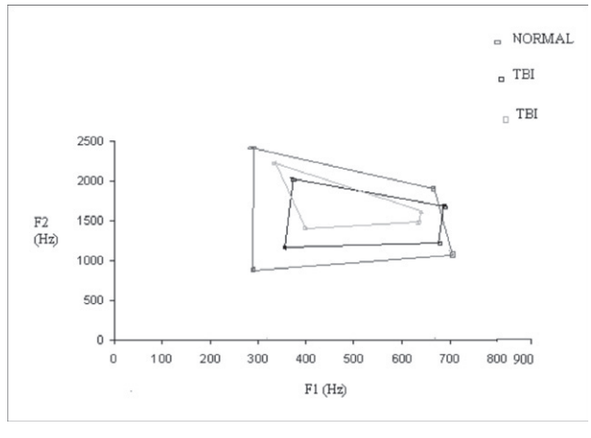

Fig 7 : Vowel quadrangle for male

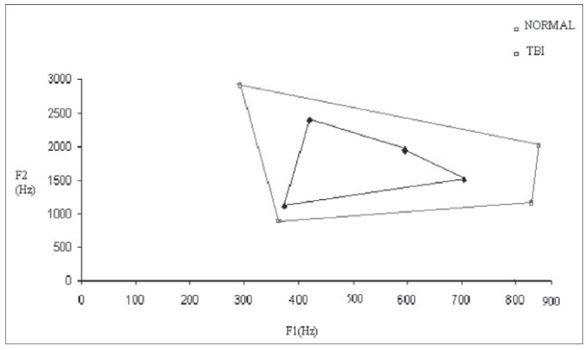

Fig 8 : Vowel quadrangle for female

Table 5: First and second formant (F1 and F2) of vowels /a/, /i/, /u/, /æ/ for patients with traumatic brain injury (TBI)

Patients	Formants	/a/	/i/	/u/	/æ/
S1	F1	693.96	387.72	383.43	700.55
	F2	1377.78	1980.62	1146.15	1568.42
S2	F1	644.36	346.83	413.2	677.82
	F2	1425.04	2138.58	1474.00	1672.8
S3	F1	704.45	419.38	373.3	595.51
	F2	1501.45	2393.1	1103.95	1944.79

Table 6 : Perceptual analysis of speech.

Parameters	Subject 1	Subject 2	Subject 3
Pitch	Normal	Normal	Normal
Loudness	Normal	Normal	Normal
Quality	Pleasant	Pleasant	Pleasant
Rate of speech	Slow	Slow	Slow
Pronunciation	Unclear	Unclear	Unclear
Prosody	Inadequate	Inadequate	Inadequate
Intelligibility rating	1	1	1

DISCUSSION

Acoustical parameters

Duration parameters: Duration of stressed word is lengthened in patients with traumatic brain injury compared to healthy controls. (Refer Table 3, 4 and Figs 1 and 2). This is the consequence of having neuromotor inco-ordination and weakness. They have slurred speech due to lack of precision and adequate force in articulatory process. Hence the time taken to produce individual speech sound or syllable is greater that of healthy control.

Frequency parameters: As shown in Figs 3 and 4, fundamental frequency in males with TBI is greater and is reduced in females with TBI compared to healthy control. Frequency range is greater in TBI (both male & female) compared to healthy controls. "Frequency parameters are increased overall in cases with TBI in comparison with healthy control. Increased vocal fold tension that is usually associated with hyperfunctional laryngeal activity was related to increase in fundamental frequency[9]. This might be because of extra efforts they need to put in to produce stress in the sentence. Literature reveals chances of developing voice problems by patients with TBI. The results of the present study do not support the results of the study which stated that the patients with TBI do have voice problems due to which their intelligibility is usually poor[10]. Intensity parameters: I0 is reduced in TBI (male & female) as compared to healthy control (Figs 5 and 6), as there is deficit in the function of respiration, phonation, resonation, articulation; patient need extra effort to produce loud voice. There respiratory support is not as good as the healthy control; hence the reduced subglottal air pressure does not allow them to produce as high intensities as their normal peers. In the neurologically impaired individual, laryngeal hyperfunction is presumed o indicate the presence of increased tone in the laryngeal musculature that results in hyperadduction of vocal folds and an increase in resistance to airflow during phonation[9]. Though there are definite difference between patients with TBI and healthy controls for intensity parameter, it cannot be considered as valid parameters as it depends upon variety of parameters (speaker to microphone distance, quality of recording system, background noise, sensitivity of microphone etc).

Vowel quadrangle : The vowel quadrangle (right, below) is a two-dimensional graphic approximation to an essentially three-dimensional vowel production array, omitting the temporal element. This useful display demonstrates the unique"locations" of both short and long vowels on a common set of X /Y axes. In this matrix, auditory identification of vowel sounds is primarily based on the relationship between the two primary resonances of the variable vocal tract as they shape the spectrum of the harmonically rich acoustic output of the vocal folds. These resonances are called formants. The first formant, lower in frequency, is called **F1.** It is attributable to the physical shape of the larger, posterior part of the variable shape vocal tract known as the pharyngeal cavity. **F2** is the primary

resonance of the smaller, anterior, **oral cavity**. Tongue placement and vocal tract shape determine the **F1 / F2 relationship.**

As it's seen in Table 5 and Figs 7 and 8, the vowel space is shrunken for TBI patients compared to healthy controls. Reduced vowel space indicates that there are deviations in articulatory movements in patients with TBI even after three years post trauma. Even though patients with TBI perceptually sound near normal but there are articulatory deviations.

Perceptual parameters*:* Evaluation reveals slower rate, affected prosody, poor intelligibility and slurred speech in patients with TBI, as shown in Table VI which is correlating with the results of acoustical analysis. The study supports the results which stated the 16 dysarthric TBI subjects were significantly less intelligible than the control subjects, and demonstrated significant impairment in 12 of the 33 speech dimensions rated perceptually[11]. Present study shows similarity in results with the study which stated excess stress for context, and decreased pitch variation may have reduced, or created ambiguity, in the information conveyed to listeners by patients with TBI[10]. Impaired laryngeal timing can interfere with the articulatory function of the larynx, resulting in a reduced ability to achieve voiced/voiceless contrasts, leading to poor differentiation of voiced cognates (t/d, k/g) and a possible reduction in intelligibility in patients with TBI.

In present study parameters such as pitch, loudness and quality of voice were not deviated in TBI patients with that of healthy control.

This study reveals that there is no statistically significant difference in acoustical parameters of speech of patients with TBI three years post-trauma and that of healthy controls. Though the difference is insignificant statistically the perception of speech of patient with TBI isn't normal. To avoid problems with documentation of definite milder form of deviations observed in such patients as compared to healthy controls, speech dimensions in TBI are still needs to be studied in detail with better assessment tools.

The present study,

Highlights the importance of speech therapy in rehabilitation of patients with TBI.

As the result of study shows that acoustical differences are present in TBI patients though not significant statistically.

Results of present study will help in planning speech therapy especially in articulation and prosodic aspects as there is a scope to improve articulatory dynamics in patients with TBI.

Present study also creates the need to carry out the study on large sample, by giving further scope of research (comparison) in terms of evaluating the speech parameters of patients with TBI with different site of lesion and also by studying other parameters of speech viz. prosody.

Study implied in research and rehabilitation field of patients with TBI in many ways but can not be generalized due to small sample size.

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