

## 양성후두질환에서 후두미세수술 전후 음성의 비교분석

백무진<sup>1</sup> · 황부현<sup>1</sup> · 엄재욱<sup>1</sup> · 권순복<sup>2</sup> · 이병주<sup>2</sup> · 왕수건<sup>2</sup>

## Comparison of Voice before and after Surgery in Benign Laryngeal Diseases

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## - ABSTRACT -

**Background and Objective** : In benign laryngeal diseases, voice quality is major concern to both patients and clinicians. The purpose of this study is to identify the acoustic parameters that can represent preoperative pathologic and postoperative improved voice and to investigate quantitative changes of them. Using these data, We intend to disclose the mechanisms of voice change and apply to programs that can predict postoperative voice using preoperative voice data. **Material and Methods** : We examined 47 patients who experienced laryngeal microsurgery due to pathologic voice with benign laryngeal diseases and 50 normal controls. The voice was analysed by Multi-Dimensional Voice Program in Computerized Speech Lab 4300 B. **Results** : All preoperative parameter's values except NHR and VTI were higher than control group. Among them, the values of frequency and amplitude perturbation related parameters increased most highly. Most parameter's values after operation showed statistically no significant difference from those of control group. Postoperative parameter's values reduced above 50% of PPQ, RAP, sPPQ, Jitt, ShdB, Jita and Shim than preoperative state. **Conclusion** : The results showed that Jitter and Shimmer represented well the pathologic voice of benign laryngeal disease and very closely related between improvements of both these parameters and voice quality after operation. We also considered that these data will be available in the program of postoperative predictive voice synthesis using preoperative voice data. (*J Clinical Otolaryngol* 2001;12:65-79)

**KEY WORDS** : Pathologic voice · Benign laryngeal diseases · Quantitative voice change.

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방  
법  
가

(Methods of voice analysis)

15 cm 가 가

3 / / / /,

/ / / / / /

3 Digital Audiotape Recorder(DAT, DTC - 59ESJ, Sony, Japan)

Computerized Speech Lab 4300 B( CSL )

Multi - Dimensional

Voice Program( MDVP )

33 가 10 23

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(Analysis of acoustic data)

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Wilcoxon rank sum test

대상 및 방법

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가 neral linear models procedure(SAS 6.2) .

37 , 13 , 20 65 6

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**Table 1.** Short and long term frequency perturbation measurements

Jita	us			83.2
Jitt	%			1.04
RAP	%	.3		0.68
PPQ	%	.5		0.84
sPPQ	%	7†	55	1.02
vF <sub>0</sub>	%			1.10

Jita : Absolute Jitter, Jitt : Jitter percent, RAP : Relative Average Perturbation, PPQ : Pitch Period Perturbation Quotient, sPPQ : Smoothed Pitch Period Perturbation Quotient, vF<sub>0</sub> : Fundamental Frequency Variation  
: Kay <sup>27)</sup>

**Table 2.** Short and long term amplitude perturbation measurements

ShdB	dB			0.35
Shim	%			3.81
APQ	%	.11		3.07
sAPQ	%		55	4.23
vAm	%			8.20

ShdB : Shimmer in dB, Shim : Shimmer Percent, APQ : Amplitude Perturbation Quotient, sAPQ : Smoothed Amplitude Perturbation Quotient, vAm : Peak Amplitude Variation  
: Kay <sup>27)</sup>

**Table 3.** Voice break related measurements

DVB	%			1.00
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DVB : Degree of voiceless : Kay <sup>27)</sup>

(short / / / / / / / / 3  
and long term frequency perturbation measurement - 48,000 Hz sampling, sp -  
ents)(Table 1), (short electrogram, 12,000 Hz  
and long term amplitude perturbation measurement - down - sampling 1 (F1),  
nts)(Table 2), (voice break related measurements)(Table 3), 2 (F2), 3 (F3)  
(noise related measurements)(Table 4), Wilcoxon rank sum test  
(tremor measurements)(Table 5),  
(fundamental frequency information measurements)(Table 6) **결 과**  
CSL MDVP 33 가  
NVB, DSH, NSH, DUV, NUV, T<sub>0</sub>, STD Tsam,  
(Methods of formant analysis) SEG, PER 10 23  
/ /,

**Table 4.** Noise related measurements

NHR		70	4,500 Hz	1500	4,500 Hz
					0.19
VTI		70	4,500 Hz	2,800	5,800 Hz
			VTI		0.061
SPI	4,500 Hz	70	1,600 Hz	1,600	14.12
		SPI	SPI	가	

NHR : Noise to Harmonic Ratio, VTI : Voice Turbulence Index, SPI : Soft Phonation Index  
: Kay 27)

**Table 5.** Tremor measurements

FTRI	%	F <sub>0</sub>	가	(F <sub>0</sub> )	가
					0.95
ATRI	%		가		4.37
Fftr	Hz	F <sub>0</sub>	가		
		FTRI			
Fatr	Hz	ATRI	가		

FTRI : F<sub>0</sub> Tremor Intensity Index  
Fftr : F<sub>0</sub> Tremor Frequency  
: Kay 27)

ATRI : Amplitude Tremor Intensity Index  
Fatr : Amplitude Tremor Frequency

**Table 6.** Fundamental frequency information measurements

Fhi	Hz		가
Flo	Hz		가
F <sub>0</sub>	Hz		
PFR	semi-Tones		

Fhi : Highest Fundamental Frequency, Flo : Lowest Fundamental Frequency, F<sub>0</sub> : Average Fundamental Frequency, PFR : Phonatory Fundamental Frequency

(p>0.05), Kay  
vF<sub>0</sub> 1.8 , SPI 1.5  
, vAm 1.3 , Jitt 1.0 5  
Jita가 3.0 가 가

, Jitt 2.8 , PPQ 2.8 , RAP 2.7 , sPPQ 2.4 ,  
vF<sub>0</sub> 2.3 (Table 7 - 12).

(p>0.05). sP-  
PQ가 1.0 (Table 11) 가 , RAP 1.2  
(Table 10), PPQ 1.2 (Table 9), Jitt 1.3 (Table  
8), vF<sub>0</sub> 1.3 (Table 12), Jita 1.5 (Table 7)

PPQ가 57.6% 가 (Table 9), RAP 57.0%  
(Table 10), sPPQ 57.0%(Table 11), Jitt 54.4%  
(Table 8), Jita 49.7%(Table 7), vF<sub>0</sub> 40.8%(Table  
12)

sPPQ가  
, vF<sub>0</sub> / / (p>0.05).  
가 47 RAP가 39.8  
(85%)(Table 10) sPPQ 39.2  
(83%)(Table 11), PPQ 38.6 (82%)(Table 9), Jita

37.6 (80%)(Table 7), Jitter 37.2 (79%)(Table 8), vF<sub>0</sub> 35 (74%)(Table 12) . 52.2% 가 , Shim 48.9%, APQ 38.9%, sAPQ 38.9%, vAm 22.6% (Table 13 - 17). ShdB가 3.3 가 , Shim 2.6 , APQ 2.4 , sAPQ 1.6 , vAm 1.2 Shim (Table 13 - 17). Shim / / / (Table 13), APQ / / / (Table 14), ShdB / / / (Table 13), APQ / / / (Table 14), vAm 1.0 가 (Table 17), sA - / / / (Table 17), sAPQ / / (Table 16), vAm / / (Table 17), Shim 1.3 (Table 14), APQ 가 (p<0.14 (Table 15), ShdB 1.6 (Table 13) . 05). 가 47 Sh-

**Table 7.** Absolute Jitter (us)

	(%)	p-value	(%)			
/ /	63.0 ± 36.1	230.3 ± 192.3	88.5 ± 57.8	61.5	0.001	37 (79)
/ /	73.4 ± 52.8	271.3 ± 192.1	151.9 ± 100.3*	43.6	0.001	38 (81)
/ /	98.0 ± 104.8	216.4 ± 176.7	118.4 ± 86.1	45.2	0.001	36 (77)
/ /	63.8 ± 41.6	170.4 ± 135.4	74.9 ± 63.5 <sup>†</sup>	56.0	0.0001	40 (85)
/ /	71.4 ± 44.2	203.3 ± 200.9	114.1 ± 180.8	43.8	0.044	37 (79)
	73.9 ± 14.2	218.3 ± 132.9	109.8 ± 66.0	49.7		37.6 (80)
Ratio	1 (0.9)	2.95 (2.6)	1.48 (1.3)			

Ratio : ( ) : Kay 83.2  
 Statistically significant between \* or † and the other vowels : p<0.05

**Table 8.** Jitter Percent (%)

	(%)	p-value	(%)			
/ /	0.9 ± 0.6	3.1 ± 2.8	1.2 ± 0.8	62.7	0.0003	36 (77)
/ /	1.0 ± 0.7	3.7 ± 2.6	1.83 ± 0.9*	49.9	0.0004	36 (77)
/ /	1.5 ± 1.9	3.1 ± 2.6	1.7 ± 1.5*	44.1	0.003	36 (77)
/ /	0.9 ± 0.5	2.4 ± 2.4	0.8 ± 0.6 <sup>†</sup>	64.1	0.0003	41 (87)
/ /	1.0 ± 0.5	3.0 ± 3.0	1.4 ± 1.7	54.1	0.006	37 (79)
	1.1 ± 0.2	3.0 ± 2.2	1.4 ± 0.7	54.4		37.2 (79)
Ratio	1 (1.0)	2.8 (2.9)	1.3 (1.3)			

Ratio : ( ) : Kay 1.04  
 Statistically significant between \* or † and the other vowels : p<0.05

**Table 9.** Pitch perturbation quotient (%)

	(%)	p-value	(%)			
/ /	0.5 ± 0.3	1.8 ± 1.7	0.6 ± 0.6*	67.2	0.0002	39 (83)
/ /	0.6 ± 0.4	2.1 ± 1.5	1.0 ± 0.9 <sup>†</sup>	53.6	0.0002	37 (78)
/ /	0.8 ± 0.9	1.6 ± 1.2	0.9 ± 0.9 <sup>†</sup>	40.7	0.0035	36 (77)
/ /	0.5 ± 0.4	1.2 ± 1.5	0.4 ± 0.4*	66.4	0.0011	43 (91)
/ /	0.6 ± 0.3	1.6 ± 1.7	0.6 ± 0.6*	61.8	0.002	38 (81)
	0.6 ± 0.1	1.7 ± 1.2	0.7 ± 0.4	57.6		38.6 (82)
Ratio	1 (0.7)	2.8 (2.0)	1.2 (0.8)			

Ratio : ( ) : Kay 0.84  
 Statistically significant between \* & † : p<0.05

im sAPQ가 38.4 (82%) (Table 14 and 16) ShdB가 36.8 (78%)(Table 13), APQ 35.6 (76%)(Table 15), vAm 33 (72%)(Table 17) . DVB 가 1.1 (Table 19 - 21). NHR 0.9 가 (Table 21), VTI 1 (Table 19), SPI 1.3 (Table 20) 82.4% / / / / / VTI가 29.1% 가 (Table 19), NHR

**Table 10.** Relative average perturbation (%)

	(%)	p-value	(%)			
/ /	0.9±0.4	1.8±1.4	0.6±0.5	66.2	0.0001	40 (85)
/ /	0.6±0.4	2.1±1.5	1.0±0.6*	52.1	0.0003	40 (85)
/ /	0.9±1.1	1.7±1.3	0.9±0.7*	47.5	0.0006	36 (77)
/ /	0.5±0.3	1.3±1.5	0.4±0.3†	69.3	0.0005	42 (89)
/ /	0.6±0.3	1.7±1.6	0.8±1.1	54.0	0.0055	41 (87)
	0.6±0.2	1.7±1.1	0.7±0.4	57.0		39.8 (85)
Ratio	1 (0.9)	2.7 (2.5)	1.2 (1.1)			

Ratio : ( ) : Kay 0.68  
 Statistically significant between \* or † and the other vowels : p<0.05

**Table 11.** Smoothed pitch perturbation quotient (%)

	(%)	p-value	(%)			
/ /	0.8±0.3	1.5±1.0	1.1±0.5*	23.4	0.281	37 (78)
/ /	0.8±0.5	1.7±0.1	1.3±0.8*	21.6	0.229	34 (72)
/ /	1.0±0.5	2.1±2.5	0.8±0.4†	64.1	0.129	40 (85)
/ /	1.2±2.6	1.4±1.9	0.6±0.3†	58.3	0.237	45 (96)
/ /	0.8±0.6	3.9±5.5	0.8±0.3†	80.2	0.054	40 (85)
	0.9±0.2	2.1±1.1	0.9±0.3	57.0		39.2 (83)
Ratio	1 (0.9)	2.4 (2.1)	1.0 (0.9)			

Ratio : ( ) : Kay 1.02  
 Statistically significant between \* & † : p<0.05

**Table 12.** Fundamental frequency variation (%)

	(%)	p-value	(%)			
/ /	1.6±0.9	4.2±3.0	2.5±2.5	40.2	0.005	37 (78)
/ /	1.7±0.8	4.3±3.8	2.8±2.8	36.6	0.026	35 (74)
/ /	2.3±1.7	3.9±3.0	3.2±3.2	16.9	0.299	30 (64)
/ /	2.2±2.8	3.9±3.1	2.50±2.5	36.4	0.036	37 (78)
/ /	2.2±1.7	6.3±9.1	2.4±2.4	61.6	0.012	36 (77)
	2.0±0.3	4.5±2.8	2.7±1.7	40.8		35 (74)
Ratio	1 (1.8)	2.3 (4.1)	1.3 (2.4)			

Ratio : ( ) : Kay 1.10

18.1%(Table 21), SPI 2.4% (Table 20) FTRI가 1.9 가 , Fatr 1.5 , Fftr 1.4 , ATRI 1.3 (Table 22 - 25).  
 가 (p>0.05) VTI / / , ATRI가 0.8 가 ,  
 / 가 (p>0.05) NHR / / , FTRI 1.3 , Fftr 1.4 , Fatr 1.5 .  
 / 가 (p<0.05). FTRI가 44.  
 가 NHR 47 35 (75%) 2%(Table 22), ATRI 40%(Table 25), Fftr - 5%  
 가 VTI 33 (71%), SPI 29 (62%) (Table 24), Fatr 1%(Table 23) .  
 (Table 19 - 21). 가  
 (p>0.05). 가

**Table 13.** Shimmer in dB (dB)

		(%)	p-value	(%)		
/ /	0.3±0.1	1.0±0.6	0.5±0.6	45.4	0.101	41 (87)
/ /	0.3±0.1	0.7±0.5	0.6±0.7	23.1	0.243	37 (78)
/ /	0.3±0.5	0.7±0.7	0.4±0.5	33.9	0.118	32 (68)
/ /	0.3±0.3	0.6±0.4	0.3±0.4	39.7	0.014	36 (77)
/ /	0.2±0.1	1.7±0.5	0.3±0.3	80.4	0.0009	38 (81)
	0.3±0.1	0.9±1.6	0.4±0.4	52.3		36.8 (78)
Ratio	1 (0.8)	3.3 (2.6)	1.57 (1.3)			

Ratio : , ( ) : Kay 0.35

**Table 14.** Shimmer Percent (%)

		(%)	p-value	(%)		
/ /	3.7±1.4	8.2±5.7	4.4±2.3	46.1	0.0004	42 (89)
/ /	3.3±1.2	8.2±4.9	4.6±3.2	43.6	0.0005	38 (81)
/ /	2.9±1.3	6.9±6.7	3.8±2.2	45.7	0.0105	33 (70)
/ /	2.2±1.4	6.1±4.5	3.1±2.5	48.6	0.0009	39 (83)
/ /	2.5±1.1	7.8±7.0	3.1±2.8	60.5	0.0001	40 (85)
	2.9±0.6	7.4±4.8	3.8±1.8	48.9		38.4 (82)
Ratio	1 (0.8)	2.56 (2.0)	1.31 (1.0)			

Ratio : , ( ) : Kay 3.81

**Table 15.** Amplitude perturbation quotient (%)

		(%)	p-value	(%)		
/ /	2.6±0.9	5.8±5.2	3.5±1.7	40.9	0.011	34 (72)
/ /	2.3±0.7	5.4±4.0	4.3±5.6*	20.6	0.341	36 (77)
/ /	2.2±0.7	5.1±6.8	3.0±2.9	40.6	0.108	35 (74)
/	1.9±1.1	4.5±4.4	2.6±2.3	41.6	0.024	37 (78)
/ /	1.7±0.9	4.6±3.6	2.1±2.0†	53.5	0.0004	36 (77)
	2.2±0.4	5.1±4.6	3.1±1.8	38.9		35.6 (76)
Ratio	1 (0.7)	2.4 (1.7)	1.4 (1.0)			

Ratio : , ( ) : Kay 3.07  
 Statistically significant between \* or † and the other vowels : p<0.05

**Table 16.** Smoothed amplitude perturbation quotient (%)

		(%)	p-value	(%)		
/ /	4.8 ± 2.2	5.8 ± 2.4	6.7 ± 5.8*	- 15.4	0.734	36 (77)
/ /	3.7 ± 1.5	6.0 ± 2.1	4.8 ± 2.4*	20.6	0.190	39 (83)
/ /	3.2 ± 1.4	5.8 ± 6.3	3.0 ± 1.5 <sup>†</sup>	40.6	0.193	37 (78)
/ /	3.4 ± 1.9	5.6 ± 5.9	3.1 ± 1.7 <sup>†</sup>	41.6	0.130	40 (85)
/ /	3.5 ± 1.7	6.0 ± 3.3	3.0 ± 1.5 <sup>†</sup>	53.5	0.006	40 (85)
	3.7 ± 0.6	5.8 ± 4.7	4.1 ± 2.6	38.9		38.4 (82)
Ratio	1 (0.9)	1.6 (1.4)	1.1 (1.0)			

Ratio : , ( ) : Kay 4.23  
 Statistically significant between \* & † : p<0.05

**Table 17.** Peak-amplitude variation (%)

		(%)	p-value	(%)		
/ /	10.9 ± 4.9	13.9 ± 6.4	10.8 ± 10.8	22.6	0.050	33 (70)
/ /	10.5 ± 5.1	12.7 ± 6.9	10.8 ± 10.8	14.6	0.282	37 (78)
/ /	9.4 ± 4.8	12.1 ± 7.7	10.2 ± 10.1	16.3	0.202	33 (70)
/ /	10.4 ± 6.7	12.1 ± 7.2	9.4 ± 9.4	21.7	0.055	29 (62)
/ /	10.5 ± 6.0	12.5 ± 7.5	7.8 ± 7.8	37.8	0.005	37 (78)
	10.3 ± 0.6	12.6 ± 5.6	9.8 ± 4.7	22.6		33.8 (72)
Ratio	1 (1.3)	1.2 (1.5)	1.0 (1.2)			

Ratio : , ( ) : Kay 8.20

**Table 18.** Degree of voice breaks (%)

		(%)	p-value	(%)		
/ /	0	9.0 ± 17.9	3.6 ± 7.9*	60.5	0.090	26 (55)
/ /	0	10.7 ± 21.0	0	100	0.003	23 (49)
/ /	0	1.6 ± 5.6	1.3 ± 4.2	18.2	0.825	13 (28)
/ /	0.4 ± 2.6	5.4 ± 11.9	1.2 ± 4.4	77.7	0.010	21 (45)
/ /	0	11.8 ± 22.7	0.7 ± 2.2	94.0	0.003	23 (49)
	0.1 ± 0.2	7.7 ± 10.2	1.4 ± 2.0	82.4		21.2 (45)
Ratio	1 (0.1)	85.5 (7.7)	15 (1.4)			

Ratio : , ( ) : Kay 1.00  
 Statistically significant between \* & the other vowels : p<0.05

FTRI ATRI가 37 (78%) . (p>0.05)(Table 27).  
 PFR  
 1.5 고 찰  
 32.4% 가 85.5 0.9 가  
 (Table 26).  
 . 1960 Leden 4)  
 가



(frequent and rapid change)  
 1970 1972 Iwata<sup>5)6)</sup>

가 (pitch perturbation)  
 1980 Horii<sup>7)</sup> 가 , 1963 Lieberman<sup>8)</sup>  
 가 0.5 msec  
 , 1972 Iwata,<sup>6)</sup> 1973 Koike  
 9)

**Table 19.** Voice turbulence index

				(%)	p-value	(%)
/ /	0.06 ± 0.05	0.09 ± 0.05*	0.06 ± 0.04*	33.1	0.004	36 (77)
/ /	0.08 ± 0.03	0.11 ± 0.07*	0.07 ± 0.03*	35.6	0.001	35 (74)
/ /	0.07 ± 0.04	0.09 ± 0.07*	0.07 ± 0.05*	19.7	0.237	31 (65)
/ /	0.04 ± 0.02	0.04 ± 0.02 <sup>†</sup>	0.03 ± 0.02 <sup>†</sup>	21.4	0.051	31 (65)
/ /	0.03 ± 0.02	0.04 ± 0.02 <sup>†</sup>	0.03 ± 0.01 <sup>†</sup>	30.8	0.004	34 (72)
	0.05 ± 0.02	0.07 ± 0.04	0.05 ± 0.02	29.1		33.4 (71)
Ratio	1 (0.9)	1.4 (1.2)	1 (0.9)			

Ratio : , ( ) : Kay 0.061  
 Statistically significant between \* & † : p<0.05

**Table 20.** Soft phonation index

				(%)	p-value	(%)
/ /	9.9 ± 5.8	14.0 ± 5.2*	12.6 ± 8.4	10.1	0.423	31 (65)
/ /	4.4 ± 2.2	10.0 ± 8.7*	9.4 ± 7.2	6.0	0.731	29 (62)
/ /	7.1 ± 4.0	16.4 ± 9.1*	4.6 ± 7.8	11.3	0.657	33 (70)
/ /	36.6 ± 24.2	40.1 ± 32.5 <sup>†</sup>	37.4 ± 18.3	6.8	0.626	29 (62)
/ /	47.3 ± 21.1	61.0 ± 28.7 <sup>‡</sup>	4.2 ± 25.5	- 5.3	0.721	23 (49)
	21.1 ± 19.6	28.3 ± 14.1	27.6 ± 10.4	2.4		29 (62)
Ratio	1 (1.5)	1.3 (2.0)	1.3 (2.0)			

Ratio : , ( ) : Kay 14.12  
 Statistically significant between \* & †, \* & ‡, † & ‡ : p<0.05

**Table 21.** Noise to harmonic ratio

				(%)	p-value	(%)
/ /	0.2 ± 0.5	0.2 ± 0.1	0.2 ± 0.1*	9.3	0.319	34 (72)
/ /	0.1 ± 0.0	0.2 ± 0.1	0.1 ± 0.1	21.8	0.002	37 (78)
/ /	0.1 ± 0.0	0.2 ± 0.1	0.1 ± 0.1	12.4	0.087	35 (74)
/ /	0.1 ± 0.1	0.2 ± 0.0	0.1 ± 0.1	10.5	0.225	33 (70)
/ /	0.1 ± 0.0	0.2 ± 0.1	0.1 ± 0.1	33.5	0.0004	38 (81)
	0.2 ± 0.1	0.2 ± 0.1	0.1 ± 0.1	18.1		35.4 (75)
Ratio	1 (0.8)	1.13 (0.9)	0.9 (0.7)			

Ratio : , ( ) : Kay 0.19  
 Statistically significant between \* & the other vowels : p<0.05

(pitch extraction error)  
 RAP PPQ<sup>10)</sup>  
 Jitter Jitter(%) Jita(msec)가 , Ji-  
 tter(%)  
 Jita, Jitt, RAP, PPQ, sPPQ, vF<sub>0</sub>  
 (Table 1). 가  
 Jitter Horii<sup>7)</sup>  
 pitch period Jitter 가

**Table 22.** Fo-Tremor intensity index (%)

	(%)	p-value	(%)			
/ /	0.4 ± 0.3	1.0 ± 0.6	0.6 ± 0.4	40.8	0.039	41 (87)
/ /	0.4 ± 0.2	0.6 ± 0.4	0.4 ± 0.3	21.8	0.415	34 (72)
/ /	0.4 ± 0.2	1.0 ± 1.7	0.6 ± 0.4	44.0	0.092	36 (77)
/ /	0.5 ± 0.4	0.4 ± 0.3	0.3 ± 0.1	41.5	0.233	44 (94)
/ /	0.4 ± 0.2	1.0 ± 1.3	0.4 ± 0.3	61.1		29 (62)
	0.4 ± 0.0	0.8 ± 0.8	0.4 ± 0.2	44.2		36.8 (78)
Ratio	1 (0.4)	1.9 (0.8)	1.1 (0.5)			

Ratio : ( ) : Kay 0.95

**Table 23.** Amplitude tremor frequency (Hz)

	(%)	p-value	(%)			
/ /	7.8 ± 4.5	8.7 ± 5.6	13.1 ± 5.8	- 51.2		42 (89)
/ /	5.9 ± 0.4	12.8 ± 4.7	11.5 ± 4.2	10.0	0.092	42 (89)
/ /	11.2 ± 2.9	7.4 ± 2.8	7.8 ± 4.7	- 6.5		41 (87)
/ /	5.9 ± 0.5	11.6 ± 5.1	9.5 ± 3.9	18.5	0.5	46 (98)
/ /	4.0 ± 0.9	11.1 ± 5.9	9.1 ± 3.4	18.3	0.202	39 (83)
	7.0 ± 2.7	10.3 ± 4.8	10.2 ± 4.4	1.1		42 (89)
Ratio	1	1.5	1.5			

Ratio :

**Table 24.** Fo tremor frequency (Hz)

	(%)	p-value	(%)			
/ /	6.6 ± 4.3	10.5 ± 5.7	12.2 ± 6.9	- 16.8	0.844	12 (74)
/ /	9.1 ± 4.9	11.5 ± 5.4	13.1 ± 6.4	- 14.0	0.179	9 (81)
/ /	8.6 ± 6.0	8.7 ± 5.5	10.8 ± 6.0	- 24.6	0.748	7 (85)
/ /	7.6 ± 5.0	1.0 ± 6.2	10.3 ± 5.1	- 2.92	0.679	6 (87)
/ /	7.0 ± 4.0	11.8 ± 7.5	8.7 ± 4.4	26.2	0.067	42 (89)
	7.8 ± 1.1	10.5 ± 6.1	11.0 ± 5.8	- 5.13		39.2 (83)
Ratio	1	1.4	1.4			

Ratio :

, F<sub>0</sub> , (type of phon- 가 (spasmodic dysphonia)  
 atory initiation), (termination)  
 F<sub>0</sub>  
 1% Jitter 가  
 Jitter 2  
 . sPPQ 가 , sPPQ  
 Jitt, RAP, PPQ 가 가 가 70 90%  
 가

**Table 25.** Amplitude tremor intensity index (%)

	(%)	p-value	(%)			
/ /	3.2±2.0	4.8±3.3	3.0±2.0	36.3		41 (87)
/ /	3.9±2.7	2.6±1.4	1.8±1.1	28.7	0.490	34 (72)
/ /	2.5±0.6	3.5±3.9	3.1±1.3	11.4	0.406	36 (77)
/ /	2.3±1.4	3.4±3.4	1.6±0.5	54.0	0.463	44 (94)
/ /	2.1±0.7	4.0±4.5	1.5±1.1	62.8		29 (62)
	2.8±0.8	3.6±3.3	2.2±1.2	39.6		36.8 (78)
Ratio	1 (0.6)	1.3 (0.8)	0.8 (0.5)			

Ratio : , ( ) : Kay 4.37

**Table 26.** Phonatory fundamental frequency range (semi-tones)

	(%)	p-value	(%)			
/ /	2.6±1.0	5±2.5	3.2±0.7	36.5	0.001	40 (85)
/ /	3.0±1.3	4.6±2.2	3.4±0.1	25.8	0.005	36 (77)
/ /	3.3±1.4	4.3±2.5	3.5±0.2	18.7	0.054	34 (72)
/ /	3.5±4.2	4.2±2.3	2.6±0.2	37.3	0.002	41 (87)
/ /	2.9±1.4	5.2±4.3	3.1±0.1	41.6	0.003	38 (81)
	3.0±0.4	4.6±1.9	3.1±1.1	32.4		37.8 (80)
Ratio	1	1.5	1			

Ratio :

**Table 27.** Comparison of formant between preoperative and postoperative state

	/ /	/ /	/ /	/ /	/ /
1	653.0±174.7	452.5±115.7	267.4± 49.6	435.7± 60.7	299.6± 36.6
(Hz)	674.5±124.6	447.3± 77.4	275.9± 35.5	436.3± 58.1	318.9± 45.5
2	1385.5±438.5	1748.3±215.6	2165.9±248.0	1031.7±359.6	885.4±230.9
(Hz)	1260.5±214.0	1832.4±179.0	2202.7±271.2	921.3±249.8	909.6±378.6
3	2736.4±267.0	2613.1±215.6	2957.4±225.0	2814.8±223.2	2643.8±247.6
(Hz)	2763.0±156.0	2645.0±196.2	2996.1±246.7	2839.1±177.2	2696.6±304.7

\* : There is no statistical difference between pre and postoperative formant value each phonation

1.03 1.5  
sPPQ

(ho-  
1977

arse and breathy voice) 가  
Koike <sup>1)</sup> 가

가 50 60%  
가 60%  
10%

가  
가 APQ

11

Jitt, RAP, PPQ Shim ShdB 가  
가 sAPQ vAm  
RAP PPQ가 sPPQ vF<sub>0</sub> 가 <sup>10)</sup>  
ShdB, Shim,

1973 APQ 2

Koike,<sup>9)</sup> 1977 Koike <sup>1)</sup> RAP PPQ가 Jitt  
(very short term) Shim, APQ, sAPQ가 40 50%

Jitt 가 , Shim  
Leden<sup>4)</sup> lw - 가 82% 가  
ata<sup>5)</sup> 가  
Iwata <sup>5)</sup>  
(correlogram) (breathy)

가 100%  
59% Shim ShdB  
50%

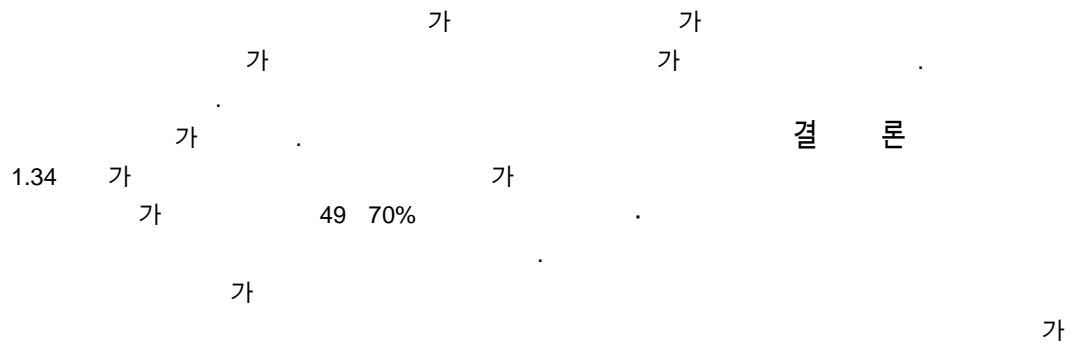
Koike <sup>1)</sup> Shim  
(amplitude modulation Shim, APQ, sAPQ가  
coefficient)

ShdB, Shim, APQ, sAPQ, vAm 40%  
(Table 2). ShdB Shim

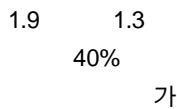
, 1970 Iwata,<sup>5)</sup> 1977 Koike <sup>1)</sup> DVB

(%)  
 (voice break) 1%  
 (Table 3).  
 Kay  
 가 85 가 1.1 가  
 15 82% 가 (18%).  
 가 45%  
 가  
 가 가 VTI  
 가 가  
 가 가  
 , 1967 Yanagihara<sup>11)</sup>  
 , 3,000 Hz 30% NHR VTI 70%  
 가  
 3가  
 가 . 1982  
 Yumoto<sup>12)</sup> 가 가 41%  
 ,  
 가 NHR 2 VTI 가  
 1986 Kasuya<sup>13)</sup> no - VTI가  
 rmalized noise energy(NNE)가  
 , , SPI  
 . 1987 Ma - 70 1,600 Hz  
 shima<sup>14)</sup> 1,600 4,500 Hz 가  
 가  
 ,  
 가  
 , SPI 가

(soft phonation)



(Table 5)



중심 단어 :

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가 2 가 ShdB, Jita, PPQ, Jitt, RAP, Shim, sPPQ, APQ,  $vF_0$

가

가

가 RAP, PPQ, Jitt, Jita, Shim, PFR, Jita

가

가

가

Yang<sup>15)</sup>

가

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