

# Voice outcomes following thyroid surgery: A study on non-nerve-related changes

*Tiroit cerrahisi sonrası ses değişiklikleri: Sinir dışı faktörler üzerine bir inceleme*

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## ABSTRACT

**Objectives:** This study aimed to examine voice changes in patients without nerve damage after thyroid surgery and to analyze the effects of the scope of surgery, age, sex, and histopathological results on voice quality.

**Patients and Methods:** A prospective study was conducted on patients who underwent thyroid surgery between April 2018 and April 2020. Harmonics-to-noise ratio (HNR), fundamental frequency (F0), jitter, shimmer, maximum phonation time, and voice-related quality of life (VRQOL) scores were evaluated at the preoperative stage and at the first-month postoperative stage. Patients were classified by surgery type, age, sex, and histopathological results, and changes in voice characteristics were examined.

**Results:** The study included 77 patients (52 females, 25 males; mean age: 45.2±9.6 years; range, 18 to 62 years). Postoperative voice changes were observed in all thyroidectomy types, except for hemithyroidectomy. Patients who underwent surgery for malignant conditions experienced significant alterations in all voice parameters and VRQOL scores. In contrast, no significant changes were found in benign pathologies. Postoperatively, jitter and VRQOL scores significantly changed in females, while HNR changed in males. In patients over 50 years, F0, jitter, and HNR were affected, while jitter and shimmer were the altered parameters postoperatively in those under 50 years.

**Conclusion:** After thyroidectomy, voice is influenced by the extent of surgery, patient demographics, and thyroid pathology. More extensive surgeries and malignant conditions lead to significant postoperative vocal changes. The influence of age and sex on voice varies and warrants further investigation.

**Keywords:** Neck dissection, thyroidectomy, voice quality.

## ÖZ

**Amaç:** Bu çalışmada, tiroit cerrahisi sonrası sinir hasarı olmayan hastalarda ses değişiklikleri incelendi ve ameliyatın kapsamı, yaş, cinsiyet ve histopatolojik sonuçların ses kalitesine etkisi analiz edildi.

**Hastalar ve Yöntemler:** Bu prospektif çalışma, Nisan 2018 - Nisan 2020 tarihleri arasında tiroit patolojisi nedeniyle ameliyat edilen hastalar ile yürütüldü. Ameliyat öncesinde ve ameliyat sonrası 1. ayda; harmonik-gürültü oranı (HNR), temel frekans (F0), jitter, shimmer, maksimum fonasyon zamanı ve sesle ilgili yaşam kalitesi ölçeği (SİYKÖ) skorları değerlendirildi. Hastalar cerrahi türü, yaş, cinsiyet ve histopatolojik sonuçlara göre sınıflandırıldı ve ses özelliklerinde meydana gelen değişiklikler incelendi.

**Bulgular:** Çalışmaya 77 hasta (52 kadın, 25 erkek; ort. yaş: 45.2±9.6 yıl; dağılım, 18-62 yıl) dahil edildi. Hemitroidotomi dışındaki tüm tiroidektomi tiplerinde ameliyat sonrası ses değişiklikleri gözlemlendi. Malignite nedeniyle ameliyat edilen hastalarda tüm ses parametrelerinde ve SİYKÖ skorlarında ameliyat sonrası anlamlı değişiklikler görüldü. Buna karşılık, benign patolojilerde anlamlı bir değişiklik bulunmadı. Ameliyat sonrası, kadınlarda jitter ve SİYKÖ anlamlı değişim gösterirken, erkeklerde HNR'de değişim görüldü. Elli yaş üzeri hastalarda F0, jitter ve HNR etkilenirken, 50 yaş altı hastalarda ameliyat sonrası jitter ve shimmer değişen parametreler idi.

**Sonuç:** Tiroidektomi sonrası ses değişiklikleri ameliyatın kapsamı, hasta demografik özellikleri ve histopatolojik tanıdan etkilenmektedir. Daha kapsamlı ameliyatlar ve malignite ameliyat sonrası önemli ses değişikliklerine yol açmaktadır. Yaş ve cinsiyetin vokal sonuçlar üzerindeki etkisi değişiklik göstermektedir ve daha fazla araştırmayı gerektirmektedir.

**Anahtar sözcükler:** Boyun diseksiyonu, tiroidektomi, ses kalitesi.

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Voice alteration is one of the main complaints after thyroid surgery. Injury to the recurrent laryngeal nerve (RLN) is the main cause of vocal changes. Damage of the external branch of the superior laryngeal nerve (EBSLN) is another factor that significantly affects the voice.<sup>[1]</sup> With advancements in surgical techniques, the incidence of nerve injuries has decreased; however, vocal changes still exhibit a high prevalence among patients after the surgery.<sup>[2]</sup> Various factors have been cited as explanations for vocal changes, including pain, swelling of the larynx, division of strap muscles, laryngotracheal tethering, trauma to the cricothyroid or cricoarytenoid joint, lesions in the neural plexus, mucosal changes due to laryngeal vascularization injuries or lymphatic drainage changes, psychological postoperative changes, edema around the laryngeal nerves, or endotracheal intubation.<sup>[3]</sup> Vocal outcomes of these changes can range from a seemingly normal voice to more severe and lasting dysphonia, notably impacting the patient's quality of life.

In the literature, there has been an increasing emphasis on vocal functions after thyroidectomy. Numerous studies have pursued to identify various factors that may be linked to post thyroidectomy changes in voice characteristics.<sup>[4-6]</sup> Understanding the risks for postoperative vocal changes is essential for healthcare professionals to tailor interventions that can facilitate a smoother recovery and restore optimal vocal function for the patient. For this purpose, we evaluated vocal changes in a group of patients without obvious nerve damage after thyroid surgery. The study aimed to analyze the effect of surgery type, age, sex, and histopathological results over voice quality.

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## PATIENTS AND METHODS

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The prospective study was conducted at the Ankara University İbni Sina Hospital, Department of Otorhinolaryngology between April 2018 and April 2020. All patients who underwent total thyroidectomy, hemithyroidectomy, total thyroidectomy with central neck dissection, and total thyroidectomy with lateral neck dissection were evaluated. Patients with a history of neck surgery, laryngeal disease, or radiotherapy were excluded from the study. The study protocol was approved by the Ankara University Ethics Committee (date: 13.03.2017, no: 05-232-17). Written informed consent was obtained from all participants. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Videolaryngostroboscopic examinations were performed on all patients before the surgery, and video recordings were taken. Acoustic and aerodynamic voice

analysis was performed using the Dr. Speech version 4.0 software (Dr. Speech Tigers DRS Inc., Seattle, USA) in an acoustically treated setting. Patients were instructed to say /a/ at a comfortable volume and fundamental frequency (F0; Hz), jitter (%), shimmer (%), harmonic noise ratio (HNR; dB), and maximum phonation time (MPT) were measured. The voice-related quality of life questionnaire (VRQOL) was used for subjective voice evaluation.

All surgeries were performed by an experienced head and neck surgeon at a single institution using the conventional transcervical technique. Intraoperative nerve monitoring was performed using NIM response version 3.0 (Medtronic Xomed, Jacksonville, FL, USA). Short acting non-depolarizing neuromuscular blocker (intravenous rocuronium bromide at 0.6 mg/kg) was administered during intubation, and no neuromuscular blockade was not administered during the procedure. After the cervical skin incision, strap muscles were retracted laterally and preserved. The vagus and the RLN were identified by direct visualization and stimulated at 1 mA, and the electromyography (EMG) amplitude was recorded in microvolts. If the surgery was bilateral, the same protocol was applied to the other side. During the dissection of the upper pole, the EBSLN was observed and stimulated over its trace over the cricopharyngeal muscle, and the EMG amplitude was noted if the human communicating nerve (the anastomoses between EBSLN and anterior branch of the RLN) was functional in that individual. Elective/therapeutic central lymph node dissection and therapeutic lateral lymph node dissection was performed if required. After dissection, the vagus and RLN were stimulated at 1 mA, and EMG amplitudes were recorded.

One month after the surgery, all patients underwent laryngoscopy to check vocal fold functions. If there was paralysis or paresis, they were excluded. Acoustic vocal measurements were repeated, and postoperative VRQOL scores were evaluated.

### Statistical analysis

Data were analyzed using IBM SPSS version 29.0 software (IBM Corp., Armonk, NY, USA). The distribution of data was tested using visual (histogram and probability graphs) and analytical methods (Kolmogorov-Smirnov/Shapiro-Wilk tests). Descriptive analyses were presented using mean  $\pm$  standard deviation (SD) for normally distributed numerical variables and median (min-max) for nonnormally distributed numerical variables. In comparing the acoustic voice analysis data and VRQOL scores before and after surgery, the paired samples t-test was used for normally

distributed data, and the Wilcoxon test was utilized for nonnormally distributed data. All tests were two-tailed, with the level of significance set at  $p < 0.05$ .

## RESULTS

A total of 77 patients (52 females, 25 males; mean age:  $45.2 \pm 9.6$  years; range, 18 to 62 years) were included in the study. Of these, 27 patients underwent total thyroidectomy, 27 underwent total thyroidectomy with central neck dissection, 14 underwent hemithyroidectomy, and nine patients underwent total thyroidectomy involving central and lateral neck dissection on one side or both. On final pathology, 60 patients were diagnosed with malignant diseases, including papillary thyroid carcinoma, medullary carcinoma, follicular carcinoma, and undifferentiated carcinoma.

For the total thyroidectomy group jitter, shimmer and HNR parameters were significantly changed postoperatively, but no differences were noted in the mean F0, MPT, and VRQOL measurements. Table 1 presents the statistical results.

Table 2 summarizes the results of the hemithyroidectomy group. No significant changes were observed in any of the analyzed parameters.

Among the patients who underwent total thyroidectomy with central neck dissection, all the acoustic analysis parameters changed significantly, and VRQOL scores and MPT decreased after surgery (Table 3). In the lateral neck dissection group, significant changes were noted in all analyzed parameters postoperatively (Table 4).

Table 5 shows the analysis of preoperative and postoperative changes according to sex, age, and histopathology. The parameters that showed a significant difference for female patients were jitter and VRQOL scores, whereas for males, only HNR showed a significant change after the operation. According to the age, in patients  $>50$  years old, F0, jitter, and HNR were significantly affected. In patients  $<50$  years old, the altered parameters were jitter and shimmer. Notably, the parameters were not significantly changed in patients with benign pathology after thyroid surgery. In contrast, for patients with malignant histopathology, all analyzed parameters were significantly changed. The acoustic

**Table 1**  
Preoperative and postoperative acoustic features of patients undergoing total thyroidectomy

	Preoperative			First postoperative month			<i>p</i>
	Mean±SD	Median	Min-Max	Mean±SD	Median	Min-Max	
F0 (Hz)	209.59±42.76			209.03±43.66			0.81
Jitter (%)		0.56	0.13-1.38		0.62	0.12-1.7	<b>0.01</b>
Shimmer (%)	2.53±0.99			2.73±1.21			<b>0.04</b>
HNR (dB)	21.84±4.06			20.82±5.11			<b>0.04</b>
MPT (sec)		11	7-19		11	5-18	0.22
VRQOL (%)		100	85-100		100	82.5-100	0.52

SD: Standard deviation; HNR: Harmonics-to-noise ratio; MPT: Maximum phonation time; VRQOL: Voice-related quality of life.

**Table 2**  
Preoperative and postoperative acoustic features of patients undergoing hemithyroidectomy

	Preoperative			First postoperative month			<i>p</i>
	Mean±SD	Median	Min-Max	Mean±SD	Median	Min-Max	
F0 (Hz)	213.71±45.34			208.28±46.07			<b>0.11</b>
Jitter (%)	0.72±0.38			0.65±0.43			<b>0.50</b>
Shimmer (%)	2.09±0.79			2.09±0.74			<b>1</b>
HNR (dB)	21.74±3.08			21.20±2.76			<b>0.06</b>
MPT (sec)	14.28±3.24			14.28±3.26			<b>1</b>
VRQOL (%)		94.28	70-100		93.03	75-100	<b>0.22</b>

SD: Standard deviation; HNR: Harmonics-to-noise ratio; MPT: Maximum phonation time; VRQOL: Voice-related quality of life.

Table 3							
Preoperative and postoperative acoustic features of patients undergoing total thyroidectomy with central neck dissection							
	Preoperative			First postoperative month			<i>p</i>
	Mean±SD	Median	Min-Max	Mean±SD	Median	Min-Max	
F0 (Hz)		205	103-275		202.06	100-275	<b>0.04</b>
Jitter (%)		0.55	0.13-1.38		0.57	0.11-1.42	<b>0.01</b>
Shimmer (%)		2.78	1.10-6.55		2.78	0.95-6.91	<b>0.03</b>
HNR (dB)	21.27 ±4.60			20.68±3.88			<b>0.03</b>
MPT (sec)	12.73±3.11			11.96±2.70			<b>0.03</b>
VRQOL (%)		98	90-100		95.83	72.50-100	<b>0.01</b>

SD: Standard deviation; HNR: Harmonics-to-noise ratio; MPT: Maximum phonation time; VRQOL: Voice-related quality of life.

Table 4				
Preoperative and postoperative acoustic features of patients undergoing total thyroidectomy with central and lateral neck dissection				
	Preoperative		First postoperative month	
	Mean±SD		Mean±SD	<i>p</i>
F0 (Hz)	171.33±47.08		159.66±43.48	<b>0.04</b>
Jitter (%)	0.25±0.92		0.47±0.13	<b>0.00</b>
Shimmer (%)	2.18±0.87		2.7±0.82	<b>0.02</b>
HNR (dB)	23.69±4.23		21.91±4.69	<b>0.04</b>
MPT (sec)	13.11±2.89		11.77±2.81	<b>0.01</b>
VRQOL (%)	98.61±2.53		93.05±4.96	<b>0.00</b>

SD: Standard deviation; HNR: Harmonics-to-noise ratio; MPT: Maximum phonation time; VRQOL: Voice-related quality of life.

Table 5						
Analysis of preoperative and postoperative changes according to sex, age, and histopathology						
	Female	Male	>50 years	<50 years	Benign	Malignant
F0	NS	NS	S	NS	NS	S
Jitter	S	NS	S	S	NS	S
Shimmer	NS	NS	NS	S	NS	S
HNR	NS	S	S	NS	NS	S
MPT	NS	NS	NS	NS	NS	S
VRQOL	S	NS	NS	NS	NS	S

HNR: Harmonics-to-noise ratio; MPT: Maximum phonation time; VRQOL: Voice-related quality of life; NS: Non significant; S: Significant.

parameters and VRQOL scores were not impacted after the operation for benign pathologies, whereas all analyzed parameters changed significantly in patients with malignant histopathology.

## DISCUSSION

Patients undergoing thyroidectomy often cite voice changes as a primary concern. In this study, we evaluated the possible patient-dependent and surgery-related

factors contributing to postoperative voice alterations, excluding RLN and EBSLN damage. The results of the study verify that voice changes after thyroidectomy involve a more intricate phenomenon beyond just vocal cord movement.

To investigate the effect of surgical extension on voice outcomes, we categorized patients based on the type of surgery, speculating that more extensive surgeries might lead to greater alterations in vocal

parameters. In our cohort, hemithyroidectomy patients exhibited no significant alterations in either acoustic voice parameters or VRQOL following surgery. On the other hand, statistically significant changes were observed in total thyroidectomy group. Voice changes were more pronounced in patients who underwent central neck dissection with or without lateral neck dissection. These results confirm the hypothesis that voice alterations are related to the extent of the surgery.

It is reasonable to suggest that the voice quality after total thyroidectomy will be worse than the voice results after hemithyroidectomy. Total thyroidectomy doubles the risk of injury to EBLSLN or RLN compared to hemithyroidectomy. With neck dissection, the dissected area enlarges, which may pose an additional risk for nerve damage. In the study cohort, there is no obvious evidence of damage to the nerve, but alterations around the nerve sheath resulting from dissection could potentially impact vocal quality. Lee et al.<sup>[7]</sup> correlated voice changes with the degree of intraoperative RLN swelling, and spontaneous recovery was observed in the majority of patients at the one-year follow-up. Our study's follow-up period was limited to one month. Two studies indicate that both objective and subjective parameters initially deteriorate after thyroidectomy but improve over time.<sup>[8,9]</sup> Extending the follow-up period in the present study could result in the loss of statistical significance in vocal changes.

Apart from the dissection around the nerve, the duration of intubation may also be a factor explaining the vocal changes in the postoperative period. Patients who undergo hemithyroidectomy have a shorter intubation period; however, as the scope of surgery increases, the duration of intubation also increases. This prolonged intubation may result in greater mechanical trauma on the vocal cords and potentially worsen vocal outcomes in longer surgeries. There was no specific data regarding surgery time in our data set. However, it is possible to attribute the more pronounced voice changes observed in neck dissection cases to intubation time. Nam et al.<sup>[10]</sup> reported similar results that lateral neck dissection worsened vocal outcomes in thyroidectomized patient, but they attributed the changes to reduced lymphatic or venous drainage after neck dissection rather than prolonged intubation.

Postoperative voice changes may also be related to the benign or malignant nature of the tumor. The change in F0, jitter, shimmer, and HNR was significant in patients undergoing surgery for malignant thyroid diseases. The VRQOL scores were significantly lower after the operation, and MPT was shorter. However, none of the analyzed acoustic parameters changed after surgery for benign pathologies. In contrast to our

findings, Soylu et al.<sup>[11]</sup> reported that the differences in acoustic voice measurements were not significant according to the final histopathology report. They evaluated only patients who underwent lobectomy or total thyroidectomy. In our study, the extent of the surgery for the malignant diseases varies from hemithyroidectomy to total thyroidectomy with central and lateral neck dissection. The difference in voice outcomes according to histopathology is also due to the difference in the planned surgeries. Another factor that may affect the postoperative voice results in malignant patients is the emotional condition. A cancer diagnosis has a negative impact on human psychology, and the voice is the expression of our emotional state.<sup>[12]</sup>

In the literature, an age above 50 years is considered a risk factor for postoperative vocal changes;<sup>[6]</sup> however, the results of this study did not support previous findings. Significant changes in F0, jitter, and HNR were observed in the group over 50 years old, while shimmer, maximum phonation time, and VRQOL did not change significantly after surgery. In patients younger than 50 years, only jitter and shimmer parameters showed significant differences postoperatively. Interpreting these changes clinically, linking them to age, and proposing age as a risk factor is difficult. Sex may be a risk factor for vocal changes after thyroidectomy. According to Park et al.'s<sup>[13]</sup> study, the female sex may be a predictor of clinically significant F0 changes following thyroidectomy. However, our findings did not support these results. The change in F0 after surgery was not significant in either males or females. Nonetheless, subjective evaluations of voice showed differences between sexes. The change in VRQOL scores after surgery was significant in females possibly because they were more likely to notice vocal changes, while males were possibly more likely to ignore them.

This study had some limitations. First, the follow-up period was limited to one month after surgery, which may have not captured the long-term recovery trajectory of vocal changes. The lack of detailed data on the duration of intubation and its potential impact on vocal outcomes was another limitation. Additionally, the sample size, particularly in subgroups undergoing lateral neck dissection, was relatively small, which may have affected the generalizability of the findings. Lastly, the subjective nature of the VRQOL scores might have introduced bias, as personal perception of voice quality can vary widely and may be influenced by psychological factors, particularly in patients diagnosed with malignant diseases. Future research should aim for a longer follow-up period, a larger sample size, and a more comprehensive assessment of intraoperative

factors to better understand the nuances of voice changes after thyroidectomy.

In conclusion, this study highlights the multifaceted nature of voice changes following thyroidectomy, emphasizing that these alterations are influenced by the extent of the surgery, patient demographics, and the nature of the thyroid pathology. Our findings indicate that more extensive surgeries, such as total thyroidectomy and those involving neck dissections, are associated with significant postoperative vocal changes, whereas hemithyroidectomy shows minimal impact. The type of thyroid disease, particularly malignant conditions, also plays a crucial role in affecting vocal parameters and quality of life after surgery. While age and sex were considered potential risk factors, their influence on vocal outcomes varied and warrants further investigation. Ultimately, these insights can guide clinicians in tailoring surgical approaches and postoperative care to optimize vocal outcomes for thyroidectomy patients.

**Data Sharing Statement:** The data that support the findings of this study are available from the corresponding author upon reasonable request.

**Author Contributions:** Material preparation, data collection, and analysis were conducted by S.Y. and M.K.G.; The first draft of the manuscript was written by S.Y. All authors contributed to the study's conception and design, provided feedback on previous versions of the manuscript, and reviewed and approved the final version.

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