

Original article

Title: Outcomes of **laryngeal framework surgeries for unilateral vocal cord paralysis in the elderly patients**

Yo Kishimoto*, Yoshitaka Kawai, Shintaro Fujimura, Koichi Omori

Department of Otolaryngology–Head and Neck Surgery, Graduate School of Medicine,
Kyoto University, Kyoto, Japan

***Corresponding author:**

Yo Kishimoto MD PhD

Department of Otolaryngology–Head & Neck Surgery

Graduate School of Medicine, Kyoto University, Kyoto, Japan

54 Shogoin Kawahara-cho, Sakyo-ku, Kyoto 606-8507, Japan

Tel: +81-75-751-3346

Fax: +81-75-751-7225

Email: y_kishimoto@ent.kuhp.kyoto-u.ac.jp

ORCID

Yo Kishimoto (0000-0002-3583-0165)

Yoshitaka Kawai (0000-0001-5263-2702)

Shintaro Fujimura (0000-0002-6564-5876)

Koichi Omori (0000-0003-3404-5461)

Outcomes of laryngeal framework surgeries for unilateral vocal cord paralysis in the elderly patients

(Laryngeal framework surgeries for elderlies)

Abstract

Objective: Laryngeal framework surgery is a widely accepted treatment for unilateral vocal fold paralysis with good functional outcomes. Recently, with the aging of the population, opportunities to perform this procedure in elderly patients have increased; however, the safety and efficacy of this procedure in elderly patients has not been established. Therefore, this study aimed to investigate the safety and functional outcomes of laryngeal framework surgery in elderly patients.

Methods: Between January 2008 and December 2017, 97 patients with unilateral vocal fold paralysis underwent laryngeal framework surgery, and 71 among them completed pre- and post-operative voice function evaluations. The clinical course of these 71 patients were retrospectively reviewed.

Results: Out of 71 patients, 35 were assigned to the younger group (< 65 years) and 36 to the elderly group ($\geq$ 65 years). Complications included post-operative edema and submucosal hematoma that were safely managed in all cases, and no differences were identified between the groups. Significant improvements were observed in maximum phonation time (MPT), mean flow rate, alternating current/direct current ratio, pitch perturbation quotient, amplitude perturbation quotient, and noise-to-harmonic ratio in both groups, and multivariate analysis of variance revealed greater improvement in the younger group in MPT.

Conclusion: Laryngeal framework surgeries for unilateral vocal fold paralysis are safe and effective, regardless of age. Better improvement was observed in the younger group in the MPT suggesting that the effects of laryngeal framework surgeries is more likely to be present in the younger group than in the elderly.

Keywords: laryngeal framework surgery, unilateral vocal fold paralysis, outcome, elderly

Introduction

Unilateral vocal fold paralysis (UVFP) occurs after damage to the recurrent laryngeal nerve and is caused by nerve injury during neck/chest surgery, trauma, or cancer involvement of the nerve. Usually, UVFP results in a breathy and weak voice, which can have a serious impact on patients' social activities and quality of life.

The fixed vocal fold causes wide glottal gap, and laryngeal framework surgeries such as medialization thyroplasty (type 1 thyroplasty: TP1) and arytenoid adduction (AA) can be therapeutic options for augmenting the paralyzed vocal fold. They were developed by Isshiki in the 1970s [1,2] and are accepted worldwide as surgical options for UVFP. Various artificial materials for implants and surgical technique modifications have been introduced, and functional improvements with these procedures are well documented [3–5].

Laryngeal framework surgeries being performed under local anesthesia are considered less invasive. Therefore, these procedures are often indicated in elderly patients with UVFP. In the elderly, there are concerns that atrophic changes in the vocal fold, muscle weakness, and decreased respiratory function may affect the outcomes of laryngeal framework surgeries; however, the effect of age on the functional outcomes of laryngeal framework surgery has not been well documented.

In addition, tissue fragility, various comorbidities, and poor nutrition in the elderly may affect the safety of surgery; however, this has not been well studied.

Therefore, we performed a retrospective chart review of patients who underwent laryngeal framework surgery for UVFP at our hospital. The patients were divided into an elderly group and a younger group and compared, to examine the effect of age on surgical outcomes and the safety of the procedures.

Materials and methods

Patients

Ninety-seven patients underwent TP1 as the initial treatment for UVFP over a 10-year period from January 2008 to December 2017. Of the 97 patients, 71 completed the pre- and post-operative voice function evaluations.

Patient characteristics and clinical information were retrospectively reviewed. The reviewed data included demographics, etiology of paralysis, treatment details, and results of functional evaluations. In this study, 65 years was used to divide the patients into two groups, because in many countries, the elderly were defined as those having a chronological age of 65 years or older [6].

This retrospective chart review study involving human participants was conducted in accordance with the Ethical Standards of the Institutional and National Research Committee and the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The study was approved by the Institutional Review Board, and the requirement for written informed consent was waived owing to the retrospective nature of the study.

Treatment strategy

For patients with UVFP, TP1 was selected and further AA was performed in cases with level differences and/or wide posterior glottal gap. Furthermore, in patients with better vocal function with cricoid-thyroid approximation, additional type 4 thyroplasty (TP4) was considered.

Assessment of Vocal Outcomes

Phonatory outcomes before and after laryngeal framework surgeries were evaluated using objective aerodynamic (PA-1000; Minato Co., Osaka, Japan) and acoustic assessments (Multidimensional Voice Program, Model 5105, KayPENTAX, Lincoln Park, NJ). Aerodynamic examinations included maximum phonation time (MPT), mean flow rate (MFR), and alternating current/direct current (AC/DC) ratio. For acoustic examinations, a microphone (SM48, Shure, Niles, IL) was used for recording. After recording sustained vowel sounds, a stable 2–3 second section of the waveform was selected for analysis. A computerized speech lab software (ver.3.3.0, Kay PENTAX, Lincoln Park, NJ, USA) was used to evaluate the pitch perturbation quotient (PPQ), amplitude perturbation quotient (APQ), and noise-to-harmonic ratio (NHR).

Assessment of Complications

To confirm the safety of the surgery, information about post-operative complications was obtained from the medical records.

Statistical analysis

JMP (SAS Institute Inc., NC, USA) was used for the statistical analysis. Chi-squared, or Wilcoxon's signed-rank tests were used for paired comparison between the groups. For comparison of the groups and the pre- and post-operative vocal outcomes, multivariate analysis of variance was used. P value < 0.05 was considered statistically significant.

Results

Patient and lesion characteristics

The patients were divided into two groups: an elderly group (≥ 65 years) and a younger group (< 65 years). The clinical information of the groups is summarized in Table 1. Of the 71 patients, 35 were assigned to the younger age group and 36 patients were assigned to the elderly group. The median age of the groups were 52 years (range, 18–64 years) and 71.5 years (range, 65–88 years), respectively, and the gender ratio did not differ between the groups.

Lung and mediastinal tumors are the most common primary diseases, followed by esophageal and thyroid cancers.

There were no differences in the primary disease between the groups.

Surgery

The treatment details are summarized in Table 2. The surgical techniques included TP1, TP4, AA, and their combinations. Forty-five patients underwent only TP1, whereas the remaining 26 patients underwent additional TP4 and/or AA. There were no differences in the surgical procedures between the groups.

Vocal outcomes

Pre- and post-operative aerodynamic and acoustic examinations were performed in 70 and 64 patients, respectively.

As post-operative examinations were not performed at the same time point in all patients, data obtained between

1 and 6 months after surgery were used for the comparison.

The mean MPT improved from 5.22 s to 12.13 s in the younger group and from 4.78 s to 8.65 s in the elderly group, respectively. The mean MFR improved from 486.54 mL/s to 269.86 mL/s in the younger group, and from 518.38 mL/s to 299.32 mL/s in the elderly group. Further, improvement in mean AC/DC ratio from 15.16% to 35.89% was observed in the younger group, and from 14.66% to 33.34% in the elderly group. Significant improvements were observed in the MPT, MFR, and AC/DC ratio (Figure 1) in both groups, and multivariate analysis of variance revealed greater improvements in the younger group in MPT (Table 3).

As for acoustic analyses, the mean APQ improved from 10.71% to 3.81% in the younger group and from 8.75% to 5.32% in the elderly group. The mean PPQ improved from 4.61% to 1.41% in the younger group, and from 4.59% to 2.38% in the elderly group. Improvement in NHR was observed from 0.31 to 0.15 in the younger group, and from 0.28 to 0.19 in the elderly group. Significant improvements were observed in PPQ, APQ, and NHR (Figure 2) in both groups (Table 3).

Complications

Laryngeal edema and submucosal hematoma were the post-operative complications observed in 15 and 5 patients in the younger group, and 15 and 4 patients in the elderly group, respectively, and no statistical differences were identified between the groups (Table 4). All complications were safely managed with conservative treatment, and none of the patients required tracheostomy.

Discussions

In this study, we retrospectively reviewed the cases of UVFP treated with laryngeal framework surgery. The patients were divided into two groups according to age, and our results revealed significant post operative improvements in vocal function without any severe complications in either group. However, multivariate analysis of variance revealed better improvement in the MPT in the younger group than in the elderly group, suggesting that the effect of laryngeal framework surgery is more likely to be present in the younger group than in the elderly.

Laryngeal framework surgeries such as TP1 and AA are widely accepted treatment for UVFP, and good functional outcomes of these procedures have been well documented [7–9]. According to a national survey in the United States, unchanged and worsened voices after medialization laryngoplasty were observed in only 3% and 1% of patients, respectively [7]; efficacy of these procedures for UVFP is reliable and satisfactory.

The presbylarynx has recently attracted considerable attention because many countries, including Japan, are becoming super-aging societies. Presbylarynx is defined as age-related morphological changes in the larynx, and these changes are observed in 12–72% of elderly people [10,11]. Typical age-related changes include atrophic vocal folds, vocal fold bowing, prominence of vocal processes, supraglottal hyperactivity (laryngeal vestibule constriction), decreased amplitude (vocal fold edge stiffness without evidence of vocal post-traumatic scar), and tremor of laryngeal structures [10,11]. In addition to these changes in the larynx, alterations in respiratory function, descending larynx, and hormonal changes can affect the voice [12], and changes in vocal function based on these age-related changes are called presbyphonia.

Laryngeal framework surgeries usually performed under local anesthesia are considered relatively less invasive.

Thus, they are sometimes indicated for patients with a low performance status, such as those at the terminal stage of malignant tumors and elderly patients. In elderly patients, the aforementioned clinical characteristics may affect the outcomes of laryngeal framework surgeries. However, these outcomes have not been examined from this perspective.

In this study, patients were divided into younger and elderly groups. Significant improvements in aerodynamic and acoustic analyses were observed post-operatively in both groups, and functional improvement was confirmed regardless of age. Among the various vocal parameters, the MPT improved more in the younger group than in the elderly group. Given that vital capacity positively correlated with speaking fundamental frequency and MPT in healthy elderly people [13] and no significant differences in MFR decrease between the groups, it was speculated that age-related decline in vital capacity may be the factor for fewer improvements in MPT in the elderly group.

Complications of laryngeal framework surgeries include wound infection, hematoma, seroma, scarring, edema, and pneumonia. According to a national survey, the overall complication rate was 15.4%, and 99.6% of the complications required further intervention [7]. In our cohort, laryngeal edema and submucosal hematoma were identified in 42.3% and 12.7% of patients, respectively, which were relatively high compared with previous reports.

Although it is difficult to check the severity of the complications because of the lack of detailed descriptions in the chart, none of the cases required surgical intervention such as tracheotomy, and all were considered mild.

Although there were concerns regarding increased post-operative edema and/or hematoma due to increased vascular permeability and fragility with aging [14], no significant differences were identified in the complication rates between the groups. Owing to the small extent of dissection in laryngeal framework surgeries, severe post-

operative complications can be avoided with careful and cautious procedures, and they are considered relatively safe even in the elderly.

One of the limitations of this study was its retrospective design. The sample size was small and vocal outcomes were not evaluated at the same time point in all cases. Further, the degree of complications could not be evaluated, since many of the cases had only medical records without any photographs. Furthermore, because respiratory function was not investigated, a detailed analysis of the factors affecting vocal function was not performed. However, we observed that laryngeal framework surgery for UVFP is safe and can contribute to improvements in vocal function, regardless of age. Further prospective studies with larger sample sizes are warranted to clarify the indications and limitations of laryngeal framework surgery for UVFP.

Conclusions

We performed a retrospective chart review of patients who underwent revision TP1, with or without AA/TP4, for UVFP. Laryngeal framework surgeries were safely performed and contributed to improvements in vocal function regardless of age. Better improvement was identified in the younger group in the MPT than in the elderly, suggesting that the effect of laryngeal framework surgery is more likely to be present in the younger group than in the elderly.

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Disclosure statements

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Competing interests

The authors have no competing interests to declare that are relevant to the content of this article.

Ethics approval

This retrospective chart review study involving human participants was conducted in accordance with the ethical standards of the institutional and national research committee and the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The Human Investigation Committee (IRB) of Kyoto University approved this study (R2387).

Consent

The requirement for written informed consent was waived given the retrospective nature of the study.

Data availability

The data that support the findings of this study are available from the corresponding author, upon reasonable request.

Authors' contributions

YKi: designed the study, main conceptual ideas, and proof outline. YKa and SF: collected the data. YKi: wrote the manuscript with support from KO. All the authors discussed the results, commented on the manuscript, and contributed to the writing of the final manuscript.

References

- [1] Isshiki N, Morita H, Okamura H, Hiramoto M. Thyroplasty as a new phonosurgical technique. *Acta Otolaryngol* 1974;78:451–7. <https://doi.org/10.3109/00016487409126379>.
- [2] Isshiki N, Okamura H, Ishikawa T. Thyroplasty type I (lateral compression) for dysphonia due to vocal cord paralysis or atrophy. *Acta Otolaryngol* 1975;80:465–73. <https://doi.org/10.3109/00016487509121353>.
- [3] Ford CN. Advances and Refinements in Phonosurgery. *Laryngoscope* 1999;109:1891–900. <https://doi.org/10.1097/00005537-199912000-00001>.
- [4] Matsushima K, Kanazawa H, Isshiki N, Tanabe M, Edamatsu H. The Use of a Titanium Plate for Medialization of the Vocal Fold. *Koutou LARYNX Jpn* 2011;23:26–9.
- [5] Hsieh L-C, Chen C-K, Chang C-W, Leu Y-S, Ho G-M. Preliminary Clinical Outcomes of VOIS-Implant in Patients With Unilateral Vocal Fold Paralysis. *The Laryngoscope* 2022;132:1622–9. <https://doi.org/10.1002/lary.29958>.
- [6] Ouchi Y, Rakugi H, Arai H, Akishita M, Ito H, Toba K, et al. Redefining the elderly as aged 75 years and older: Proposal from the Joint Committee of Japan Gerontological Society and the Japan Geriatrics Society. *Geriatr Gerontol Int* 2017;17:1045–7. <https://doi.org/10.1111/ggi.13118>.
- [7] Young VN, Zullo TG, Rosen CA. Analysis of laryngeal framework surgery: 10-year follow-up to a national survey. *Laryngoscope* 2010;120:1602–8. <https://doi.org/10.1002/lary.21004>.
- [8] Ryu IS, Nam SY, Han MW, Choi S-H, Kim SY, Roh J-L. Long-term voice outcomes after thyroplasty for unilateral vocal fold paralysis. *Arch Otolaryngol Head Neck Surg* 2012;138:347–51. <https://doi.org/10.1001/archoto.2012.42>.
- [9] Mes SD, Hendriksma M, Heijnen BJ, Goudsmit BFJ, Jansen JC, Langeveld APM, et al. Long-term voice outcomes of laryngeal framework surgery for unilateral vocal fold paralysis. *Eur Arch Otorhinolaryngol* 2022;279:1957–65. <https://doi.org/10.1007/s00405-021-07177-7>.
- [10] Santos M, Freitas SV, Sousa CA e., da Silva ÁM. Presbylarynx: stratifying endoscopic signs for future researches. *Eur Arch Otorhinolaryngol* 2021;278:2157–8. <https://doi.org/10.1007/s00405-021-06735-3>.
- [11] Santos M, Freitas SV, Sousa CA e., da Silva ÁM. Stratifying Presbylarynx: Characterization of its Three Types. *J Voice* 2022. <https://doi.org/10.1016/j.jvoice.2022.09.019>.
- [12] Bruzzi C, Salsi D, Minghetti D, Negri M, Casolino D, Sessa M. Presbyphonia. *Acta Bio Medica Atenei Parm* 2017;88:6–10. <https://doi.org/10.23750/abm.v88i1.5266>.
- [13] Awan SN. The aging female voice: Acoustic and respiratory data. *Clin Linguist Phon* 2006;20:171–80. <https://doi.org/10.1080/02699200400026918>.
- [14] Oakley R, Tharakan B. Vascular Hyperpermeability and Aging. *Aging Dis* 2014;5:114–25. <https://doi.org/10.14336/AD.2014.0500114>.

Tables

Table 1 Patient characteristics

Table 2 Treatment protocols

Table 3 Multivariate analysis of variance

Table 4 Post-operative complications

Figure legends

Fig. 1 Results of pre- and post-operative aerodynamic examinations

Significant improvements are observed in the MPT, MFR, and AC/DC ratios, and greater improvement is identified in the younger group in MPT (*, $P < 0.05$).

MPT, maximum phonation time; MFR, mean flow rate; AC/DC, alternating current/direct current

Fig. 2 Results of pre- and post-operative acoustic examinations

Significant improvements are observed in PPQ, APQ, and NHR. No significant differences are observed between the groups (*, $P < 0.05$).

APQ, amplitude perturbation quotient; PPQ, pitch perturbation quotient; NHR, noise-to-harmonic ratio

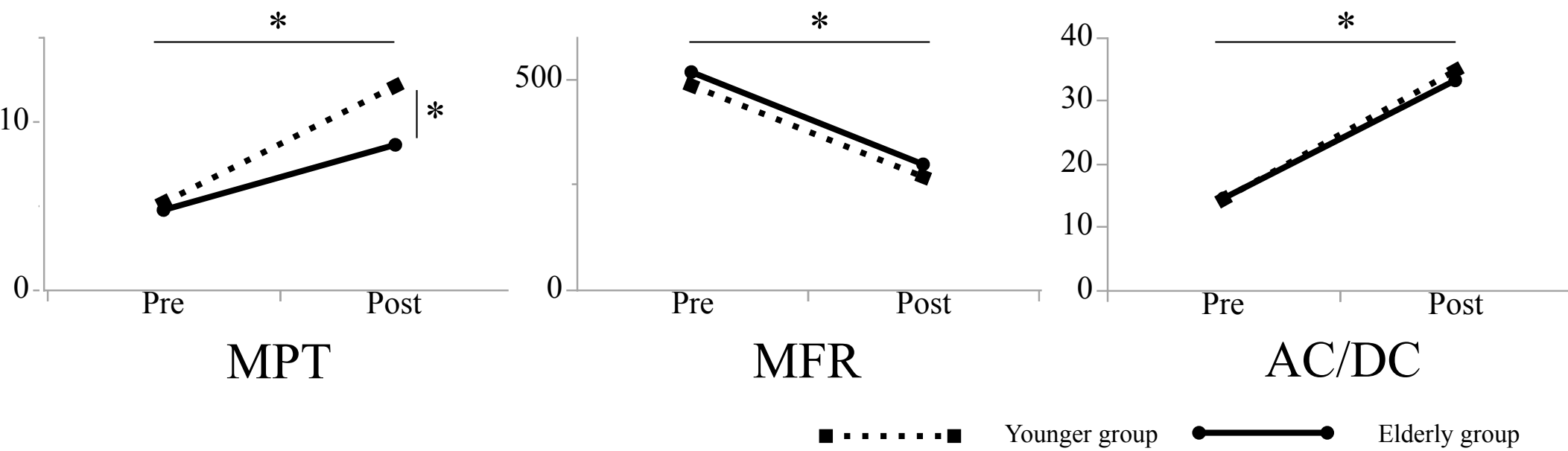


Figure 2

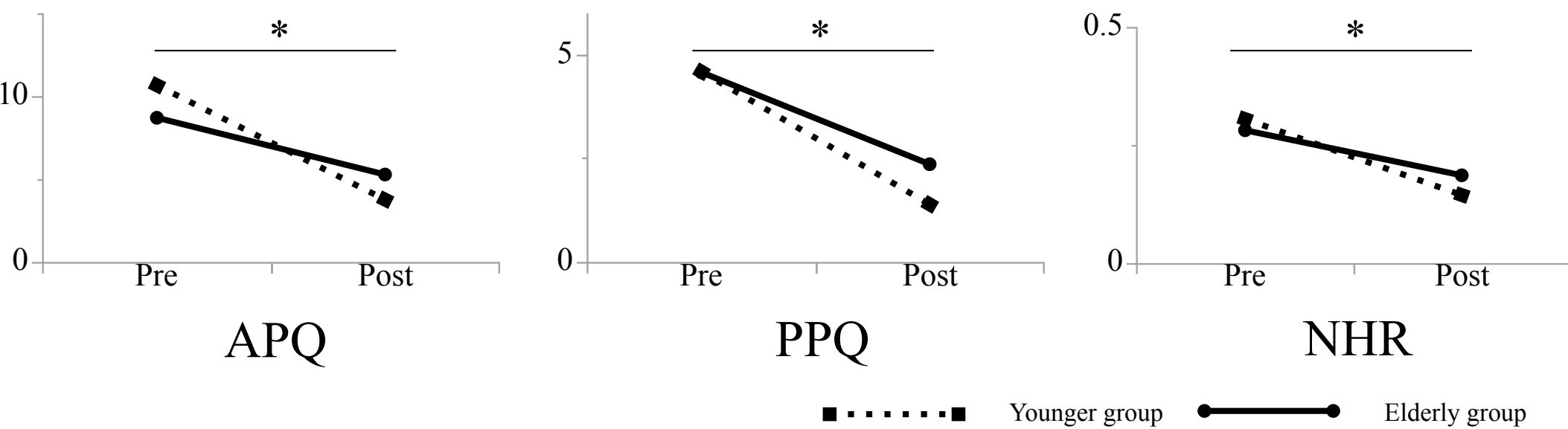


Table 1 Patient characteristics

Groups	Younger (<65)	Older ($\geq$ 65)	P-value
Number of patients	35	36	
Median age	52	71.5	<.0001
	18-64	65-88	
Male/Female	23/12	20/16	NS
Primary disease			NS
Lung cancer / mediastenal tumor	13	13	
Esophageal cancer	6	6	
Breast cancer	3	2	
Thyroid cancer	3	6	
Cardiovascular disease	3	5	
Others	4	0	
Idiopathic	3	4	

NS, not significant

Table 2 Treatment protocols

Procedures	Younger (<65)	Older (≥ 65)	Significance
TP1	19	26	
TP1+TP4	3	2	
TP1+AA	8	3	
TP1+TP4+AA	5	5	
Total	35	36	NS

TP1: type 1 thyroplasty; TP4: type 4 thyroplasty; AA: arytenoid adduction; NS: Not significant

Table 3 Multivariate analysis of variance

Variables	Time	Younger (<65)		Older (≥ 65)			F	DFn	DFd	p
		Median	IQR	Median	IQR					
MPT	Pre	4.00	3.00	4.00	3.00	Group	4.7014	1	68	0.0336
	Post	11.00	10.50	8.12	4.00	Time	60.6517	1	68	<.0001
						Group*Time	4.8187	1	68	0.0316
MFR	Pre	441.00	331.00	453.00	352.00	Group	0.3839	1	67	0.5376
	Post	187.00	238.00	243.50	175.25	Time	47.009	1	67	<.0001
						Group*Time	0.0014	1	67	0.9703
AC/DC	Pre	13.00	15.50	9.50	11.63	Group	0.4356	1	67	0.5115
	Post	38.00	24.00	35.50	23.75	Time	73.7495	1	67	<.0001
						Group*Time	0.2000	1	67	0.6562
APQ	Pre	9.380	11.216	7.676	5.864	Group	0.0464	1	62	0.8302
	Post	2.814	2.649	4.436	4.191	Time	37.4961	1	62	<.0001
						Group*Time	4.2503	1	62	0.0434
PPQ	Pre	3.549	4.384	2.833	2.583	Group	0.5654	1	62	0.4549
	Post	0.794	0.859	1.633	1.899	Time	26.2749	1	62	<.0001
						Group*Time	0.8675	1	62	0.3553
NHR	Pre	0.190	0.219	0.242	0.186	Group	0.0612	1	62	0.8054
	Post	0.128	0.053	0.158	0.099	Time	15.5235	1	62	0.0002
						Group*Time	1.0132	1	62	0.3181

MPT: maximum phonation time

MFR: mean flow rate

AC/DC: alternating current/direct current ratio

APQ: amplitude perturbation quotient

PPQ: pitch perturbation quotient

NHR: noise-to-harmonic ratio

IQR: interquartile range

DFn: numerator degrees of freedom

DFd: denominator degrees of freedom

Table 4 Post-operative complications

Complications	Younger (<65)	Older (≧ 65)	
Laryngeal edema	15	15	NS
Submucosal hematoma	5	4	NS

NS, not significant