

## Original Research Article

# Study of maximum phonation time and S/Z ratio in laryngeal paralysis

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### ABSTRACT

**Background:** Alterations in human voice occur frequently and patients usually complain of hoarseness of voice. Laryngeal paralysis is an important differential diagnosis in patients complaining change of voice. Because of simplicity and ease, maximum phonation time (MPT) and S/Z ratio have become the most frequently used clinical tools to assess phonatory mechanics. Published research studying analysis of MPT and S/Z ratio in patients with vocal cord paralysis (VCP) is scanty. Hence this study was taken up to study MPT and S/Z ratios in patients with laryngeal paralysis.

**Methods:** 62 patients with VCP were included in our study. Complete history was taken and examination was done in all patients. VCP was confirmed by indirect laryngoscopic examination. The MPT and S/Z ratios were evaluated in a quiet room. Data was analyzed using IBM SPSS Version 22.

**Results:** Mean MPT in males with VCP was  $6.71 \pm 0.54$  and in females it was  $6.80 \pm 2$ . Mean S/Z ratio in males was  $1.69 \pm 0.54$ , in females  $1.59 \pm 0.35$ . The difference between laterality of VCP and MPT was statistically highly significant and the difference between laterality of VCP and S/Z ratio was also statistically highly significant. Our study shows no statistically significant difference in MPT and S/Z ratio with respect to age and gender. There was a significant negative correlation between MPT and S/Z ratio.

**Conclusions:** Irrespective of age and gender MPT and S/Z ratio are simple and effective objective clinical tests to diagnose paralytic laryngeal pathologies. As laryngeal pathology heals on treatment MPT and S/Z ratio are expected to normalize indicating therapeutic progress.

**Keywords:** Vocal cord paralysis, Maximum phonation time, S/Z ratio

### INTRODUCTION

The larynx occupies the most esteemed position in the neck and phonation is an important function of larynx. Alterations in human voice occur very frequently and the patients usually complain of hoarseness or breathiness of voice.<sup>1</sup> Any pathological changes of the structure of vocal cord, changes in the mechanical properties that are intrinsic to larynx or denervation of vocal cord leads to vocal instability.<sup>2,3</sup> Vocal cord paralysis (VCP) is a sign of underlying central, peripheral diseases or it can be idiopathic but it is not a disease per se.<sup>4,6</sup> The etiology may be along the course of vagus nerve across cranial,

cervical or thoracic part. Hoarseness of voice is the main presenting complaint in laryngeal paralysis. The position of paralyzed vocal cord determines the degree of hoarseness of voice.<sup>1,7</sup> In patients presenting with airway obstruction, change of voice and aspiration symptoms, laryngeal paralysis is an important consideration among the differential diagnosis.<sup>8</sup> Therefore the life threatening sequelae from anoxia, hypoxia or aspiration can be prevented by early recognition of VCP and application of appropriate treatment. Though there are many tools for a clinician to assess the vocal cord function, because of simplicity and ease the maximum phonation time (MPT) and S/Z ratio have become the most frequently used clinical tools to assess phonatory mechanics.

The capacity of a person to control the respiratory, aerodynamic and myoelastic forces of the larynx during phonation is the maximum phonation time.<sup>1,9,10</sup> The longest duration for which a person can sustain phonation of a vowel sound typically /a/ is the MPT. It roughly indicates the respiratory support and the phonatory function. It is fast non-invasive and an objective method.<sup>9,11</sup>

S/Z ratio is another measure of phonation time where maximum sustained time of /S/ is divided by the maximum sustained time of /Z/. According to Boone, in persons with normal vocal cords S/Z ratio approximates to 1 as the normal vocal cords prolong the voiceless /S/ and voiced /Z/ phonemes for the same length of time.<sup>12</sup> Eckel and Boone also hypothesized that it would be difficult to prolong the voiced /Z/ for the same duration as voiceless /S/ for patients with laryngeal pathology due to a decrement in glottal efficiency.<sup>11</sup> Published research studying analysis of MPT and S/Z ratio in patients with VCP is scanty. Hence this study was taken up to study the MPT and S/Z ratios in patients with laryngeal paralysis.

**METHODS**

This is a prospective study conducted for a period of 1 year from June 2018 to June 2019, in the department of Otorhinolaryngology Head and Neck Surgery, VIMS, Ballari, Karnataka, India. The patients were selected on simple random basis after taking informed written consent. The statistically calculated sample size that is 62 patients of both genders attending as outpatients or inpatients to the department of Otorhinolaryngology who were clinically diagnosed with vocal cord paralysis were included in our study

Complete history was taken and examination was done in all patients. The Vocal cord paralysis was confirmed by indirect laryngoscopic examination or by Hopkins rod indirect laryngoscope without any local anaesthesia.

Inclusion criteria was clinically diagnosed patients with unilateral or bilateral vocal cord paralysis who have not undergone treatment for vocal cord paralysis and exclusion criteria were included, fixed vocal cord due to laryngeal and other malignancies, congenital vocal cord, paralysis, treated cases of vocal cord paralysis, patients with other concomitant pathologies of vocal cord, patients who were not willing for evaluation.

The Maximum Phonation Time and S/Z ratios were evaluated in a quiet room. The procedures were instructed verbally in addition to a visible and audible trial performance by the researcher. To calculate MPT, patients were instructed to perform a deep inspiration and then to prolong the vowel /a/ as long as possible at a comfortable pitch and loudness. The time duration sustained was measured using a stopwatch. Patients repeated the procedure for three times and the longest

value of the three trials was considered as the MPT of the patient.

To obtain S/Z ratio, following a demonstration the patients were asked to sustain the consonant /S/ for as long as possible after a deep inspiration. The values were obtained on three separate trials. The patients performed the same task during production of consonant /Z/ on three separate trials. S/Z ratio was calculated by dividing the maximum duration for which /S/ was sustained by the maximum duration for which /Z/ was sustained.

**Statistical analysis**

Data was collected by using a structured proforma. Data was entered in MS Excel sheet and analyzed by using IBM SPSS Version 22 for windows. Mean and Standard deviation was calculated for continuous variables. Multiple comparisons were done with ANOVA. Mean between two groups were analyzed by using Students unpaired t test. A p-value of less than 0.05 was considered statistically significant. To assess the relation between MPT and S/Z ratio Pearson’s correlation was applied and correlation graph was plotted.

**RESULTS**

In our study of 62 patients, age ranged from 10 to 78 years with mean age of 46 years. Maximum numbers of patients were in age group of 50 to 75 years. 37 (59.67%) were males and 25 (40.32%) were females. Thus male to female ratio in our study was 1.48:1 (Table 1).

**Table 1: Distribution of patients according to age and gender.**

Age (in years)	No.	Males	Females
0-24	10	6	4
25-49	22	9	13
50-75	29	21	8
>75	1	1	0
<b>Total</b>	<b>62</b>	<b>37</b>	<b>25</b>

Among 62 patients 95.16% presented with hoarseness of voice, 12.90% with breathing difficulty, 9.67% with aspiration symptoms, 8.06% patients presented with dysphagia (Table 2). Out of 62 patients, VCP was observed in 9 (14.51%) patients after surgery, 8(12.90%) were associated with neoplasm, 5(8.06%) were post traumatic, 2(3.22%) were related to CVS causes and 2(3.22%) were related to CNS causes. Nine (14.51%) patients had other causes like cervical abscess, tuberculosis, benign thyroid swellings. Twenty-seven (45.16%) were idiopathic (Table 3).

Left side involvement was most common. Left vocal cord palsy was seen in 36 patients (58.06%), followed by right

vocal cord palsy in 17 patients (27.41%) and bilateral vocal cord palsy in 9 patients (14.51%) (Table 4).

**Table 2: Distribution of the patients according to presenting complaints.**

Complaints	Frequency
Hoarseness of voice	59
Breathing difficulty	8
Aspiration symptoms	6
Dysphagia	5

**Table 3: Distribution of patients according to the cause of vocal cord paralysis.**

Etiology	Frequency
Post surgery	9
Neoplastic	8
Traumatic	5
CVS	2
CNS	2
Idiopathic	27
Others	9
Total	62

The paralyzed vocal cord was most commonly found in paramedian position in 44 patients (70.96%), followed by median position in 13 patients (20.96%) and intermediate position in 5 patients (8.06%) (Table 5). The mean MPT in male patients with VCP was 6.71±2.15 and in female patients it was 6.80±2. The mean S/Z ratio in males was 1.69±0.54, in females 1.59±0.35 (Table 6). The mean

**Table 6: MPT and S/Z ratios according to gender.**

Variables	Gender	No.	Mean	Std. Deviation	Unpaired t Test	
					P value	Significance
MPT	Male	37	6.71	2.15	0.862	Not significant
	Female	25	6.80	2.00		
S/Z ratio	Male	37	1.69	0.54	0.423	Not significant
	Female	25	1.59	0.35		

**Table 7: MPT according to laterality of vocal cord paralysis.**

Laterality of VCP	No.	MPT		ANOVA	
		Mean	Std. Deviation	P value	Significance
U/L - right	17	7.96	1.86	0.000	Highly significant
U/L - left	36	6.69	1.82		
Bilateral	9	4.69	1.86		

**Table 8: S/Z ratio according to laterality of vocal cord paralysis.**

Laterality of VCP	N	S/Z ratio		ANOVA	
		Mean	Std. Deviation	P value	Significance
U/L - right	17	1.45	0.23	0.000	Highly significant
U/L - left	36	1.56	0.21		
Bilateral	9	2.38	0.83		

MPT in right VCP was 7.96±1.86, in left VCP was 6.69±1.8 and in bilateral VCP mean MPT was 4.69±1.86 (Table 7). The mean S/Z ratio in right VCP was 1.45±0.23, in left VCP was 1.56±0.21 and in bilateral VCP mean S/Z ratio was 2.38±0.83 (Table 8).

**Table 4: Distribution of patients according to laterality of vocal cord paralysis.**

Laterality	Frequency	Males	Females
Right VCP	17	11	6
Left VCP	36	21	15
Bilateral VCP	9	5	4
Total	62	37	25

**Table 5: Distribution of patients according to position of the paralyzed vocal cord.**

Position of vocal cord	Frequency
Paramedian	44
Median	13
Intermediate	5
Abducted	0
Total	62

The difference between laterality of VCP and MPT was statistically highly significant (0.000) and the difference between laterality of VCP and S/Z ratio was also statistically highly significant (0.000). Our study shows no statistically significant difference in MPT and S/Z ratio with respect to age and gender (Figure 1 and Figure 2).

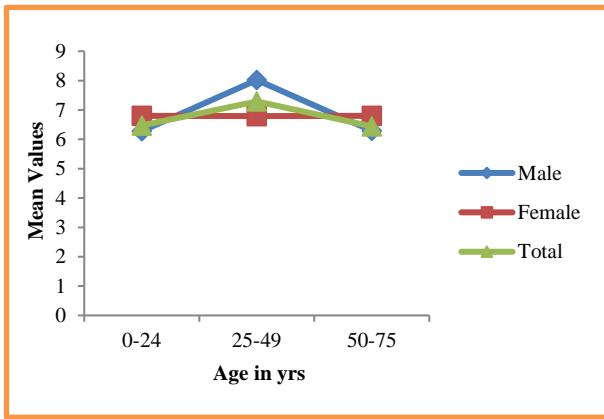


Figure 1: MPT according to age and gender.

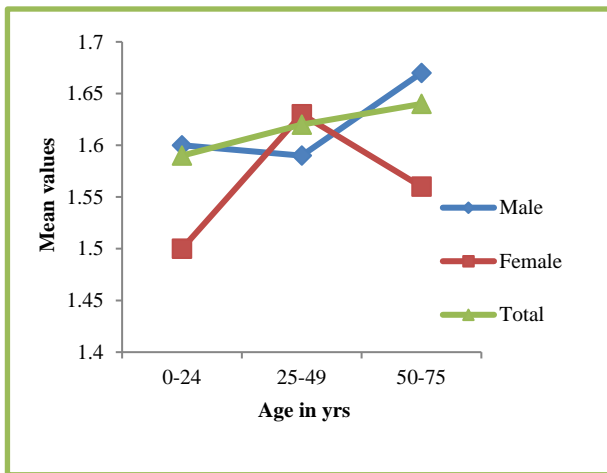


Figure 2: S/Z ratios according to age and gender.

To assess the correlation between MPT and S/Z ratio Pearson’s correlation was applied, in our study there was no correlation of age with MPT and S/Z ratio. There was a significant negative correlation between MPT and S/Z ratio. Increase in MPT showed decrease in S/Z ratio (Figure 3).

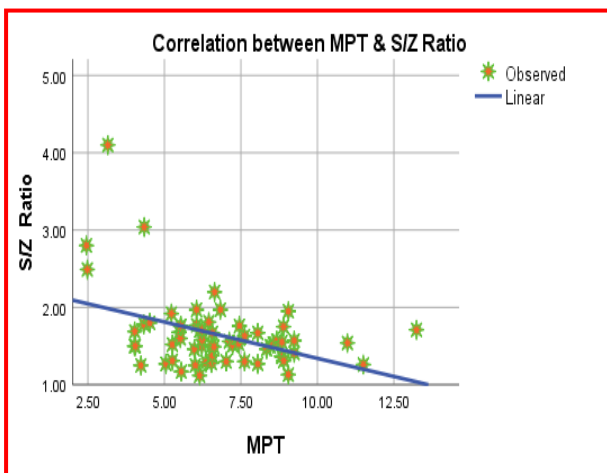


Figure 3: Corelation between MPT and S/Z ratio.

## DISCUSSION

Out of 62 patients attending the Department of ENT with laryngeal paralysis, the age ranged from 10 to 78 years with mean age of 46 years. Majority of the patients were in the age group of 50 to 75(46.77%). This is very well in agreement with a study by Benninger et al and Ahmed et al.<sup>13,14</sup> Beninger et al stated that vocal cord paralysis is more common with advancing age because of the increased incidence of neurologic and neoplastic disorders, which may affect laryngeal function. Ahmed et al. in their study on incidence and etiopathology of VCP found that most of the patients (77.2%) presented in the 5<sup>th</sup> and 6<sup>th</sup> decades of life.

Among the patients with VCP male preponderance was seen with male to female ratio of 1.48:1. Our study is in accordance with study by Nerurkar et al.<sup>15</sup> In their study male female ratio was 2:1. The most common symptom was hoarseness of voice, similar observations were made by swift et al.<sup>16</sup> Most of the cases of VCP were due to Neoplasm, surgery. Idiopathic VCP was the most common group. This is consistent with study by cunning et al.<sup>17</sup> In their study on unilateral VCP, idiopathic VCP was most common (31.3%).

Paralysis of the left vocal cord has been reported 2.11 times more than right side. In our study, bilateral paralysis was 14.51%, left paralysis 58.06% and right 27.41% that was consistent with Ko et al.<sup>18</sup> reporting nearly 68% paralysis in left side and Srirompotong et al.<sup>19</sup> reporting 73% of the paralysis in left side.

In most patients of VCP the vocal cord was in paramedian position (70.96%) followed by median (20.96%) and intermediate (8.06%). In a study by Siromptong et al.<sup>19</sup> on patients with VCP, the paralyzed cord was mostly fixed in paramedian position (81%) followed by median in 12% and cadaveric position in 7%.

MPT is obtained through a simple test aiming to asses glottic efficiency. The normal expected values for men is 25 to 35 seconds and for women it is 15 to 25 seconds.<sup>20</sup> MPT value lower than 10 seconds is considered to be pathological.<sup>20</sup> In our study the mean MPT in male patients with VCP was 6.71±2.15. Hence it was significantly reduced compared to normal subjects. Colton and Casper<sup>1</sup> referred an average MPT of 4 to 5 seconds for Vocal cord paralysis.

The S/Z ratio provides interesting data about phonation dynamics and it has been considered a very reliable tool to asses glottic efficiency.

According to Boone, who first developed this technique, persons with normal vocal folds could be expected to prolong the voiceless /s/ and the voiced /z/ phonemes for about the same length of time, resulting in an s/z ratio of approximating one.<sup>12</sup> Eckel et al also hypothesized that patients with laryngeal pathologies, would have difficulty

prolonging the voiced sound /z/ for the same duration as voiceless /s/, because of a “decrement in glottal efficiency.”<sup>11</sup> Hence patients with vocal cord pathology may have a ratio more than one.

In our study the mean S/Z ratio in males was 1.69±0.54, in females 1.59±0.35. This is consistent with findings of Sorenson et al.<sup>21</sup> They concluded that S/Z ratio was significantly increased in patients with vocal cord pathology.

The difference between laterality of VCP and MPT was statistically highly significant and the difference between laterality of VCP and S/Z ratio was also statistically highly significant. In our study MPT values were significantly reduced in bilateral VCP as compared to unilateral VCP and S/Z ratio was significantly increased in bilateral VCP as compared to unilateral VCP.

In our study there was a significant negative correlation between MPT and S/Z ratio. Increase in MPT showed decrease in S/Z ratio. Our study shows no statistically significant difference in MPT and S/Z ratio with respect to age and gender.

## CONCLUSION

Irrespective of age and gender the MPT and S/Z ratio are simple and effective objective clinical tests to diagnose paralytic laryngeal pathologies and these can be used as indicators for laryngeal valving and glottic efficiency. As the laryngeal pathology heals on treatment, the MPT and S/Z ratio are expected to normalize indicating therapeutic progress.

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