on Pre-hemodialysis in patients with renal failure is 21.7151±4.08539and the comparison of Mean and Standard Deviation, Post-hemodialysis in patients with renal failure is 22.4948±2.96251.

The voice acoustic analysis in Pre- and Post-hemodialysis in Male and Female categories of patients with renal failure are given in the table 3 and table 4(Refer Appendix for additional information) below.

Gender	Parameters	Group	N	Mean	Std. Deviation	P- Value
F	*fo*	pre	14	286.33	27.20	<0.05
		post	6	254.15	13.95	
	JITTER	pre	14	0.62	0.28	>0.05
		post	6	0.70	0.38	
	SHIMMER	pre	14	0.30	0.08	>0.05
		post	6	0.30	0.11	
	HNR	pre	14	23.24	3.69	<0.05
		post	6	20.57	3.92	
M	*fo*	pre	6	144.59	15.97	<0.05
		post	14	152.37	15.10	
	JITTER	pre	6	0.65	0.15	>0.05
		post	14	0.70	0.17	
	SHIMMER	pre	6	0.23	0.05	>0.05
		post	14	0.32	0.14	
	HNR	pre	6	18.13	2.44	<0.05
		post	14	23.31	2.11	

TABLE 3: COMPARISON OF VOICE ACOUSTIC ANALYSESIN PRE- AND POST-HEMODIALYSIS IN MALE AND FEMALE CATEGORIES OF PATIENTS WITH RENAL FAILURE

On comparison of the parameters between two groups (Pre-HD and Post-HD groups) in Male and Female categories; the *fo* and HNR values in the Post- HD group decreased significantly in PRAAT ($p<0.05$), whereas the other parameters like Jitter, Shimmer and HNR valueswhen comparedhad significantly no much differences than those of the Pre-HD group (Table 3).

The comparison of Mean and Standard Deviationin Pre- and Post-hemodialysis in Male and Female categories of patients with renal failure are as follows:

In Females,The comparison of Mean and Standard Deviation for *fo*, on Pre-hemodialysis in patients with renal failure is 286.3309±27.20437and the comparison of Mean and Standard Deviation, Post-hemodialysis in patients with renal failure is 254.1563±13.95185. The comparison of Mean and Standard Deviation for Jitter, on Pre-hemodialysis in patients with renal failure is 0.6209±0.28113and the comparison of Mean and Standard Deviation, on Post-hemodialysis in patients with renal failure is 0.7022±0.38194. The comparison of Mean and Standard Deviation for Shimmer, on Pre-hemodialysis in patients with renal failure is 0.3067±0.08965and the comparison of Mean and Standard Deviation, Post-hemodialysis in patients with renal failure is 0.3092±0.11961. The comparison of Mean and Standard Deviation for HNR, on Pre-hemodialysis in patients with renal failure is 23.2488±3.69477and the comparison of Mean and Standard Deviation, Post-hemodialysis in patients with renal failure is 20.5737±3.92584.

In Males, The comparison of Mean and Standard Deviation for *fo*, on Pre-hemodialysis in patients with renal failure is 144.5933±15.97947 and the comparison of Mean and Standard Deviation, Post-hemodialysis in patients with renal failure is 152.3736±15.10625. The comparison of Mean and Standard Deviation for Jitter, on Pre-hemodialysis in patients with renal failure is 0.6528±0.15588and the comparison of Mean and Standard Deviation, on Post-hemodialysis in patients with renal failure is 0.7077±0.17500. The comparison of Mean and Standard Deviation for Shimmer, on Pre-hemodialysis in patients with renal failure is 0.2343±0.05602 and the comparison of Mean and Standard Deviation, Post-hemodialysis in patients with renal failure is 0.3276±0.14510. The comparison of Mean and Standard Deviation for HNR, on Pre-hemodialysis in patients with renal failure is 18.1365±2.44464 and the comparison of Mean and Standard Deviation, Post-hemodialysis in patients with renal failure is 23.3181±2.11329.

Thus, as there is maximum differences in *fo* values in general category andmaximum differences in *fo* and HNR values in Male and Female categories which will indicate that stability of vocal folds will be affected and thus there will be presence of abnormal voice.

DISCUSSION

As there is less number of studies to prove the voice complications experienced by Post-HD, this study helps in throwing light onthese aspectsinorder to improve the communication ability and quality of life. This study has shown that there is difference in *fo* values in general category and maximum differences in *fo* and HNR values in Male and Female categories which confirms that there is significantly higher rate ofinstability of vocal fold vibrations than the Male and Female categories with Pre-HD (general group). Thus proving the presence of an abnormal voice in the Male and Female categories with Post-HD (experimental group).The different domains of voice are experimented in this study, i.e., Fundamental Frequency (*fo*), Jitter (%), Shimmer (dB) and HNR parameters. This study affirms the fact that the voice characteristics gets affected on undergoing hemodialysis. The Vocal Fold behavior with respect to pitch is attributed to Fundamental Frequency (*fo*). The results confirmedthat there waschange in voice quality in patients who undergo Hemodialysis. Therefore establishing the impact of Hemodialysis on Vocal function or laryngeal function producing the voice characteristics.

Most important feature of the voice is frequency which is number of vibrations of the vocal folds per second. The Fundamental Frequency (*fo*) means the frequency of fundamental voice which is occurs at the level of larynx. Mean *fo* value during normal speech is between 100–180Hz in the males and 180–250Hz in the females. HNR is the ratio of total energy of the fundamental voice which is said as harmonic components to the energy of the noise. The dB is the unit used to measure and higher values show that the ratio of noise is high in the voice (Unver S, Hardal U, et al., 2015).

The change in fundamental frequency is already proved in various studies (Hamdan AL, Medawar W, et al., 2005). The increased subglottic pressure and decreased vocal fold thickness along with other factors like length, tension, and elasticity of vocal fold is affected after hemodialysis causing vocaldistructions (Jung SY, Ryu JH, et al., 2014). According to the few authors the reduced Vocal Fold volume due to the delayed muscle fiber contraction which is responsible for reduced muscle strength (Hassan ES, 2014). During the Hemodialysis there will be removal of excessive body fluid accumulated in interstitial space, thereby

expecting the excessive fluid in Reinke's Space of Vocal folds (Superficial Lamina Propria) will also be removed. This results implies in reduction of thickness of vocal folds (True VF) (Ori Y, Sabo R, Binder Y, et al., 2006). There will be improved respiratory functions due to increased muscle function after removal of excessive fluid from interstitial space and uremic toxins from the body. Thus improved lung function affects the subglottic pressure and transglottal airflow rate (Jung SY, Ryu JH, et al., 2014). The negative fluid imbalance after hemodialysis results in reduction of intravascular and extravascular volumes of lung fluids along with reduction of fluid in Lamina Propria, after which there will be increment in pitch and decrement in mass or volume. According to the study by Nesic M, Veljkovic S,et al., in 1996., as it is unable to rule-out the both vocal intensity and perturbation changes, the Jitter and Shimmer remains unexplained. As the laryngeal efficiency mirrors the voice turbulence index and noise/harmonics ratio, incomplete closure of glottis or prolonged glottis opening gives rise to excessive airflow becoming turbulent and perceived as aperiodic noise, which has no harmonics and the energy of it gets scattered over all frequencies resulting no much effects on HNR values (Hamdan AL, Medawar W, et al., 2005). But degree of hoarseness is related to the glottal closure. So it is known that glottal gap and hoarseness decreases after hemodialysis (Jung SY, Ryu JH, et al., 2014). It is also said that the reduced vocal fold volume also results in hoarseness of voice and increases vocal gap, thus arising incomplete glottal closure (Ori Y, Sabo R, et al., 2006). There are additional problems suffered after HD, along with hoarseness and coughing, i.e., heart related complication, abdominal discomfort, yawning, sighing, vomiting, restlessness, cramping, anxiety, etc. (Zumrutdal A, 2013).

Inorder to understand in depth about the complications of voice after Hemodialysis, it is better to use more advanced technologies to estimate the further details and come out with better remedial measures.

CONCLUSION

The results of this study were based on the scores obtained from the PRAAT,the parameters taken (Pitch, Jitter, Shimmer and Harmonics to Noise ratio) from the two groups; in our study population.This study confirmed that there is change in voice quality pre and post HD. A detailed case history can help in gathering additionalinformation regarding demographic data, medical history, presenting complaints and symptoms, dietary patterns, the other environmental factors and familiar history that may lead to the development of health problems. It is essential to include other acoustical analysis using different instruments having different standards to arrive at better results that can assist in developing proper intervention measures. Thus, the researchers in further can take this research findings apply on different other population. Hence, this study would help the professionals to find out the rate of occurrence of voice related complications in individuals with renal failure after the hemodialysis and develop appropriate measures to manage them.

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APPENDIX

RESULTS:

TABLE 2: COMPARISON OF VOICE ACOUSTIC ANALYSES PRE- AND POST-HEMODIALYSIS IN PATIENTS WITH RENAL FAILURE

Gender		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
fo	Equal variances assumed	2.16	0.15	2.71	18	0.01	32.17	11.83	7.30	57.04
	Equal variances not assumed			3.48	17.10	0.00	32.17	9.23	12.69	51.65
JITTER	Equal variances assumed	030	0.58	-0.53	18	0.60	-0.08	0.15	-0.40	0.23
	Equal variances not assumed			-0.47	7.43	0.65	-0.08	0.17	-0.48	0.32
SHIMMER	Equal variances assumed	0.11	0.73	-0.05	18	0.96	-0.00	0.04	-0.10	0.09
	Equal variances not assumed			-0.04	7.52	0.96	-0.00	0.05	-0.12	0.12
HNR	Equal variances assumed	0.04	0.83	1.45	18	0.16	2.67	1.83	-1.17	6.53
	Equal variances not assumed			1.42	9.01	0.18	2.67	1.88	-1.58	6.93
fo	Equal variances assumed	0.03	0.85	-1.03	18	0.31	-7.78	7.49	-23.52	7.95
	Equal variances not assumed			-1.01	9.05	0.33	-7.78	7.67	-25.11	9.55
JITTER	Equal variances assumed	0.04	0.82	-0.66	18	0.51	-0.05	0.08	-0.22	0.11
	Equal variances not assumed			-0.69	10.66	0.50	-0.05	0.07	-0.22	0.11
SHIMMER	Equal variances assumed	7.31	0.01	-1.50	18	0.14	-0.09	0.06	-0.22	0.03
	Equal variances not assumed			-2.07	17.96	0.05	-0.09	0.04	-0.18	0.00
HNR	Equal variances assumed	0.19	0.66	-4.80	18	0.00	-5.18	1.07	-7.44	-2.91
	Equal variances not assumed			-4.51	8.38	0.00	-5.18	1.14	-7.80	-2.55

TABLE 4: COMPARISON OF VOICE ACOUSTIC ANALYSES IN PRE- AND POST-HEMODIALYSIS IN MALE AND FEMALE CATEGORIES OF PATIENTS WITH RENAL FAILURE

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
fo	Equal variances assumed	5.33	0.02	3.14	38	0.00	60.90	19.38	21.66	100.13
	Equal variances not assumed			3.14	34.16	0.00	60.90	19.38	21.52	100.27
JITTER	Equal variances assumed	0.25	0.61	-0.97	38	0.33	-0.07	0.07	-0.23	0.08
	Equal variances not assumed			-0.97	37.99	0.33	-0.07	0.07	-0.23	0.08
SHIMMER	Equal variances assumed	4.18	0.04	-1.03	38	0.30	-0.03	0.03	-0.10	0.03
	Equal variances not assumed			-1.03	32.34	0.30	-0.03	0.03	-0.11	0.03
HNR	Equal variances assumed	3.00	0.09	-0.69	38	0.49	-0.77	1.12	-3.06	1.50
	Equal variances not assumed			-0.69	34.65	0.49	-0.77	1.12	-3.07	1.51