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RESEARCH ARTICLE

Efficacy of Endobiliary Radiofrequency Ablation in the Treatment of Benign Biliary Strictures

Benign Biliyer Darlıklarının Tedavisinde Endobiliyer Radyofrekans Ablasyon Yöntemi Etkinliği

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ABSTRACT

Objective: This study aimed to evaluate the efficacy of endobiliary radiofrequency ablation (RFA) in the percutaneous treatment of benign bilioenteric anastomotic strictures that are resistant to percutaneous balloon dilatation and long-term drainage.

Materials and Methods: The clinical data of 22 patients who underwent endobiliary RFA between September 2016 and June 2019 were included in the study. Indications comprised bilioenteric anastomotic strictures secondary to cholecystectomy (n = 8; 36.36%), the Whipple procedure (n = 6; 27.28%), Klatskin tumor (n = 6; 27.28%), and anastomotic strictures related to transplantation (n = 2; 9.09%). In these patients treated with endobiliary RFA, technical and clinical success rates, recurrence, and procedure-related morbidity and mortality rates were evaluated.

Results: Endobiliary RFA was performed in 19 patients with bilioenteric anastomotic strictures resistant to standard percutaneous treatment, in one patient with a bilioenteric anastomotic stricture accompanied by a significant stone burden in the bile ducts, and in two patients with post-transplant anastomotic strictures. Marked reductions in serum biomarkers were observed after the procedure. The mean duration of drainage catheter use prior to endobiliary RFA was 82 days (standard deviation: 39 days). During this period, seven patients (31.81%) developed symptoms of cholangitis due to catheter-related complications and were treated with catheter exchange and appropriate antibiotics. The mean symptom-free period after endobiliary RFA and catheter removal was 587 days. No major complications related to endobiliary RFA were observed. The technical success rate was 100%, and the primary clinical success rate was 95.4%.

Conclusion: Currently, there is no established standard definitive treatment for benign biliary strictures. Recurrence rates associated with all treatment modalities remain unacceptably high. In our study, endobiliary RFA yielded effective results in a selected group of patients who had been treated with percutaneous interventions but, despite the benign etiology, could not be freed from catheterization, which significantly impaired patient comfort.

Keywords: Benign biliary stricture, endobiliary radiofrequency ablation, percutaneous treatment

ÖZET

Amaç: Perkütan balon dilatasyonuna ve uzun süreli drenaja dirençli olan benign bilioenterik anastomoz darlıklarının perkütan tedavisinde endobiliyer radyofrekans ablasyon (RFA) etkinliğini değerlendirmek amaçlandı.

Gereç ve Yöntemler: Eylül 2016-haziran 2019 yılları arasında endobiliyer RFA uygulanmış 22 hasta bulguları çalışmaya dahil edildi. Endikasyon olarak kolesistektomi (n:8; % 36,36), Whipple prosedürü (n:6 ;%27,28), Klatskin tümörü (n:6 %27,28) nedeniyle bilioenterik anastomoz darlıkları ve nakile (n:2 % 9,09) bağlı anastomoz darlıkları vardı. Endobiliyer RFA uygulanan bu hastalarda teknik ve klinik başarı, nüks, prosedüre bağlı morbidite ve mortalite oranları incelendi.

Bulgular: Standart perkütan tedaviye dirençli 19 hasta, bilioenterik anastomoz darlığı ve safra yollarında belirgin taş yükü bulunan tek hasta ve karaciğer nakilli anastomoz darlığı bulunan 2 hastaya endobiliyer RFA uygulandı. Prosedür sonrası serum belirteçlerinde belirgin düşüşler gözlendi. Endobiliyer RFA öncesinde drenaj kateterlerinin ortalama kullanım süresi 82 gün (standart sapma 39 gün) oldu. Bu süreçte yedi hastada (% 31,81) kateter ilişkili komplikasyonlar nedeniyle kolanjit semptomları gelişti ve kateter değişimi ve uygun antibiyotikler ile tedavi edildi. Endobilier RFA ve kateter çıkarıldıktan sonraki ortalama semptomsuz geçen süremiz ortalama 587 gün oldu . Endobiliyer RFA ya bağlı majör komplikasyon izlenmedi. Teknik başarı oranımız % 100, primer klinik başarı oranımız % 95,4 idi.

Sonuç: Benign biliyer darlıklarının günümüzde standart kesinleşmiş tedavisi yoktur. Tüm modalitelerin nüks oranları halen kabul edilebilir düzeylerde değildir. Çalışmamızda perkutan girişimle tedavi edilmiş ancak benign bir neden olmasına rağmen hasta konforunu ciddi oranda bozan kateterizasyondan kurtulamayan seçilmiş hasta grubunda endobiliyer RFA sonuçlarının etkin olduğu bilgisi elde edildi.

Anahtar Kelimeler: Benign biliyer darlık, endobiliyer radyofrekans ablasyon, perkütan tedavi

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INTRODUCTION

Benign biliary stricture is a rare condition, with most cases resulting from surgical trauma during open or laparoscopic cholecystectomy. Biliary strictures may also develop during the healing process following hepatobiliary surgeries that involve the creation of a bilioenteric anastomosis, such as liver transplantation and the Whipple procedure, due to ischemia or inflammation (1). Patients may be asymptomatic or may present with jaundice, pain, pruritus, bile stones, cholangitis, sepsis, or biliary cirrhosis. Treatment options include endoscopic interventions, percutaneous interventions, and surgical reconstruction. Although the choice of optimal treatment depends on the operator, it remains controversial (2). No significant differences have been demonstrated in success rates among various techniques, including surgical treatment, percutaneous interventional treatment, multiple plastic stent placement, or covered metallic stents (3). Recurrence rates associated with these procedures are high, with an average of approximately 20% (2). Although endobiliary radiofrequency ablation (RFA) is primarily used in the treatment of malignant biliary obstruction, data on its use in the treatment of benign bilioenteric anastomotic strictures remain limited (3–5).

This study aimed to evaluate the safety and efficacy of endobiliary RFA in the treatment of benign bilioenteric anastomotic strictures that are resistant to percutaneous balloon dilatation and long-term drainage.

MATERIALS AND METHODS

This retrospective study was conducted in accordance with the ethical principles and was approved by the local ethics committee (No. 2306/2020). Prior to treatment, the benefits and potential complications of the procedure were explained to the patients, and written informed consent was obtained. Institutional data records between September 2016 and June 2019 were retrospectively reviewed. Data from 22 patients who underwent endobiliary RFA were obtained. Demographic characteristics of the patients were recorded. Exclusion criteria included the presence of malignant biliary strictures or response to standard percutaneous treatments. The study population comprised 19 patients who did not respond to balloon dilatation followed by long-term drainage with large-caliber catheters, one patient who developed cholestatic findings and large intrahepatic bile duct stones secondary to a bilioenteric anastomotic stricture, and two patients who developed anastomotic strictures after liver transplantation. Clinical data obtained from patient records and radiological data from the hospital imaging archive system were reviewed. Data regarding technical success, clinical success, recurrence, and procedure-related morbidity and mortality were collected. Technical success was defined as the spontaneous passage of bile into the intestines via the natural biliary pathway following removal of the existing catheter. Clinical success was defined as the absence of cholestatic findings and normalization of related laboratory parameters, including aspartate aminotransferase (AST), alanine aminotransferase (ALT), gamma-glutamyl transferase (GGT), total bilirubin, and alkaline phosphatase.

Complete blood count, prothrombin time, partial thromboplastin time, international normalized ratio (INR), and platelet count were assessed. Patients with an INR < 1.5 and a platelet count > 100,000/mL were considered suitable for the procedure. All procedures were performed under moderate sedoanalgesia and local anesthesia. Sedoanalgesia was administered by an external anesthesia team using a combination of fentanyl (50–100 µg), midazolam (3–4 mg), ketamine (10–20 mg), and propofol (20–50 mg). For local anesthesia, 10 cc of prilocaine was used. After placement of a 0.035-inch guidewire (Radifocus® Guidewire M Stiff Type Guide Wire, Terumo) through the existing catheter with its tip positioned in the intestine, a 10F vascular sheath was introduced, and cholangiograms were obtained to localize the stricture. An 8F (2.6 mm), 90-cm bipolar RFA probe (Habib Percutaneous HBP, EMcision) was advanced over the guidewire and positioned centrally within the stricture. The distal end of the catheter contains two stainless steel electrodes spaced 8 mm apart, generating thermal energy over a 25-mm zone (Figure 2B). The RFA probe was connected to a generator (ERBE, VIO), and ablation was performed twice using a power output of 7 W for a total duration of 90 seconds (40 + 40 + 10 seconds), in accordance with the manufacturer's protocol. In patients with both right and left biliary drainage catheters, endobiliary RFA was performed separately for each side. Following endobiliary ablation, balloon dilatation was carried out using high-pressure balloon catheters with diameters of 8–10 mm (Mustang™ PTA Balloon Dilatation Catheter, Boston Scientific), after which a 14F internal–external biliary drainage catheter (Biliary Drainage Catheters, Bioteque Corporation) was placed (Figure 1a–d). A broad-spectrum antibiotic effective against biliary pathogens (cefixime 400 mg), initiated prior to treatment, was recommended to be continued for 15 days after the procedure. The first follow-up evaluation was performed 30 days later by injecting contrast material through the existing catheter. In patients with no residual stricture on cholangiography and normal passage of contrast into the intestine, a 5F safety catheter with its distal tip positioned in the bowel was placed. After two weeks, patients were re-evaluated using the same method, and in the absence of signs of cholangitis or cholestasis, the catheter was removed.

After completion of treatment, patients were followed at 3-month intervals during the first year and at 6-month intervals thereafter. Follow-up assessments included hepatobiliary ultrasonography and evaluation of laboratory parameters (AST, ALT, total bilirubin, GGT, and alkaline phosphatase).

Statistical Analysis

Statistical analyses were performed using IBM SPSS (Statistical Package for the Social Sciences) Statistics version 31. Descriptive statistics, including mean, standard deviation, median, quartiles, and minimum–maximum values, were used for numerical (quantitative) variables. Frequency tables with counts and percentages were used for categorical (qualitative) variables. To determine whether statistically significant differences existed between dependent numerical

variables measured at two different time points (pre- and post-treatment), difference values were first calculated. The normality of data distribution was assessed using the Kolmogorov–Smirnov and Shapiro–Wilk tests. For data that did not demonstrate a normal distribution, the Wilcoxon signed-rank test was used to evaluate differences between paired measurements. A confidence level of 95% was applied, and p values < 0.05 were considered statistically significant.

Sample Size and Power Analysis

Power analysis for the sample size of 22 patients was conducted using data from the direct bilirubin variable, which was considered the primary outcome parameter. With an effect size of 0.68, a margin of error of 0.05, and a confidence level of 95%, the minimum required statistical power of 80% to detect a difference of 2.48 units was achieved, indicating that the sample size was adequate for the study.

RESULTS

Endobiliary RFA was performed in 22 patients (mean age, 60.5 years; range, 31–80 years), of whom 81.81% (n = 18) were male and 18.18% (n = 4) were female, who presented to our unit between September 2016 and June 2019. Presenting symptoms among patients undergoing endobiliary RFA included jaundice (n = 12), right upper quadrant pain (n = 5), pruritus (n = 17), and cholangitis (n = 15), at varying frequencies. Indications for percutaneous endobiliary RFA are listed in Table 1. In 20 patients, the initial intervention was performed via a percutaneous approach due to a history of

Table 1. Indications for percutaneous endobiliary RF ablation

		Etiology		
Etiology	**Frequency**	**Percent**	**Cumulative Frequency**	**Cumulative Percent**
Cholecystectomy (iatrogenic)	8	36.36	8	36.36
Klatskin tm	5	22.73	13	59.09
Periampullary region tm	1	4.55	14	63.64
Pancreas tm	5	22.73	19	86.36
Hepatocellular carcinoma	1	4.55	20	90.91
Transplantation	2	9.09	22	100.00

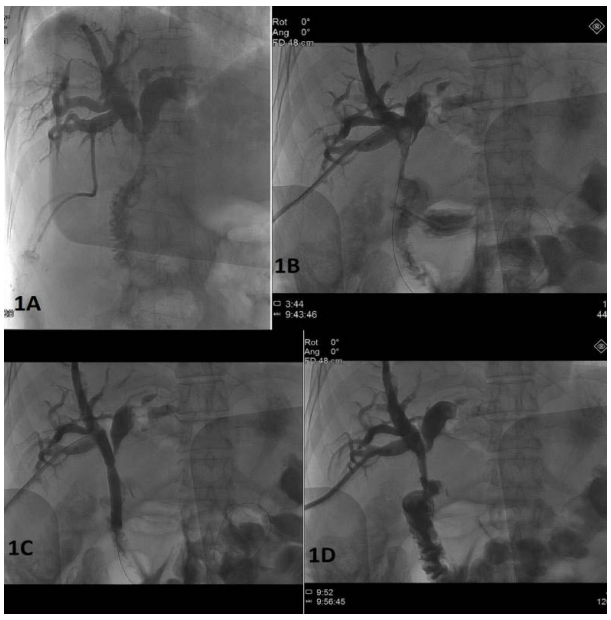

Figure 1.
- Standard percutaneous treatment approach in bilioenteric anastomotic stricture, long-term catheterization
- Endobiliary rf ablation application in stricture area
- Dilatation of stricture area through balloon catheters right after endobiliary rf ablation
- Insertion of a large diameter (10-14F) catheter after endobiliary RF ablation and balloon dilatation

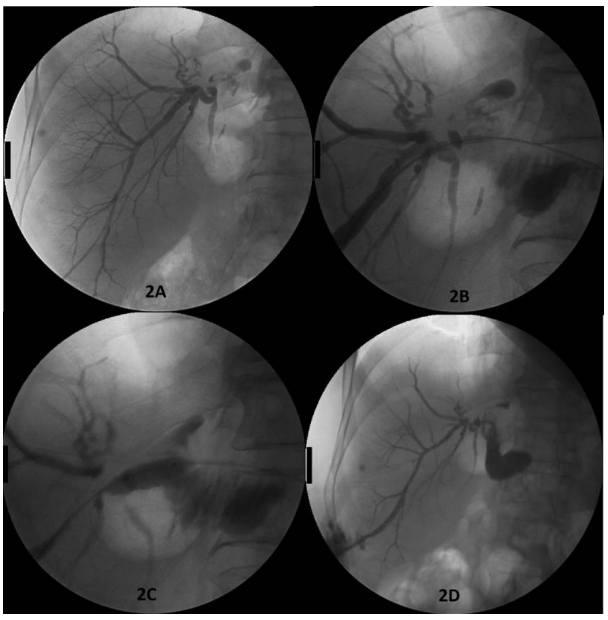

Figure 2.
- Bilioenteric anastomotic stricture in the transplanted liver in percutaneous transhepatic cholangiography
- Endobiliary rf ablation application in stricture area
- Dilatation of the stricture area with balloon catheters right after endobiliary rf ablation
- Insertion of a large diameter (10-14F) catheter after endobiliary RF ablation and balloon dilatation

prior surgical procedures. In the remaining two patients who had undergone liver transplantation, an endoscopic approach was initially attempted. Bilateral access and catheterization were performed in seven patients (31.82%) with bilioenteric anastomoses, and endobiliary RFA was applied from both sides. Right-sided access was used in 14 patients (63.64%), while left-sided access was used in one patient (4.55%).

In the two liver transplant recipients, percutaneous intervention was performed due to unsuccessful endoscopic treatment. To shorten the catheterization period in these immunosuppressed patients, endobiliary RFA and balloon dilatation were performed one month after establishing percutaneous biliary drainage, followed by catheter-based follow-up using a 14F catheter for one month. After this period, control cholangiograms were obtained, and catheterization was continued with a 5F catheter for an additional two weeks. In the absence of cholestasis or cholangitis, the safety catheter was removed (Figure 2a–d). In one patient with common bile duct injury following cholecystectomy who developed a stricture at the bilioenteric anastomosis, multiple large stones were present in the intrahepatic bile ducts. These large intrahepatic stones were visualized using cholangioscopy, fragmented using pneumatic and laser lithotripsy, and removed percutaneously. After percutaneous cholangioscopy and cholangiography, balloon dilatation of the stricture was performed, and a 14F catheter was placed. Despite the absence of cholestasis or cholangitis at the 1-month follow-up, endobiliary RFA was performed for the anastomotic stricture based on a multidisciplinary board decision due to the patient's predisposition to stone formation (Figure 3a–d).

Prior to endobiliary RFA, the mean duration of drainage catheter use was 82 days (standard deviation: 39 days). During this period, seven patients (33%) developed symptoms of cholangitis due to catheter-related complications and were treated with catheter exchange and appropriate antibiotic therapy. In all 19 patients who did not respond to biliary drainage with balloon dilatation and long-term large-caliber catheters, in one patient with a bilioenteric anastomosis in whom intrahepatic stones were fragmented and removed percutaneously, and in the two liver transplant recipients, catheter removal was successfully achieved after endobiliary RFA. The technical success rate was 100%. The primary clinical success rate was 95.94% (n = 21). The mean symptom-free period after endobiliary RFA and catheter removal was 587 days (range: 210–1170 days). In four patients (18.18%) who experienced recurrence of symptoms after the procedure, secondary clinical success was improved by repeat percutaneous intervention consisting of endobiliary RFA, balloon dilatation, and biliary drainage with a 14F catheter for one month (Tables 2 and 3).

Serum biochemical markers in patients who underwent percutaneous biliary intervention and endobiliary RFA demonstrated statistically significant reductions after treatment. Significant differences were observed between pre- and post-treatment values of AST, ALT, GGT, alkaline

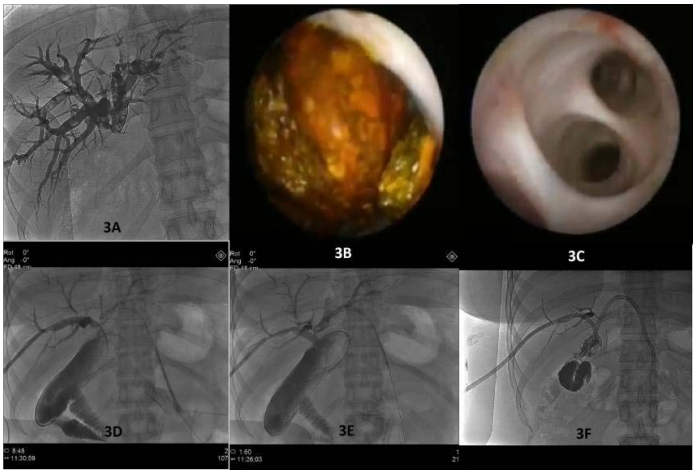

Figure 3.

- Stricture in percutaneous transhepatic cholangiography and many stones in intrahepatic bile ducts are observed in the patient with bilioenteric anastomotic stricture formation following choledochal injury in gall bladder operation.
- Stones are observed in bile ducts in the percutaneous cholangioscopy.
- Monitorization of bile ducts through cholangiography after the pneumatic and laser lithotripsy of biliary stones and their percutaneous removal
- Endobiliary rf ablation application in stricture area
- Dilatation of stricture area through balloon catheters right after endobiliary rf ablation
- Insertion of large diameter (10-14F) biliary catheters accessing through both lobes after endobiliary RF ablation and balloon dilatation

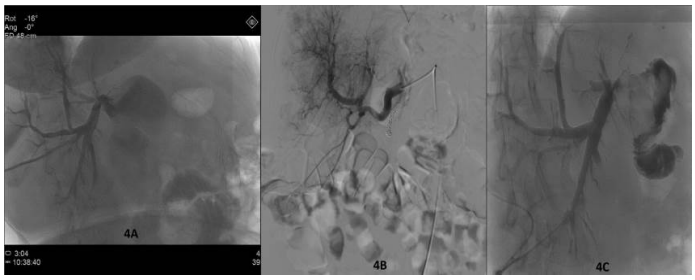

Figure 4.

- Biliary drainage catheter insertion following endobiliary RF ablation in the patient who had bilioenteric anastomosis due to Klatskin tumor.
- Bleeding from the mass in the jejunum, in the vicinity of anastomosis three months after endobiliary RF ablation
- Filling defect for the polypoid tumoral mass filling jejunal loop in percutaneous transhepaticcholangiography (arrow)

Table 2. Descriptive statistics for numerical variables

	The Smallest	The largest	Mean± Standard Deviation
Age	31	80	60,55±10,65
Time from initial biliary intervention to endobiliary radiofrequency ablation (months)	0	7	2,73±1,31
Time elapsed (months) for additional biliary intervention after endobiliary radiofrequency ablation	0	24	3,91±6,63
Duration of additional endobiliary radiofrequency ablation (months)	0	24	2,32±5,81
Symptom-free period following radiofrequency ablation (months)	7	39	19,59±9,88

Table 3. Frequency table for the categories of numerical variables

		Number	Percentage
Time from the first biliary intervention to endobiliary radiofrequency ablation (months)	0	1	4,5
	1	3	13,6
	2	1	4,5
	3	16	72,7
	7	1	4,5
Time elapsed (months) for additional biliary intervention after endobiliary radiofrequency ablation	0	15	68,2
	7	1	4,5
	8	1	4,5
	9	1	4,5
	11	1	4,5
	12	1	4,5
	15	1	4,5
	24	1	4,5
Duration of additional endobulbar radiofrequency ablation (months)	0	18	81,8
	7	1	4,5
	9	1	4,5
	11	1	4,5
	24	1	4,5
Symptom-free period following endoscopic radiofrequency ablation (months)	7	1	4,5
	8	1	4,5
	9	1	4,5
	11	1	4,5
	12	3	13,6
	14	1	4,5
	15	3	13,6
	16	1	4,5
	17	1	4,5
	18	1	4,5
	24	2	9,1
	30	1	4,5
	31	1	4,5
	32	1	4,5
	34	1	4,5
	36	1	4,5
	39	1	4,5
	Total	22	100,0

Table 4. Examination of whether there is a statistically significant difference between serum marker measurements before and after endobiliary radiofrequency ablation

	Mean± Standard Deviation	The Smallest	The Greatest	Median (Q2)	Q1-Q3	p-value
Pre-RF SGOT	560,13±1629,27	13	7729	84	43,25-279,25	
Post-RF SGOT	68,66±212,05	9,2	1017	23,1	15,55-31,52	<0,001
Pre-RF SGPT	89,73±80,64	12	400,2	78,15	38,75-119,2	
Post-RF SGPT	26,27±15,36	6,2	73	23,2	15,4-34,47	<0,001
Pre-RF GGT	376,55±306,54	99	1377	287,5	169,75-389,5	
Post-RF GGT	125,82±103,41	24	422	98,5	55,5-129,25	<0,001
Pre-RF alkaline phosphatase	411,18±214,37	118	983	379	254,25-528	
Post-RF alkaline phosphatase	188,73±92,85	73	422	178,5	112,25-231,25	<0,001
Pre-RF direct bilirubin	3,11±3,85	0,27	17,1	1,77	0,62-3,70	
Post-RF direct bilirubin	0,63±0,50	0,12	1,9	0,41	0,24-0,95	<0,001
Pre-RF total bilirubin	4,23±4,46	0,55	20,02	2,81	1,74-4,31	
Post-RF total bilirubin	1,03±0,76	0,18	2,81	0,82	0,50-1,27	<0,001

Q1: 1. Quarter, Q3: 3. Quarter

phosphatase, direct bilirubin, and total bilirubin ($p < 0.001$) (Table 4).

No complications, including bleeding, perforation, bile leakage, pancreatitis, or cholecystitis, were observed after endobiliary RFA. Three patients experienced transient postprocedural pain that responded to analgesic therapy. In one patient with a history of tumor surgery, signs of gastrointestinal bleeding developed three months after endobiliary RFA. Computed tomography angiography revealed a tumoral mass with active bleeding in the jejunum adjacent to the choledochojejunostomy. Hemostasis was achieved by endovascular coil embolization (Figure 4a, b). This patient died 12 months after endobiliary RFA due to progression of the primary tumor.

DISCUSSION

It was revealed that combining endobiliary RFA with standard percutaneous interventions contributes to a shorter treatment course and a reduction in complications, and that endobiliary RFA is an effective and safe treatment option for patients with resistant biliary strictures. Endoscopic retrograde cholangiopancreatography (ERCP) is the first-line modality for the diagnosis and treatment of biliary strictures. Repeated aggressive endoscopic interventions and placement of multiple plastic stents are generally considered the initial step in management (6–8). When endoscopic access to the biliary system is not feasible, percutaneous techniques serve as an alternative approach (9,10). The percutaneous approach is typically employed in cases where endoscopic access is not possible due to prior surgery or after failed endoscopic treatment (11). The cornerstone of percutaneous management consists of long-term biliary drainage and repeated balloon dilatation procedures (11–17). Metallic stents are not considered appropriate or preferred for the treatment of benign biliary strictures because of frequent recurrent cholangitis and occlusion of the stent lumen (18). Although the use of removable covered stents has been recommended, high rates of stent migration have been reported, particularly in short stricture segments (19,20). Another alternative is the placement of biodegradable stents; however, stent availability is limited, and data regarding their use remain scarce (21). If endoscopic and percutaneous interventions fail, open surgical revision remains the final definitive treatment option. However, surgical management is associated with high complication and recurrence rates (2,22). In the present study, an alternative treatment modality to those reported in the literature was applied for the management of benign biliary strictures. Percutaneous endobiliary RFA was found to be an effective and safe therapeutic option for biliary strictures.

Hu et al. applied balloon dilatation followed by temporary stent placement after endoscopic endobiliary RFA in stenotic segments (4). Supporting these findings, they reported rapid improvement of strictured biliary segments without serious adverse effects after RFA. Similarly, Ozdemir M. et al. applied percutaneous endobiliary RFA and balloon dilatation in 22 patients with benign biliary strictures and achieved a clinical success rate of 88.9% (5). In the study by Akinci D, et al., catheter removal was successfully achieved in all seven patients who could not be liberated from catheterization despite repeated balloon dilatations and long-term drainage after endobiliary RFA (3). In that study, the technical success rate was 100%, and the clinical success rate was 95.2%. In the present study, we achieved a technical success rate of 100% and a clinical success rate of 95.45%. Our results regarding technical success, clinical success, complication rates, and recurrence rates are consistent with those reported in the literature. We believe that the use of large-caliber biliary drainage catheters (14F) with prolonged catheterization, together with the effectiveness of endobiliary RFA, contributed to the high clinical success rate observed in our study. When high-frequency electrical current is applied to tissue via RFA probes, intracellular ions move in opposite directions. This ionic movement generates frictional

heat around the probe, resulting in thermal destruction of scar tissue (23,24). We believe that this destruction of scar tissue enhances the response to balloon dilatation and long-term catheterization and prolongs their effectiveness. Procedure-related complications associated with endobiliary RFA performed via both endoscopic and percutaneous routes, including bleeding, perforation, bile leakage, pancreatitis, and cholecystitis, have been reported more frequently in malignant biliary strictures (25,26). Wener Dolak et al. reported complications such as hepatic infarction, cholangitis, cholangiosepsis, gallbladder empyema, hepatic coma, and newly diagnosed left bundle branch block following endoscopic endobiliary RFA performed for malignant biliary strictures (27). In the present study, three patients experienced abdominal pain that responded to analgesics, and no major complications were observed. We believe that the use of a lower power output (7 W) instead of the 10 W commonly applied in malignant strictures may have prevented thermal injury severe enough to cause complications in the bile ducts and anastomotic region. Further studies are warranted to substantiate this hypothesis with stronger evidence.

Biliary strictures after liver transplantation occur either as proximal strictures at the anastomotic site or as peripheral strictures resulting from ischemic cholangiopathy related to hepatic artery anastomosis. End-to-end anastomotic strictures occur in approximately 8–30% of liver transplant recipients and are typically reported to arise from scar formation at the suture line (28). In the two liver transplant recipients included in our study, endobiliary RFA was performed following unsuccessful endoscopic interventions, based on a multidisciplinary board decision. Complete technical and clinical success was achieved without any significant complications. Moreover, shortening the catheterization period reduces the risk of infection and serious morbidity in immunosuppressed patients. In patients with large and multiple intrahepatic bile duct stones accompanied by recurrent episodes of cholangitis, treatment options extending as far as hepatectomy or even transplantation have been reported in the literature (29). Intrahepatic stones can be removed using percutaneous lithotripsy (30). In this study, we benefited from our experience with percutaneous lithotripsy. After fragmenting bile stones using pneumatic and laser lithotripsy and removing them percutaneously, endobiliary RFA, balloon dilatation, and catheterization for one month were applied to the existing stricture. The patient's benign biliary stricture responded well to treatment, and symptoms regressed. No biliary stone formation, cholestasis, or cholangitis was observed during follow-up. This study demonstrates that patients with a high intrahepatic stone burden secondary to benign biliary stricture can be successfully treated using minimally invasive techniques without the need for surgery.

The primary limitation of this study is its retrospective design. A second limitation is the relatively small sample size and the inclusion of patients with different etiologies within the same study cohort. At present, there are no large-scale studies with substantial case numbers on this topic, and randomized controlled trials are needed. Recurrence remains the most significant challenge in the treatment of benign biliary strictures. Meta-analyses comparing the success rates of different techniques, including surgery, percutaneous treatment, multiple plastic stent placement, and covered metallic stents, have not demonstrated a significant difference among these modalities (3). Recurrence rates remain unacceptably high across all procedures, at approximately 20% (2). In this study, the mean symptom-free period after endobiliary RFA and catheter removal was 587 days (range: 210–1170 days). The addition of endobiliary RFA to standard percutaneous intervention shortened the overall treatment duration and prolonged the symptom-free interval. In standard percutaneous approaches, prolonged catheterization adversely affects patient comfort and may lead to catheter-related infections and cholangitis. The findings of this study indicate that combining endobiliary RFA with standard percutaneous interventions contributes to a reduction in complications.

CONCLUSION

Due to variability in recurrence rates, there is currently no established standard definitive treatment for benign biliary strictures. This study demonstrates that, in a selected group of patients who were treated with percutaneous interventions but could not be liberated from catheterization despite the benign etiology and experienced significant impairment in quality of life, endobiliary RFA is a safe adjunctive technique that enhances the effectiveness of percutaneous treatment.

DECLARATIONS

Conflict of Interest: *The authors declare no conflict of interest.*

Financial Disclosure: *The authors declare that there is no financial conflict of interest related to this study*

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