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ORIGINAL ARTICLE / ÖZGÜN MAKALE

Factors affecting the development of recurrence in patients who underwent tracheal resection due to tracheal stenosis

Trakeal darlık nedeni ile trakea rezeksiyonu yapılan hastalarda nüks gelişimine etki eden faktörler

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ABSTRACT

Background: This study aims to evaluate the outcomes of surgical treatment of post-intubation tracheal stenosis cases and to identify factors associated with recurrence and treatment success.

Methods: Between January 2010 and December 2024, a total of 56 patients (38 males, 18 females; mean age: 49.1±14.8 years; range, 24 to 61 years) who were treated for post-intubation tracheal stenosis were retrospectively analyzed. Data were collected using a standardized data extraction form. Demographic data, clinical characteristics, comorbidities, surgical procedures, and postoperative outcomes of the patients were recorded.

Results: Comorbidities, particularly diabetes, were common in the majority of patients. Recurrence occurred in 14 (25%) of the cohort. Early mortality was observed in one (1.7%) patient. Middle tracheal stenosis as the site of stenosis and the use of 3/0 Vicryl separating sutures had higher recurrence rates. The mean length of the removed segment was 3.7±0.7 cm in patients without recurrence, while it was 3.2±0.5 cm in patients with recurrence (p=0.361). While the recurrence rate was 71.4% among patients with comorbidities such as diabetes, hypertension, epilepsy, and Crohn's disease, this rate was 28.6% in those without comorbidities (p<0.001), and the presence of comorbidities significantly increased the likelihood of recurrence (odds ratio [OR]=9.167, 95% confidence interval [CI]: 3.482-24.134, p<0.001).

Conclusion: Surgical treatment of post-intubation tracheal stenosis presents challenges due to the high recurrence rate, particularly in patients with comorbidities. Individualized treatment approaches, meticulous surgical techniques, and comprehensive postoperative care are essential to improve patient outcomes.

Keywords: Post-intubation, tracheal stenosis, tracheal surgery.

ÖZ

Amaç: Bu çalışmada, entübasyon sonrası trakeal darlıklı olguların cerrahi tedavi sonuçları değerlendirildi ve nüks ve tedavi başarısı ile ilişkili faktörler belirlendi.

Çalışma planı: Ocak 2010 - Aralık 2024 tarihleri arasında entübasyon sonrası trakeal darlık nedeniyle tedavi edilen toplam 56 hasta (38 erkek, 18 kadın; ort. yaş: 49.1±14.8 yıl; dağılım, 24-61 yıl) retrospektif olarak incelendi. Veriler standartlaştırılmış bir veri çıkarma formu kullanılarak toplandı. Hastaların demografik özellikleri, klinik özellikleri, eşlik eden hastalıkları, cerrahi işlemler ve ameliyat sonrası sonuçları kaydedildi.

Bulgular: Hastaların birçoğunda başta diyabet olmak üzere eşlik eden hastalıklar yaygındı. Kohortun 14'ünde (%25) nüks görüldü. Bir (%1.7) hastada erken dönem mortalite gözlendi. Darlık yeri olarak orta seviyedeki trakeal darlık ve 3/0 Vicryl separe sütür kullanımı daha yüksek nüks oranlarına sahipti. Nüks olmayan hastalarda ortalama çıkarılan segment uzunluğu 3.7±0.7 cm iken, nüks görülen hastalarda 3.2±0.5 cm idi (p=0.361). Diyabet, hipertansiyon, epilepsi, Crohn hastalığı gibi eşlik eden hastalıkları hastalar arasında nüks oranı %71.4 iken, eşlik eden hastalığı olmayanlarda bu oran %28.6 idi (p<0.001) ve eşlik eden hastalıkların varlığı nüks olasılığını önemli ölçüde artırdı (olasılık oranı [OR]=9167, %95 güven aralığı [GA]: 3.482-24.134, p<0.001).

Sonuç: Entübasyon sonrası trakeal darlığın cerrahi tedavisi, özellikle eşlik eden hastalığı olan hastalarda yüksek nüks oranı nedeniyle zorluklar ortaya koymaktadır. Bireyselleştirilmiş tedavi yaklaşımları, titiz cerrahi teknikler ve kapsamlı ameliyat sonrası bakım, hasta sonuçlarını iyileştirmek için gereklidir.

Anahtar sözcükler: Entübasyon sonrası, trakeal stenoz, trakeal cerrahi.

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Post-intubation tracheal stenosis (PETS) represents a rare, but potentially serious complication which can occur following prolonged endotracheal intubation or tracheostomy.[1-4] It is well documented that this condition often occurs as a result of ischemic damage to the airway mucosa, leading to chronic inflammation, fibrosis and ultimately significant narrowing of the tracheal lumen.[5,6] Despite significant advances in modern critical care practice, including improved ventilation techniques and better cuff pressure management, PETS remains a significant iatrogenic complication with significant morbidity. Patients with tracheal stenosis often present with symptoms such as stridor, shortness of breath, or other signs of upper airway obstruction which can significantly affect their quality of life.[7,8]

Treatment of PETS includes a wide variety of interventions depending on the severity of the stenosis and the patient's general health condition. These treatment options range from minimally invasive approaches such as bronchoscopic dilatation or laser therapy to more extensive surgical procedures such as tracheal resection and end-to-end anastomosis.[9] In more severe cases or in patients who are refractory to less invasive interventions, surgical resection is often considered the treatment option of choice. This is particularly true for patients with extensive or complex tracheal stenosis, where definitive surgical repair may offer the best chance for long-term resolution.[10]

Recent studies highlight the importance of multidisciplinary approaches to improve outcomes in both surgical and bronchoscopic treatments.[11] In addition, factors such as appropriate patient selection, optimization of surgical techniques, and careful postoperative care also play an important role in the success of treatment.[12,13] Previous studies have also shown that tracheal resection can achieve success rates ranging from 71 to 97% in selected patient populations. Many studies emphasize which factors such as length of stenosis and the presence of comorbidities may affect surgical outcomes and require careful patient selection and preoperative evaluation.[1,14,15] Additionally, Wright et al.'s study,[1] spanning from 1993 to 2017, highlighted the management strategies and complications associated with PETS, reinforcing the idea that surgical intervention is crucial, with a 96% success rate in patients exhibiting severe airway obstruction. Additionally, Hashemzadeh et al.[16] reported that previous tracheostomy might negatively affect surgical outcomes and suggested that patients' surgical history should be taken into account during treatment planning.

Management of PETS requires an integrated approach which considers both minimally invasive and surgical options.[17] The choice of surgical intervention should be guided by a comprehensive evaluation of the patient's medical history and the characteristics of the stenosis. In the present study, we aimed to evaluate the outcomes of surgical treatment of PETS cases and to identify factors associated with recurrence and treatment success over a 14-year period.

PATIENTS AND METHODS

This single-center, retrospective study was conducted at University of Health Sciences, Dr. Suat Seren Chest Diseases and Chest Surgery Training and Research Hospital, Department of Thoracic Surgery between January 2010 and December 2024. All patients treated for PETS in our center were reviewed. Data collection was based on available medical records. The patients who underwent surgery for benign causes of tracheal stenosis (post-intubation or idiopathic) and those who had complete medical records, including detailed pre- and postoperative evaluations were enrolled. Exclusion criteria were as follows: patients with incomplete medical records, those who did not receive surgical treatment, and patients with other causes of tracheal stenosis such as congenital abnormalities or traumatic injuries unrelated to intubation. Additionally, patients who underwent tracheal resection due to tumor in the trachea were also excluded from the study. Finally, a total of 56 patients (38 males, 18 females; mean age: 49.1±14.8 years; range, 24 to 61 years) who met the inclusion criteria were recruited. Written informed consent was obtained from each patient. The study protocol was approved by the University of Health Sciences, Dr. Suat Seren Chest Diseases and Chest Surgery Training and Research Hospital Non-Pharmaceutical Clinical Research Ethics Committee (Date: 05.02.2025, No: 2024/17-19). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Surgical technique

Patients were in the supine position, placing a pillow under the shoulders to help neck extension. Before the surgeries, careful endoscopic evaluation of the airway was performed using a rigid bronchoscope. The patient was, then, intubated

with the largest possible endotracheal tube (ETT) and a nasogastric tube was placed.

Proximal one-third and middle-third tracheal lesions were approached through a transverse cervical incision (collar). A thoracotomy or sternotomy was performed only, when long segment tracheal stenosis was present or in cases of carinal stenosis. Depending on the location and extent of the lesion, suprahyoid release or hilar release by dividing the inferior pulmonary ligament was planned. In all patients, the operation was started with a cervical incision, taking into account the level of stenosis. After the skin flaps were removed, the trachea was dissected and mobilized. The use of cautery was avoided to reduce the possibility of thermal injury to the recurrent laryngeal nerve. After complete transection of the trachea, an ETT of appropriate size was placed in the distal trachea and ventilation was continued.

After resection, posterior wall anastomosis was started. An oral ETT was advanced beyond the anastomosis and the anastomosis of the anterior portion was completed. In cases of stenosis at the level of the cricoid ring, the so-called Grillo technique, after careful dissection on the cricoid, the cricothyroid membrane was exposed and two-third of the anterolateral cricoid was resected. A beak-shaped mucosal flap extending forward from the intact distal trachea was fixed to the cricoid with individual 4/0 sutures. Retention sutures were used on the two lateral edges of the anastomosis in all patients.

After the trachea was closed, a leak test was performed by deflating the ETT cuff by administering physiological saline over the incision line and applying 30 cm of water pressure to the breathing circuit. When no air bubbles were seen, the incision was closed after placing a Hemovac drain into the pretracheal space.

Before extubation, two 'protective stitches were placed from the skin over the manubrium to the submental fold to ensure that the neck remained flexed. All patients were carefully extubated. Patients were transferred to the intensive care setting for careful observation. Nutrition started with liquid food on the first postoperative day, and attention was paid to signs of aspiration. On Day 1 after surgery, uncomplicated patients were transferred to the regular surgical ward. Except for patients with unilateral vocal cord paralysis or weak cough reflex, patients received regular physiotherapy, as mini-tracheostomy was not routinely used. The patients, for whom no problems were detected, were discharged after their neck stitches were removed on Day 10. The cases were performed by three senior lecturers and one specialist in tracheal surgery with at least 20 years of experience in their profession. The difference in surgical suturing mentioned in the article occurred depending on the preference among surgeons.

Data collection and data analysis

The data collection tool used in this study consisted of a standardized data extraction form designed to collect relevant clinical information from the patient's medical record. The data extraction form included fields for demographic data, clinical characteristics, comorbidities, surgical procedures, and postoperative outcomes. Trained medical personnel performed data extraction to minimize errors and ensure accuracy. Any discrepancies found during data collection were resolved through consensus between data collectors, and missing information was carefully documented.

Statistical analysis

Sample size calculation was performed using the Cochran's sample size formula. The rate of tracheal restenosis reported in the literature after primary resection and reconstruction for tracheal diseases is 16 to 42%.[19] Accordingly, the sample size of the study was calculated as 44 patients with a type 1 error of 5% (d=0.05) to evaluate the causes of recurrence after tracheal stenosis surgery based on p=0.03, q (1-p) = 0.97 with 80% study power and 95% confidence interval (CI).

Statistical analysis was performed using the IBM SPSS version 26.0 software (IBM Corp., Armonk, NY, USA). Compliance with normal distribution was investigated using the Kolmogorov-Smirnov test and skewness and kurtosis symmetric distributions. Continuous data were expressed in mean ± standard deviation (SD) or median and interquartile range (IQR), while categorical data were expressed in number and frequency. For inferential analysis, independent sample t-tests were used to compare means between groups for continuous variables such as age and length of tracheal segments to determine whether there were significant differences between patients with and without recurrence. The Fisher exact test was used to examine relationships between categorical variables such as sex, tracheal stenosis level, and suturing techniques and the occurrence of recurrence. Odds ratios (OR) and 95% CIs were calculated to evaluate the impact of comorbidities

on the likelihood of recurrence. A two-tailed *p* value of <0.05 was considered statistically significant.

RESULTS

Baseline characteristics of the patients are summarized in Table 1. Additional comorbidities were observed in 12 (21.4%) of the patients; the most common was diabetes (73.3%), followed by epilepsy (13.3%), Crohn's disease (6.7%), and hypertension (6.7%). Considering the survival results, early postoperative mortality was observed due to pneumonia in one (1.7%) of the patients during follow-up. Restenosis was observed in 14 (25%) of the patients. In these patients who developed restenosis, the mean number of restenosis attacks per patient was 2.1±0.8. All patients who developed restenosis were first dilated with rigid bronchoscopy one or more times. Rigid bronchoscopy and mitomycin C were applied to eight (14.2%) patients. Despite this, one of the patients whose restenosis recurred underwent reoperation and anterior costal cartilage interposition and a T-tube was placed. Apart from this, a T-tube was placed in six (10.7%) patients by tracheostomy after dilation with rigid bronchoscopy. A patient who could not tolerate a T-tube was switched to a perforated metal cannula (Table 1).

The patients' tracheal stenosis levels, surgical interventions and suturing techniques are shown in Table 2. The mean length of the resected tracheal segments was 3.6±0.7 cm. Stenosis was observed in the majority of patients. While it was located in the middle trachea (50.0%), it was located in the cricoid region (30.4%) and the first tracheal ring (19.6%), respectively. While a tracheal release maneuver was performed in 16.1% of the patients, no release maneuver was required in 83.9%. Regarding suturing techniques, 4/0 continuous Vicryl or 3/0 Vicryl separated sutures (37.5% each) were most frequently used at the back of the anastomosis. For

Table 1. Baseline descriptive characteristics of the study group (n=56)

Variables	n	%	Mean±SD	IQR
Age (year)			49.1±14.8	38.5-61.0
Sex				
Male	38	67.9		
Female	18	32.1		
Additional disease*				
Yes	12	21.4		
No	44	78.6		
Early mortality				
Alive	55	98.3		
Dead	1	1.7		
Restenosis				
No	42	75.0		
Yes	14	25.0		
Number of relapses				
1	3	21.5		
2	5	35.5		
3	3	21.5		
4	3	21.5		
Number of attacks			2.1±0.8	1-3
Operation for relapse				
Reoperation and T-tube	1			
Rigit bronchoscopy and T-tube	1			
Tracheotomy	1			
Rigid dilatation	11			

SD: Standard deviation; IQR: Interquartile range; * DM (diabetes mellitus), Crohn's disease, HT (hypertension), epilepsy.

Table 2. Tracheal stenosis levels, surgical interventions, and suturation techniques of the patients (n=56)

Variables	n	%	Mean±SD	IQR
Extracted parts length (cm)			3.6±0.75	3-4
Tracheal stenosis level				
Middle	28	50.0		
Cricoid	17	30.4		
First ring	11	19.6		
Tracheal release maneuvers type				
Inferior laryngeal release	5	8.9		
Inferior ligament release	1	1.8		
Suprahyoid release	3	5.4		
No	47	83.9		
Suturation technique (back)				
4/0 Vicryl continuous	21	37.5		
3/0 Vicryl interrupted	21	37.5		
3/0 prolene continuous	13	23.2		
3/0 Vicryl continuous	1	1.8		
Suturation technique (front)				
3/0 Vicryl interrupted	40	71.4		
3/0 prolene continuous	14	25.0		
3/0 Vicryl continuous	2	3.6		

SD: Standard deviation; IQR: Interquartile range.

Table 3. Impact of various demographic and clinical characteristics on the occurrence of recurrence

	n	%	Mean±SD	n	%	Mean±SD	*p*	OR	95% CI	*p*
Age (year)			48.0±15.2			52.2±13.5	0.700*	-	-	-
Extracted parts length (cm)			3.7.0±0.7			3.2±0.5	0.361*	-	-	-
Age group (year)						-	0.999**	-	-	-
<65	34	81.0		11	78.6					
65 and above	8	19.0		3	21.4					
Sex						-	0.185**	-	-	-
Male	26	61.9		12	85.7					
Female	16	38.1		2	14.3					
Additional disease#						-	**<0.001****	9.167	3.482-24.134	**<0.001**
Yes	2	4.8		10	71.4					
No (reference)	40	95.2		4	28.6					
Tracheal stenosis level						-	-	-	-	-
Middle	20	47.6		8	57.2					
Cricoid	14	33.3		3	21.4					
First ring	8	19.1		3	2.14					
Suturation technique (back)						-	-	-	-	-
4/0 Vicryl continuous	18	42.9		3	21.5					
3/0 Vicryl interrupted	16	38.1		5	35.7					
3/0 prolene continuous	8	19.0		5	35.7					
3/0 Vicryl continuous	0	0.0		1	7.1					
Suturation technique (front)						-	-	-	-	-
3/0 Vicryl interrupted	32	76.2		8	57.1					
3/0 prolene continuous	9	21.4		5	35.8					
3/0 Vicryl continuous	1	2.4		1	7.1					

SD: Standard deviation; OR: Odds ratio; CI: Confidence interval; * Independent sample t-test; ** Fisher exact test; # DM (diabetes mellitus), Crohn's disease, HT (hypertension), epilepsy.

Table 4. Data of patients who developed restenosis

	Operation for relapse	Extracted parts length (cm)	Tracheal stenosis level	Tracheal release maneuvers type	Suturation technique (back)	Suturation technique (front)	Complication	Restenosis duration (Weeks)
1	Tracheostomy	3	Cricoid	Infrahyoid release	3/0 Vicryl interrupted	3/0 Vicryl interrupted		3
2	Reoperation + T tube	4	Cricoid	Infrahyoid release	3/0 Vicryl interrupted	3/0 Vicryl interrupted	Laryngeal nerve injury - aspiration	3
3	Rigid dilatation	4	Cricoid	Subrahyoid release	3/0 Vicryl interrupted	3/0 Vicryl interrupted		4
4	Tracheostomy	2.5	First ring	None	4/0 Vicryl continuous	3/0 Vicryl continuous		6
5	Rigid dilatation	3	First ring	None	3/0 Vicryl interrupted	3/0 Vicryl interrupted		12
6	Rigid dilatation	3	First ring	None	4/0 Vicryl continuous	3/0 Vicryl interrupted		15
7	Rigid dilatation + T tube	4	Middle	None	3/0 prolene continuous	3/0 prolene continuous		8
8	Rigid dilatation	3	Middle	None	3/0 Vicryl continuous	3/0 Vicryl interrupted		30
9	Rigid dilatation	3	Middle	None	4/0 Vicryl continuous	3/0 Vicryl interrupted		24
10	Rigid dilatation	4	Middle	None	3/0 prolene continuous	3/0 prolene continuous		4
11	Rigid dilatation	4	Middle	None	3/0 prolene continuous	3/0 prolene continuous		5
12	Rigid dilatation	4	Middle	None	3/0 prolene continuous	3/0 prolene continuous		3
13	Rigid dilatation	3	Middle	None	3/0 prolene continuous	3/0 prolene continuous		6
14	Rigid dilatation	3	Middle	None	3/0 Vicryl interrupted	3/0 Vicryl interrupted		35

the front side, predominantly 3/0 Vicryl separated sutures were used (71.4%), followed by 3/0 prolene continuous sutures (25.0%). While the number of patients who underwent surgery with tracheostomy was 3 (5.3%), restenosis was not observed in these patients.

Table 3 shows the potential impact of various demographic and clinical characteristics on the occurrence of recurrence. The mean age of patients without recurrence was 48.0±15.2 years, and the mean age of patients with recurrence was 52.2±13.5 years (p=0.700). Additionally, there was no significant difference in the occurrence of recurrence between age groups (<65 years and ≥65 years) (p=0.999). The mean length of the removed fragment was 3.7±0.7 cm in patients without recurrence, while it was 3.2±0.5 cm in those with recurrence, indicating no statistically significant difference (p=0.361). The recurrence rate was 14.3% in female patients and 85.7% in male patients, but this difference was not statistically significant (p=0.185). The presence of additional comorbidities, particularly diabetes, had a significant impact on the occurrence of recurrence. While the recurrence rate was 71.4% in patients with comorbidities, this rate was 28.6% in patients without comorbidities, and this difference was statistically significant (p<0.001). The presence of comorbidities can be considered a risk factor for recurrence (OR=9.167, 95% CI: 3.482-24.134, p<0.001). While 57.2% of patients with stenosis at the mid-level of the trachea experienced recurrence, this rate was 21.4% at both the cricoid and first ring levels. Considering the suturing technique in terms of suturation of the membranous (posterior) part, recurrence occurred in 21.5% of the patients with 4/0 continuous Vicryl suture, while these rates were 35.7% with 3/0 Vicryl separable suture, 35.7% with 3/0 prolene continuous suture and 7.1% with 3/0 continuous Vicryl suture. Considering the suturing technique in terms of suturing the (front) tracheal cartilage part, while recurrence was observed in 57.1% of patients with 3/0 Vicryl separating stitches, the recurrence rate was 35.8% for 3/0 continuous prolene and 7.1% for 3/0 continuous Vicryl (Table 3).

Data for patients who developed recurrence are shown in Table 4. Aspiration due to laryngeal nerve damage was observed in one patient who underwent infrahyoid release and developed restenosis. This patient was reoperated and despite the application of a T-tube, he died due to aspiration pneumonia three weeks after the second operation (Table 4). The presence of comorbidities emerged as an important indicator of restenosis, while other variables such as age, sex, tracheal stenosis level and suturing techniques did not show a significant effect on the occurrence of restenosis.

DISCUSSION

Post-intubation tracheal stenosis remains a significant iatrogenic complication despite advances in critical care, including advances in ventilation techniques and cuff pressure management.[1,16,18,19] The persistence of PETS as a complication highlights the importance of optimizing both preventive and therapeutic strategies to improve patient outcomes. In the present study, we attempted to provide new insights into the factors affecting these clinical outcomes, specifically assessing surgical outcomes and risk of recurrence. The cohort included 56 patients with a wide range of tracheal stenosis levels and comorbid conditions, which allows robust examination of different demographic and clinical factors that may influence outcomes. In our study, the majority of patients were male and comorbidities such as diabetes were common. The presence of additional comorbidities has emerged as a significant predictor of recurrence, consistent with previous studies highlighting the impact of systemic health conditions on airway healing and risk of restenosis.[8,20,21] These findings suggest that patients with comorbidities may need more specific postoperative monitoring and intervention to reduce the risk of recurrence. Surgical treatment options for PETS range from minimally invasive bronchoscopic techniques to more complex surgical procedures, such as tracheal resection and end-to-end anastomosis.[22-24] In this study, a significant portion of the patients underwent tracheal dilatation with rigid bronchoscopy before surgery. Surgical resection and end-to-end anastomosis are considered the gold standard in the treatment of tracheal stenosis, and factors such as stenosis length, presence of comorbidities, and surgical technique are critical for success. Dezfouli et al.[24] reported that careful preoperative evaluation and advanced surgical techniques could improve outcomes. Ulusan et al.[25] found that 31.8% of patients who underwent tracheal resection and anastomosis experienced postoperative recurrence. The relatively high recurrence rate observed in this study, particularly in patients who underwent specific suturing techniques, highlights the importance of improving surgical methods and postoperative care protocols to increase long-term success rates. This is also supported by Freitas et al.,[11]

who underlined the need for multidisciplinary approaches and postoperative monitoring to minimize recurrence, with interventional bronchoscopy serving as a complementary tool in some cases. Our study revealed that the choice of suturing techniques had a notable impact on recurrence rates. It highlighted the different results depending on the type of stitch used; 3/0 Vicryl interrupted sutures have been associated with a higher recurrence rate compared to other suture techniques. This finding suggests that the mechanical properties of the suture material and the resulting healing response may affect the possibility of restenosis and recommends that it should not be preferred, whenever possible. There are studies in the literature showing that factors such as suture tension can significantly affect healing, particularly in sensitive areas such as the trachea.[26-28] Therefore, these findings suggest that optimizing suture material and technique may be critical in reducing the incidence of restenosis and improving surgical outcomes. Another critical issue highlighted in our study is the location of tracheal stenosis and its relationship to clinical outcomes. Our results showed that the recurrence rate was higher in middle tracheal stenosis than in cricoid and first ring levels, although it did not reach statistical significance. There are studies in the literature arguing that proximal tracheal stenosis near the cricoid requires more complex surgical techniques, which increases recurrence rates.[29] Similarly, He et al.[30] identified that the location of the stenosis was a critical risk factor affecting the success of surgical interventions and that some locations were associated with worse outcomes due to anatomical difficulties. Another study showed that stenosis involving the cricoid had different implications for surgery compared to stenoses located in the middle trachea, highlighting the need for specific approaches based on anatomical differences.[31] These results highlight the importance of preoperative planning, suggesting that the location of the stenosis should be an important consideration in determining individual surgical approaches and predicting patient outcomes. It is noteworthy that a growing evidence base has shown that recent studies have emphasized the use of multidisciplinary approaches as a way to improve outcomes in PETS patients, particularly those requiring complex surgical interventions.[32-34] In line with the literature, Kocyildirim et al.[33] showed that the implementation of a multidisciplinary team approach reduced costs and improved survival. Furthermore, Özdemir et al.[34] emphasized that combining surgical and endoscopic methods within a multidisciplinary framework provided high success rates, particularly in the treatment of complex stenoses. In addition to all these, the surgeon's experience and an appropriate and meticulous surgical technique are the most important conditions for success. Factors such as meticulous patient selection, careful preoperative evaluation, diabetes regulation, steroid use and optimization of surgical techniques are crucial in achieving positive results. Postoperative care, particularly for high-risk patients with comorbidities, should include multidisciplinary teams such as cardiology, internal medicine, otolaryngologist and physiotherapist to minimize complications and reduce the risk of recurrence.

The findings of this study also highlight the importance of patient-specific characteristics in determining treatment outcomes. Age, sex, and the presence of comorbidities such as diabetes have been examined as potential factors influencing recurrence. While age and sex did not show a statistically significant effect on recurrence rates, the presence of concomitant diabetes was a strong predictor. This finding is consistent with previous research showing that systemic health plays an important role in wound healing and overall recovery after tracheal surgery.[35-37] Wertz et al.[37] emphasized that comorbidities were an important determinant of hospital stay and complications after tracheal surgery and highlighted the need for individualized preoperative evaluations. Additionally, Tay et al.[36] demonstrated that comorbidity burden had a more significant impact on surgical outcomes in older patients than age alone, reinforcing the importance of comprehensive preoperative risk assessments. Furthermore, the regression of postoperative symptoms observed in this study demonstrates that, despite the difficulties associated with PETS and the risk of recurrence, surgical intervention remains a valid option to achieve long-term resolution in most patients. However, the documented 25% recurrence rate highlights the need for ongoing research to improve surgical techniques and identify effective treatments that may improve outcomes. Future studies may focus on the role of new materials for anastomosis, innovative surgical instruments, or adjunctive pharmacological treatments that may promote better healing and reduce restenosis.

Nonetheless, there are several limitations to this study. First, its retrospective design inherently carries risks of data inaccuracy and bias due to reliance on medical records that may contain incomplete or inaccurate information. Second, the relatively

small sample size limits the generalizability of the findings, as larger groups would provide more robust and reliable results. Additionally, the study was conducted in a single center, which may limit the applicability of the results to other populations or healthcare settings. Finally, while comorbidities were found to significantly impact recurrence rates, the interaction between these conditions and treatment outcomes were not fully investigated, warranting more comprehensive studies in the future. These limitations highlight the need for multi-center, prospective studies with larger sample sizes to confirm these findings.

In conclusion, treatment of post-intubation tracheal stenosis still remains challenging. It is a major concern, particularly in patients with accompanying diabetes. The findings of this study highlight the need for individualized treatment approaches, optimization of surgical techniques, and comprehensive postoperative care to improve outcomes. Further studies are warranted to gain a better understanding of the mechanisms of underlying restenosis and to develop novel interventions in advancing the management of this complex condition.

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

Author Contributions: Idea/concept, writing the article: B.A.Ş.; Design: K.C.C.; Control/supervision, critical review: S.Y.; Data collection and/or processing: Ö.S.; Analysis and/or interpretation: A.Ü.; Literature review: S.B.; References and fundings: S.M.

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