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ORIGINAL ARTICLE / ÖZGÜN MAKALE

Surgical outcomes following tracheal reconstruction in patients with post-intubation tracheal stenosis

Postentübasyon trakeal darlığı olan hastalarda trakeal rekonstrüksiyon sonrası cerrahi sonuçlar

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ABSTRACT

Background: The aim of this study was to evaluate the surgical outcomes of patients who underwent tracheal resection due to post-intubation tracheal stenosis.

Methods: Between January 2014 and December 2021, a total of 44 patients (32 males, 12 females; median age: 48.2 years; range, 13 to 68 years) who underwent tracheal resection and reconstruction for post-intubation tracheal stenosis in our clinic were retrospectively analyzed. Demographic and clinical data of the patients, radiological imaging, and laboratory results and operative and postoperative follow-up data were recorded.

Results: The most common reason for intubation among the patients included in the study was trauma. All patients had stridor. Twenty-six (59.1%) patients had at least one comorbidity. Stenosis was located in the upper half of the trachea in 33 (75%) and in the lower half of the trachea in 11 (25%) patients. The length of the tracheal segment removed during surgery was <3 cm in 26 (59.1%) and >3 cm in 18 (40.9%) patients. A total of 16 (36%) patients developed complications. Complications were more frequent in patients with a history of preoperative tracheostomy, presence of comorbidities and resection of the upper half of the trachea. The patients did not receive jaw-neck sutures thanks to the use of retention sutures in our clinic. The median length of stay in the hospital was 5 (range, 4 to 16) days.

Conclusion: Significant predisposing factors for complications include preoperative tracheostomy history, comorbidities and resection of the upper half of the trachea. In our study, the patients did not receive jaw-neck sutures thanks to the use of retention sutures, which increased patient comfort in the postoperative period and decreased the frequency of anastomosis-related complications.

Keywords: Bronchoscopy, post-intubation tracheal stenosis, retention suture.

ÖZ

Amaç: Bu çalışmada postentübasyon trakeal darlık nedeni ile trakeal rezeksiyon yapılan hastaların cerrahi sonuçları değerlendirildi.

Çalışma planı: Ocak 2014 - Aralık 2021 tarihleri arasında kliniğimizde postentübasyon trakeal darlık nedeni ile trakeal rezeksiyon ve rekonstrüksiyon yapılan toplam 44 hasta (32 erkek, 12 kadın; medyan yaş: 48.2 yıl; dağılım, 13-68 yıl) retrospektif olarak incelendi. Hastaların demografik ve klinik verileri, radyolojik görüntüleme ve laboratuvar sonuçları ve ameliyat ve ameliyat sonrası takip verileri kaydedildi.

Bulgular: Çalışmaya alınan hastalarda en sık entübasyon nedeni travma idi. Hastaların tamamında stridor mevcuttu. Hastaların 26'sının (%59.1) en az bir eşlik eden hastalığı vardı. Stenoz, hastaların 33'ünde (%75) trakeanın üst yarısında, 11'inde (%25) ise trakeanın alt yarısında lokalize idi. Hastaların 26'sında (%59.1) ameliyatta çıkarılan trakeal segmentin uzunluğu 3 cm'nin altında, 18'inde (%40.9) ise 3 cm'nin üzerinde idi. Toplamda 16 (%36) hastada komplikasyon görüldü. Ameliyat öncesi trakeostomi öyküsü, eşlik eden hastalık varlığı olan ve trakeanın üst yarısına rezeksiyon yapılan hastalarda komplikasyon daha sık görüldü. Kliniğimizde uygulanan retansiyon sütürleri sayesinde hastalara çene-boyun sütürü atılmadı. Medyan hastanede kalış süresi 5 (dağılım, 4-16) gün idi.

Sonuç: Komplikasyon için önemli yatkınlaştırıcı faktörler arasında ameliyat öncesi trakeostomi öyküsü, eşlik eden hastalıklar ve trakeanın üst yarısına yapılan rezeksiyonlar yer almaktadır. Çalışmamızda retansiyon sütürleri sayesinde hastalara çene-boyun sütürü atılmaması, ameliyat sonrası dönemde hasta konforunu artırmış ve anastomoz ile ilişkili komplikasyonların görülme sıklığını azaltmıştır.

Anahtar sözcükler: Bronkoskopi, postentübasyon trakeal stenoz, retansiyon sütürü.

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Post-intubation tracheal stenosis (PITS) is defined as the formation of granulation tissue and stenosis in the trachea as a result of overinflation of the intubation tube cuff. Tracheal resection offers the most optimal long-term results, if feasible. The first recorded tracheal surgery was performed by Belsey[1] in 1950. Grillo[2] and Pearson et al.[3] developed and revised the surgical technique during the 1980s. The success rate of tracheal resection and reconstruction ranges from 71 to 95%, with a reported mortality rate of 1.2%.[4] Non-surgical methods, including repeated dilatation, laser treatment, and tracheal stenting, are preferred in cases where surgical intervention is not possible due to the characteristics of the stenosis or when the patient is not eligible for surgical treatment.

In the present study, we aimed to evaluate surgical outcomes following tracheal reconstruction in patients with PITS.

PATIENTS AND METHODS

This single-center, retrospective study was conducted at Karadeniz Technical University, Faculty of Medicine, Department of Thoracic Surgery between January 2014 and December 2021. A total of 44 patients (32 males, 12 females; median age: 48.2 years; range, 13 to 68 years) who underwent resection and anastomosis for PITS were included. Those with tracheal stenosis associated with lung cancer and mediastinal masses, compression due to thyroid pathologies, and primary tumors of the trachea, which did not require resection after dilatation by rigid bronchoscopy, were excluded from the study. Patient data were analyzed for demographic characteristics, medical history, clinical manifestations, preoperative interventions, high-resolution computed tomography (CT) (Figure 1a), three-dimensional (3D) reconstruction of the neck and thorax with or without tracheobronchial tree (Figure 1b), and postoperative complications. Routine rigid bronchoscopy was performed to assess the vocal cords, glottis, cricoid, and tracheal mucosa (Figure 2). A written informed consent was obtained from each patient. The study protocol was approved by the Karadeniz Technical University Faculty of Medicine Scientific Research Ethics Committee (date: 15.04.2021, no: 2021/130). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Surgical technique

The patients were not premedicated because of dyspnea associated with tracheal stenosis. All the operated patients were preoperatively assessed via rigid bronchoscopy to determine the distance to the vocal cords and the shape and diameter of the tracheal stenosis. The patients with critical stenosis underwent dilatation. Surgery was performed as described by Pearson et al.[3] and Grillo et al.[5] Upon intubation, a small pillow was placed under the patients' shoulders while in the supine position to ensure hyperextension of the neck. A collar incision was made to cross the skin, subcutaneous fatty tissue, and platysma muscle. The hyoid muscles were excised to expose the trachea. Dissection was completed while preserving the tracheal blood supply, recurrent laryngeal nerves, and esophagus, and the stenotic segment was released. The cartilaginous part of the trachea was first cut below the stenosis after determining the proximal and distal area of the stenosis (Figure 3a). Viewing the tracheal lumen from below, the stenotic area was resected through an incision made anterior to the intact trachea just above the proximal point, where the stenosis began (Figure 3b).

A sling suture (often 2.0 polyglactin) was placed at the bottom of the tracheal incision on both the right

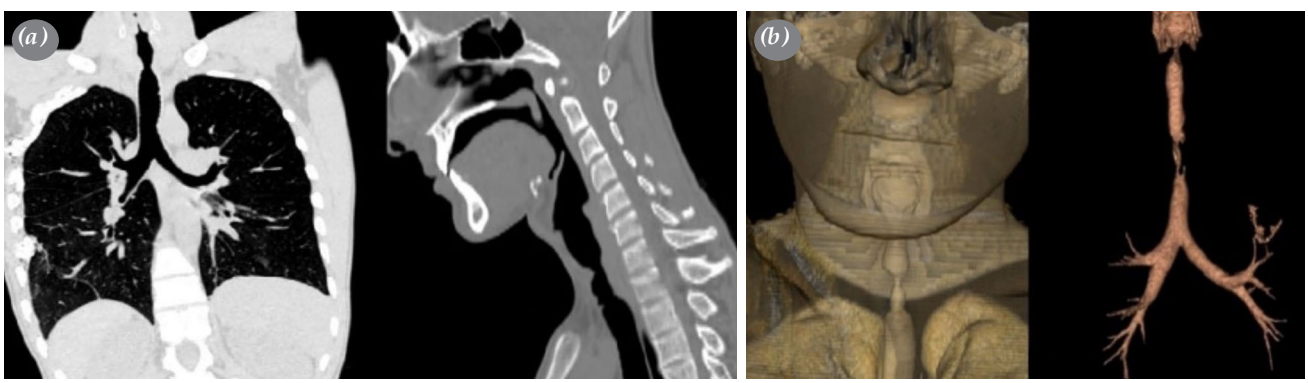

Figure 1. (a) PITS neck and thorax CT view. **(b)** PITS virtual bronchoscopy image.
PITS: Post-intubation tracheal stenosis; CT: Computed tomography.

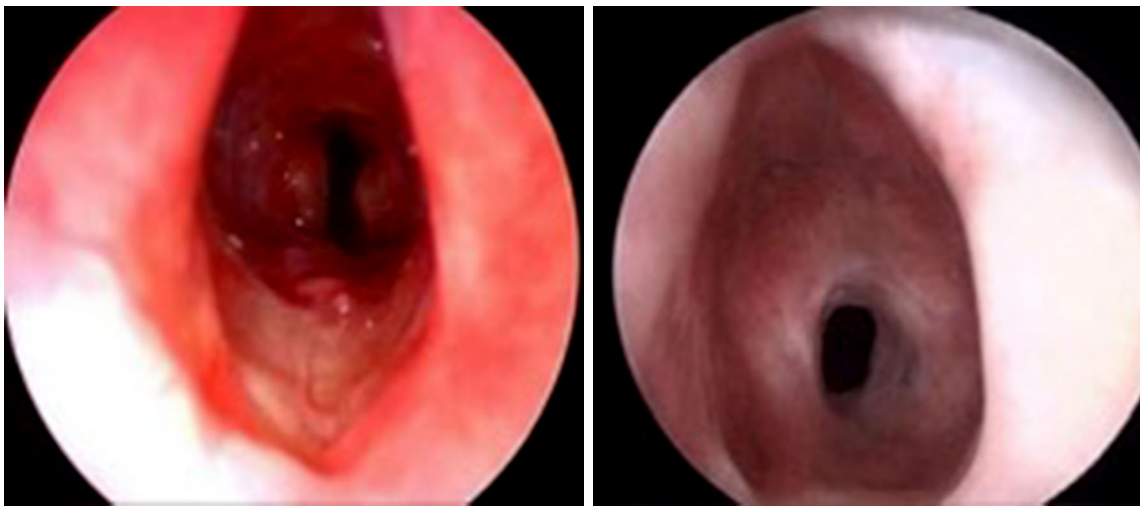

Figure 2. Post-intubation tracheal stenosis tracheal lumen view using bronchoscopy.

and left sides under 1-2 cartilages to prevent the trachea from shifting distally, when the horizontal incision was completed. The orotracheal intubation tube was pulled proximally, and the distal trachea was intubated through the incision site with a second spiral tube (Figure 3c). This intubation tube was, then, connected to the ventilator using a previously prepared sterile circuit and included in the operating field. Circular resection of the upper and lower borders of the lesion was completed, and the stenotic area was removed. A retention suture was then placed on the right and left sides of the upper part of the trachea.

Anastomosis was performed started from the posterior wall. The posterior membranous wall was continuously anastomosed using a 3.0 polyglactin suture. Then, a new 3.0 polyglactin was used to continuously suture from the right lateral wall to the middle of the anterior wall. The midline was accessed, and continuous anastomosis was performed with a 3.0 polyglactin from the left lateral wall (Figure 4a). After all sutures were placed in the trachea, the intubation tube previously placed in the distal trachea was removed and circularly tied, with the knots left outside (Figure 4b). The orotracheal intubation tube was then carefully reinserted distally. Retention sutures placed on the right and left lateral walls, both above and below the anastomosis line, were connected to each other as U-shaped retention sutures (Figure 4c).[6] The patients without any postoperative comorbidities which required mechanical ventilation were extubated in the operating room at the end of the procedure.

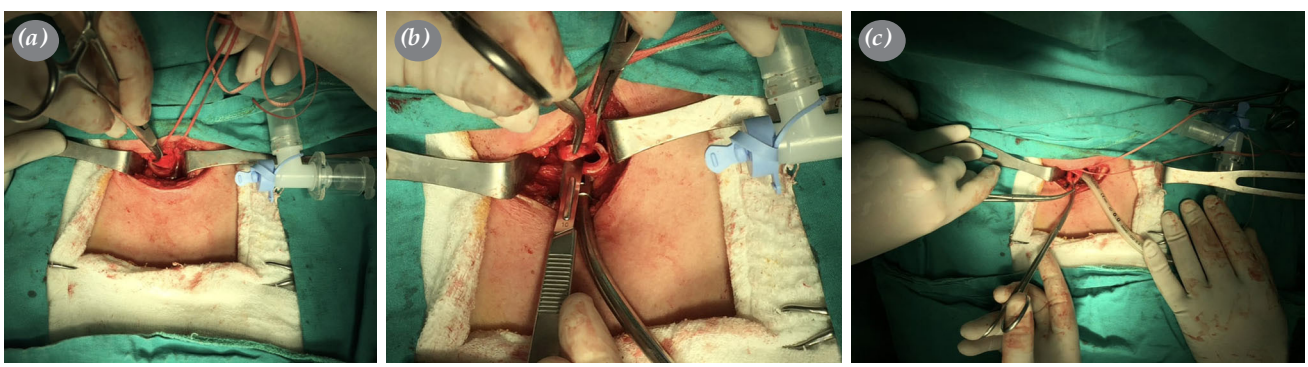

Figure 3. Thoracic resection and reconstruction. **(a)** After determining the proximal and distal areas of the stenosis, the trachea was first cut below the stenosis. **(b)** Viewing the tracheal lumen from below, an incision was made in front of the intact trachea just above the proximal point where the stenosis began. **(c)** The orotracheal intubation tube was pulled proximally, and the distal trachea was intubated through the incision site with a second spiral tube.

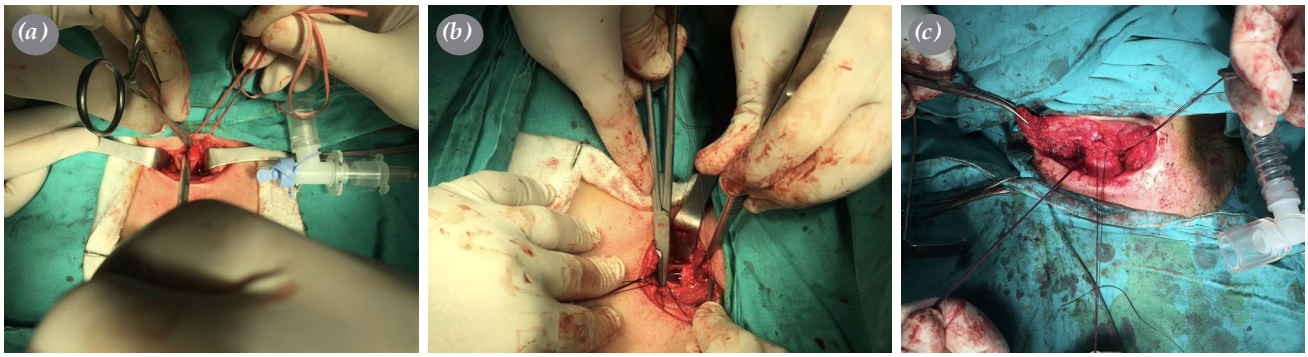

Figure 4. Thoracic resection and reconstruction. **(a)** Anastomosis was performed starting from the posterior wall and the midline was accessed. **(b)** Placement of all sutures in the trachea, removal of the intubation tube placed in the distal trachea and circular tying of knots. **(c)** Retention sutures placed on the right and left lateral walls both above and below the anastomosis line were tied together as U-shaped retention sutures.

Statistical analysis

Statistical analysis was performed using the IBM SPSS version 23.0 software (IBM Corp., Armonk, NY, USA). Categorical data were presented as number (n) and percentage (%); measurement data were presented as mean ± standard deviation (SD), median (min-max) values. Chi-square or Fisher test was used in the comparison of categorical data. Compliance with normal distribution was assessed with the Shapiro-Wilk test. Mann Whitney U test was used in the comparison of measurement data that did not show normal distribution. A p value of <0.05 was considered statistically significant.

RESULTS

Of 44 patients with PITS who underwent tracheal resection and reconstruction, all received rigid bronchoscopy to determine the location and size of the lesion in the trachea. In 41 (93.2%) patients, cervical and thoracic CT was performed in addition to bronchoscopy to determine the localization of the lesion and the relationship of the trachea with adjacent structures. All patients included in the study had stridor. Additionally, 41 (93.2%), 15 (34.1%), 10 (22.7%) patients, and eight (18.2%) presented with symptoms of dyspnea, hoarseness, expectoration, and cough, respectively. Trauma was the most prevalent reason for intubation (Table 1).

Twenty-six patients (59.1%) had at least one comorbidity. Coronary artery disease was present in 17 (38.6%), hypertension in 15 (34.1%), diabetes mellitus (DM) in seven (15.9%), chronic obstructive pulmonary disease (COPD) in seven (15.9%), cerebrovascular disease (CVA) in three (6.8%), epilepsy in two (4.5%), and obesity in two (4.5%) patients. Thirty-eight (86.4%) patients received collar incision. Four (9%) patients underwent partial sternotomy, one (2.2%) underwent median sternotomy, and one (2.2%) with proximal carina stenosis underwent right thoracotomy. Ten (22.7%) patients had a history of preoperative tracheostomy. Thirty (68.2%) patients underwent dilatation via rigid bronchoscopy for stenosis assessment and symptomatic treatment prior to tracheal resection.

Tracheal resection was divided into two sections based on the surgical site: the lower half and upper half of the trachea. The first 5 cm starting from the vocal cords was considered the upper half of the trachea, whereas the section from the end of the upper half to the carina was considered the lower half. Stenosis was located in the upper and lower half of the trachea in 33 (75%) and 11 (25%) patients, respectively. Comparing the prevalence of complications between the upper and lower halves of the trachea, 14 of 33 (42.4%) patients who underwent resection of the upper half experienced complications. In contrast, two of 11 (18.2%) patients who underwent resection of the lower half experienced complications (p=0.27).

The patients were further divided into two groups (below 3 cm and above 3 cm) according to the length of the tracheal segment removed during the operation. The length of the tracheal segment removed during surgery was below 3 cm in 26 (59.1%) and above 3 cm in 18 (40.9%) patients. Complication rates based on the length of the removed tracheal segment were as follows: 11/26 patients (42.3%) with a segment length of <3 cm experienced complications, whereas 5/18 patients (27.8%) with a segment length of ≥3 cm experienced complications (p=0.32) (Table 2).

Table 1. Preoperative patient data

Variables	n	%	Mean	Range
Age (year)			48.2	13-68
Sex				
Male	32	72.7		
Female	12	27.3		
Presenting symptoms				
Stridor	44	100		
Dyspnea	41	93.2		
Hoarseness	15	34.1		
Expectoration	10	22.7		
Cough	8	18.2		
Reasons for intubation				
Trauma	13	29.5		
COVID-19 pneumonia	9	20.4		
Surgery	8	18.1		
Myocardial infarction	7	15.9		
Others (CVA, epilepsy, heart failure, poisoning)	7	15.9		
Comorbidity				
Coronary artery disease	17	38.6		
Hypertension	15	34.1		
Diabetes mellitus	7	15.9		
COPD	7	15.9		
CVA	3	6.8		
Epilepsy	2	4.5		
Obesity	2	4.5		

COVID-19: Coronavirus disease 2019; CVA: Cerebrovascular disease; COPD: Chronic obstructive pulmonary disease; .

Forty-two (95.4%) patients were extubated in the operating room and admitted to the intensive care unit (ICU). Two patients could not tolerate postoperative extubation and were extubated in the ICU within one to two days.

In total, 16 (36%) patients developed complications (n=5 females, n=11 males) (p=0.73), and some patients had multiple complications. Complications were classified as surgical site infection in three (6.8%), vocal cord paralysis in six (13.6%), re-stenosis in 10 (22.7%), and anastomotic dehiscence in two (4.5%) patients.

Rigid bronchoscopy was performed in 10 patients with stridor in the first postoperative week and stenosis was observed. In one patient, dense granulation tissue and stenosis were observed circularly in the anastomosis line. This patient underwent anastomotic line revision. In one patient, partial granulation tissue was observed to cover the anterior part of the anastomosis line and stenosis was observed. This patient was not considered for reoperation due to

Table 2. Analysis of complications

	n	%	*p*
Sex			0.73
Male	11	25	
Female	5	11.3	
Age grouping (years)			0.72
<45	6	13.6	
>45	10	22.7	
Surgical site of tracheal resection			0.27
Trachea upper half	14	31.8	
Trachea lower half	2	4.5	
Length of tracheal segment removed during operation			0.32
<3 cm	11	25	
>3 cm	5	11.3	
Comorbidity status			0.72
Comorbidity (+)	10	22.7	
Comorbidity (–)	6	13.6	
Presence of preoperative tracheostomy			0.45
Preoperative tracheostomy (+)	5	11.3	
Preoperative tracheostomy (–)	11	25	

Table 3. Postoperative complications

	n	%	Therapy/results	
Surgical site infection	3	6.8	Antibiotics	3
Vocal cord paralysis	6	13.6	Temporary	5
			Permanent	1
Re-stenosis	10	22.7	Reoperation	1
			Stent	1
			Dilatation	8
Anastomotic dehiscence	2	4.5	Revision	2

resection over 3 cm. Instead, T-tube application was performed, as the symptoms did not regress in rigid bronchoscopy performed at two-week intervals. The tube was terminated at six months postoperatively and no problem was detected during follow-up. In eight patients, it was decided to follow-up, as minimal fibrotic tissue was observed in the suture line in rigid bronchoscopy, dyspnea was described with low intensity with exertion and there was no stridor. Afterwards, control rigid bronchoscopy performed in eight patients at four weeks postoperatively showed good tracheal lumen patency and good healing of the anastomosis line (Table 3).

Anastomotic dehiscence occurred on an average one week postoperatively. These patients were re-operated. Intraoperatively, anterior suture separation was noted in two patients, which was re-sutured. No problems were observed during the postoperative follow-up period of the patients. The median length of stay in the hospital was 5 (range, 4 to 16) days.

DISCUSSION

Post-intubation tracheal stenosis still persists despite technologically advanced and improved intensive care conditions and intubation-associated innovations. It requires treatment and increases mortality and morbidity, if left untreated. The present study reviewed the treatment options, follow-up period, and factors that might cause complications in patients who underwent tracheal resection due to PITS. This study underlines five key points: *(i)* All patients had stridor and tracheal resection and end-to-end anastomosis were preferred as the primary treatment. *(ii)* Most of the cases had at least one of the serious comorbid diseases, primarily coronary artery disease, hypertension, and diabetes mellitus, which are associated with an increased risk of morbidity and complications in operated patients. *(iii)* Stenosis was located in the upper half of the trachea in 3/4 of the patients and in the lower half of the trachea in 1/4. More complications were observed in resections performed in the upper half of the trachea. *(iv)* The length o f the tracheal segment removed at surgery was less than 3 cm in 26 (59.1%) patients. *(v)* In all cases, U-shaped retention sutures were placed from the upper and lower parts of the anastomosis area to the right and left lateral tracheal walls and no jaw-neck suture was applied.

In the literature, PITS occurs in 0.1 to 20% of chronic intubation cases.[7] Nevertheless, only a much smaller rate of these cases develop into clinically significant stenoses.[8] Patients usually develop symptoms, when the stenosis occupies approximately 70% of the regular tracheal lumen. Therefore, stenoses that are not associated with significant narrowing of the trachea cannot be detected. Surgical treatment is considered for a small number of symptomatic patients with advanced stenosis. Dyspnea and cough are considered late non-specific symptoms of tracheal stenosis. With symptoms similar to those of COPD or asthma, the diagnosis may be delayed, and patients are often followed for a certain period with bronchodilator therapy. In the present study, all patients had stridor, and 41 patients (93.2%) had dyspnea. Consistently, Grillo[2] and Pearson and Andrews[9] reported in their series that stridor and dyspnea on exertion were the significant symptoms of stenosis in patients with PITS.

Treatment of PITS requires experience and a multidisciplinary approach. There are multiple conservative methods, including bronchoscopic balloon dilatation, T-tube, tracheostomy, and stent placement, along with surgical treatment. Tracheostomy or prolonged stenting fail to help with recovery,

enlarging the damaged area and complicating further surgery.[4] A study by Marel et al.,[10] which compared surgical methods with therapeutic bronchoscopy (Nd-YAG laser, electrocautery, or stenting) in 80 patients with benign tracheal stenosis. The study reported that interventional bronchoscopy may be a viable alternative for patients who are not eligible for surgery. Furthermore, another study suggested that laser ablation and endoluminal stenting could provide palliation until the optimal time for surgery, particularly in patients with subglottic stenosis.[11] A study by Grillo et al.[12] reported that laser treatment was unsuccessful at a rate of 23 to 43%, and conservative methods could be successful only in selected correct cases. Segmental tracheal resection has been the most preferred method for PITS treatment.[11,13] In our study, we preferred tracheal resection and end-to-end anastomosis in the treatment of 44 patients with PITS, who had no metabolic, neurological, and psychological conditions, and who were considered to have an uneventful postoperative period.

A history of preoperative tracheostomy may cause intense fibrosis on both the inner and outer surface of the trachea, altering its anatomical structure. This complicates intraoperative dissection, increasing the likelihood of complications.

The occurrence of comorbidities in operated patients is associated with an increased risk of morbidity and complications. Complications may occur as a result of disrupted collateral circulation at the tip of the incised trachea. It is well-established that DM has adverse effects on tissue healing due to impaired microcirculation. Obesity restricts surgical field exposure and reduces the patient's ability to adapt to postoperative respiratory exercises. In the present study, 10 of 16 patients with complications had comorbidities. Regarding comorbidities, hypertension was noted in six patients. Hypertension-related problems in vascular structures may have caused difficulties and problems in healing of the anastomosis line. Hypertension was followed by DM. Poor blood glucose regulation in patients with DM leads to impaired blood supply at the surgical site. Therefore, this may cause delayed wound healing and even the occurrence of infections at the wound site.

For resections in the upper half of the trachea, the likelihood of complications increases based on the proximity to the vocal cords and the course of the recurrent laryngeal nerve through the lateral wall of the trachea.[3] Therefore, in the present study, there was a higher number of complications associated with resections in the upper half of the trachea. Vocal cord paralysis was detected in six patients. Bilateral vocal cord paralysis was noted in one of these patients. A permanent tracheostomy was performed in the early postoperative period, because the patient developed dyspnea on postoperative Day 1 and aspirated secretions. Five patients with hoarseness complaints and post-prandial cough were referred to an otolaryngology clinic for consultation. Unilateral vocal cord paralysis was noted in five patients. Complaints in four patients improved within six months postoperatively. In one patient, hoarseness was considered permanent. The patient underwent vocal cord lateralization procedure. Vocal cord paralysis should not be considered a worrying condition. Patients' symptoms may improve within six months. Vocal cord lateralization in patients without improvement as performed by the otorhinolaryngology clinic can aid in recovery from the symptoms.

Surgical site infection was noted in three patients. Redness, increased temperature, and a small amount of discharge from the suture line were seen at the surgical incision site. Symptoms improved within one week upon medical treatment and anti-biotherapy.

In the present study, 30 (68.2%) of the 44 operated patients had at least one previous dilatation. Re-stenosis was observed in these patients at Weeks 4 to 6 upon dilatation. We consider segmental tracheal resection and end-to-end anastomosis the most effective method in patients with PITS.

The main principles are suggested to reduce complications associated with tracheal resection. These include reduction of excessive tension force on the anastomosis, preservation of trachea vascularity, and meticulous dissection. Release techniques are performed to reduce the tension force at the anastomosis. Although the resection limit was 2 cm in a previous study, this limit could have been increased up to 6.5 cm owing to the development of release techniques.[14]

Typically, the tip of the jaw and anterior aspect of the sternum are sutured together to reduce the tension of the anastomosis line and to prevent separation of the anastomosis line with hyperextension of the neck during the postoperative period. This suture remains in place for an average of one week, and difficulty in oral intake, aspiration, muscle joint pain, and mobilization problems during that week disrupt the quality of life in affected patients. Furthermore, U-shaped retention sutures were placed on the right and left lateral tracheal walls above and below

the anastomosis site using polyglactin sutures in our clinic, and anastomotic tension is controlled by performing various neck movements, including preoperative hyperextension. None of the patients who received this procedure had anastomosis line tension and no anastomosis-related complications, particularly dehiscence, were observed.[6]

The novel Coronavirus disease 2019 (COVID-19) pandemic affected the entire world, and the occupancy rates in ICUs increased due to COVID-19-associated pneumonia.[15] The majority of ICU patients with COVID-19 pneumonia required intubation.[16,17] Therefore, unlike previous studies, nine patients (20.4%) in our study needed intubation due to COVID-19 pneumonia and subsequently developed tracheal stenosis. We believe that the increase in the number of intubated patients in ICUs due to the COVID pandemic led to an increase in cases of PITS.

In the present study, 16 (36%) of 44 operated patients had complications. A study by Grillo et al.[12] reported complications in 164 (32.6%) patients in a series of 503 cases. A study by Wright et al.[4] reported complications in 174 (29.5%) out of a total of 589 cases of PITS. Therefore, the complication rate in the present study is consistent with that reported in the aforementioned studies.

Re-stenosis occurs on an average at four to six weeks postoperatively. It is difficult to determine the cause of re-stenosis. Overvoltage and devascularization are considered the main causes. In the treatment, dilatation, T-tube, tracheostomy, and re-operation are considered. Donahue et al.[18] reported re-stenosis in 32 (7.1%) patients in a study of 450 patients, 50% of whom were re-operated. In the present study, granulation and re-stenosis were noted in 10 (22.7%) patients. Two patients had stridor; one of these patients was re-operated, and the other patient had a T-tube. Eight patients reported minor dyspnea on exertion and no stridor. Upon control rigid bronchoscopy, eight patients had granulation at the suture line at Week 4 postoperatively. Intraoperative dilatation was performed in five patients, and all patients who underwent bronchoscopy were prescribed etodolac 10 mg/kg/day for two weeks. During the follow-up period, no symptoms occurred and no additional treatment was necessary. The occurrences of postoperative re-stenosis in the present study were mild and did not require further intervention.

The main limitations to this study include its single-center, retrospective design and relatively small sample size.

In conclusion, due to the anatomical challenges associated with the trachea, there is only a limited number of studies involving patients who underwent tracheal surgery evaluating surgical techniques and complications in the literature. Although factors affecting tracheal resection, including the reason for intubation, age, sex, location of the stenotic region, and length of the resected tracheal segment, were associated with significant results in large case series, no statistically significant differences were noted in the present study. Previous studies still provide guidance on selecting the eligible patients and preventing complications. Owing to the retention sutures applied in our clinic, the patients did not require jaw–neck suture application. Accordingly, patient comfort was ensured in the postoperative period, decreasing the prevalence of anastomosis-related complications. Based on these findings, we believe that tracheal resection and reconstruction surgery, which is performed with care in experienced clinics in cases of tracheal stenosis, can be performed by minimizing the possibility of complications.

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

Author Contributions: Have given substantial contributions to the literature search, data collection, study design, analysis of data, manuscript preparation and review of manuscript: M.S., O.T., S.K., A.T., A.A.; Analysis interpretation of the data and review of manuscript. All authors have participated to drafting the manuscript: M.S., O.T., A.A., C.T.; Revised it critically. All authors read and approved the final version of the manuscript: M.S., O.T., S.K.

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