Recanalization of refractory benign biliary stricture using magnetic compression anastomosis

Authors Sung Ill Jang[1], Kwangwon Rhee[1], Haewon Kim[1], Yong Hoon Kim[1], Jieun Yun[2], Kwang-Hun Lee[3], Seungmin Bang[4], Jae Bok Chung[4], Dong Ki Lee[1]

Institutions Institutions are listed at the end of article.

submitted: 13. June 2013
accepted after revision: 10. September 2013

Bibliography
DOI http://dx.doi.org/10.1055/s-0033-1358907
Published online: 19.11.2013
Endoscopy 2014; 46: 70–74

Stuttgart · New York
ISSN 0013-726X

Corresponding author
Dong Ki Lee, MD PhD
Department of Internal Medicine
Gangnam Severance Hospital, Yonsei University College of Medicine
211 Eonju-Ro, Gangnam-Gu
Seoul
Korea
Fax: +82-2-34633882
dklee@yuhs.ac

Background and study aims: Endoscopic or percutaneous treatments are preferentially attempted for benign biliary stricture (BBS). However, these methods are not feasible if a guide wire cannot be passed through the stricture. This study evaluated the usefulness and technical requirements of magnetic compression anastomosis (MCA) in refractory BBS.
Patients and methods: MCA was performed in patients with BBS that had not been resolved with conventional treatments. One magnet was delivered through the percutaneous transhepatic biliary drainage tract and the other magnet was advanced through three different routes. After magnet approximation and recanalization, an internal drainage catheter was placed for 6 months and then removed.
Results: Seven patients underwent MCA, and recanalization was successfully achieved in five. MCA failure in two cases was attributed to long stenotic segments and parallel alignment of the axes of the magnets. The mean follow-up period after recanalization was 485.2 days. Five patients with successful recanalization showed no MCA-related complications or restenosis.
Conclusions: MCA represents an alternative nonsurgical method of BBS recanalization that cannot be treated with conventional methods.

Introduction

Benign biliary stricture (BBS) can occur as a postoperative complication or a consequence of ischemia or inflammatory diseases such as cholangitis, chronic pancreatitis, primary sclerosing cholangitis, or vasculitis [1, 2]. Surgical management of BBS is associated with high morbidity [3], and it is not suitable for patients with severe cholangitis or complications. Therefore, nonsurgical methods, such as endoscopic or percutaneous approaches, are preferred in the treatment of BBS [3, 4]. However, these methods are feasible only if a guide wire can be passed through the stricture. Severe biliary stricture or complete obstruction can hinder nonsurgical methods, necessitating operations or maintenance of a drainage catheter. In 1998, Yamanouchi et al. [5] suggested magnetic compression anastomosis (MCA) for patients with biliary stricture that cannot be resolved by conventional means. We have previously reported the usefulness of MCA for biliary stricture occurring after living donor liver transplantation (LDLT) [6]. We now report the application of MCA in refractory and completely obstructive BBS of various causes other than as a sequela of LDLT.

Patients and methods

MCA was performed in patients with BBS that had not resolved with conventional endoscopic or percutaneous means. Patients with severe stenosis or complete BBS, through which contrast media or a guidewire did not pass with endoscopic retrograde cholangiopancreatography (ERCP) or percutaneous transhepatic cholangioscopy (PTCS), were included. We used a pair of cylindrical samarium-cobalt (Sm-Co) rare-earth magnets of 5500 gauss (diameter 4 mm, width 10 mm; Taewoong, Kimpo, Korea), which is the same model that was used in previous reports [6].

Method of magnet delivery

The route of magnet delivery for MCA varied. Basically, one magnet was delivered through the percutaneous transhepatic biliary drainage (PTBD) tract. The other magnet was advanced through one of three different routes.

Method 1: PTBD tract and endoscopic approach

This method was used in patient #1. After a transparent cap had been attached to the tip of a colonoscope, a magnet was anchored to the colono-

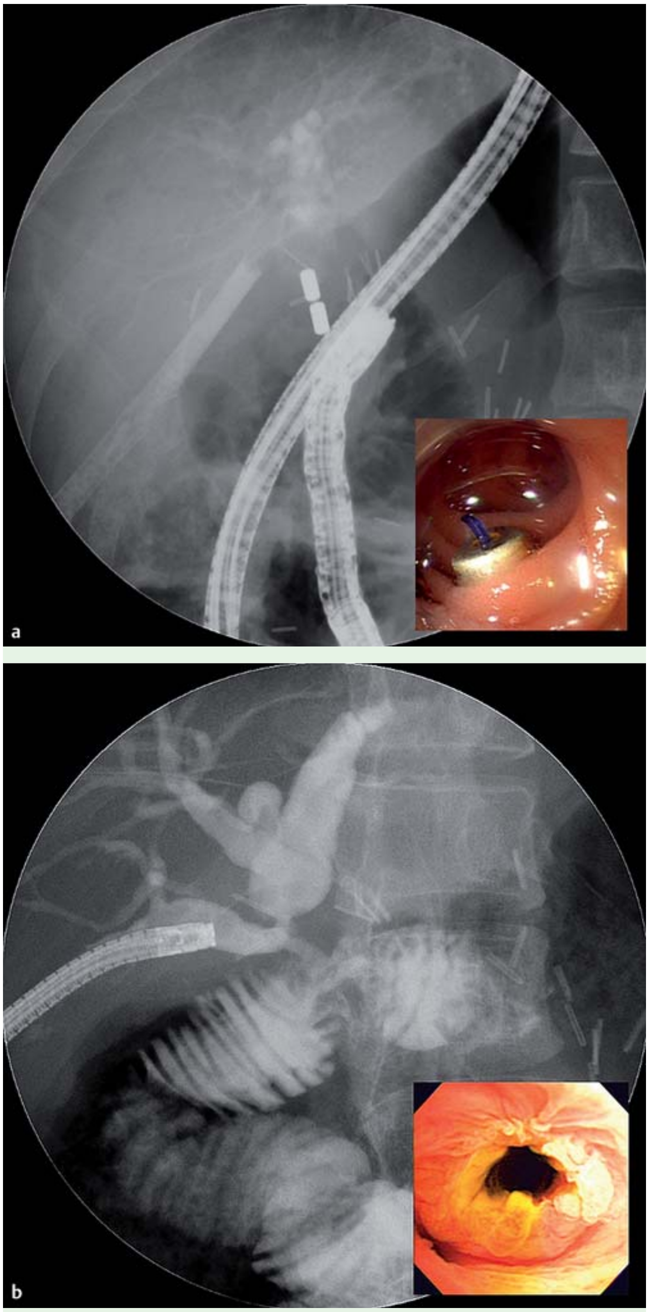

Fig. 1 Cholangiogram showing the process of magnetic compression anastomosis (MCA) in bilioenteric strictures. a A magnet is delivered by colonoscopy, attached using a polypectomy snare. Another magnet is delivered through the PTBD tract and the magnets are successfully approximated. b The indwelling percutaneous transhepatic cholangioscopy (PTCS) catheter is removed, and patency of the anastomosis is confirmed

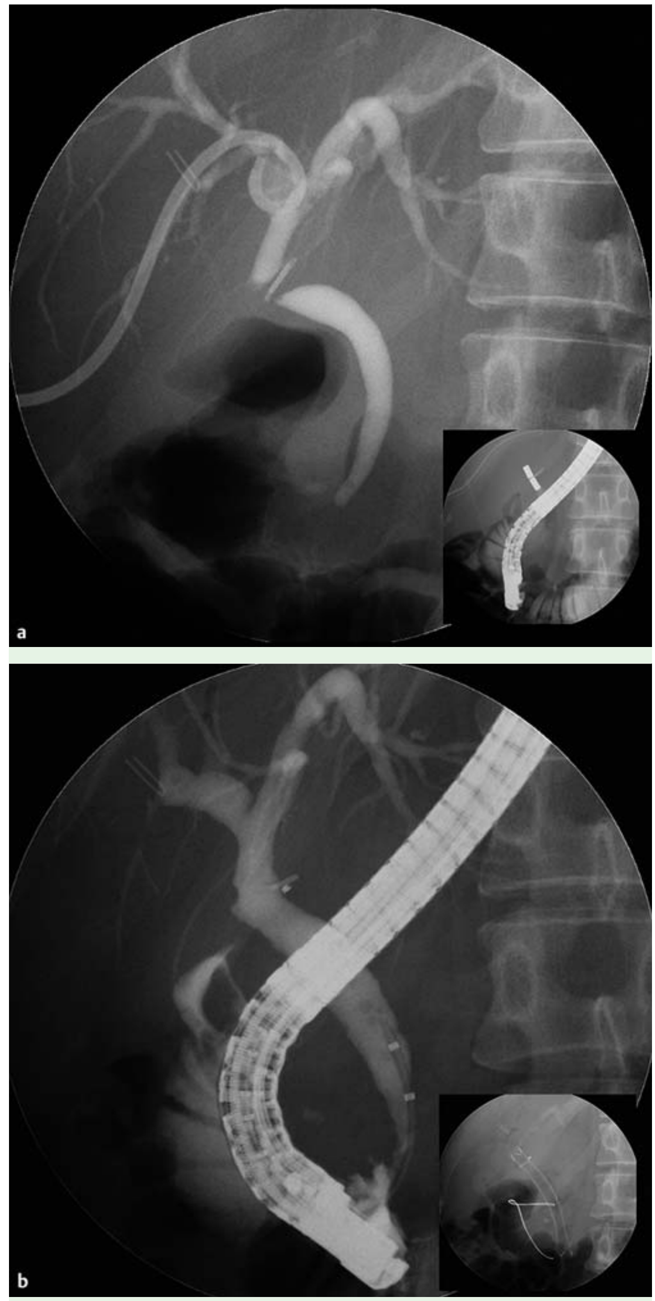

Fig. 2 Cholangiogram showing the process of magnetic compression anastomosis in duct-to-duct stricture. a Stricture of common bile duct after cholecystectomy, and successful approximation of magnets. b Patency of the reanastomosis is confirmed after removal of a fully covered self-expandable metal stent.

scope with a polypectomy snare and advanced to the afferent loop of the jejunum. The 16-Fr PTBD catheter was replaced with an 18-Fr sheath, and the other magnet was delivered to the anastomosis site via the PTBD tract. After approximation of the two magnets had been fluoroscopically confirmed (▶ **Fig. 1 a**), the 18-Fr sheath was removed, and the PTBD catheter was re-inserted. Compression by the approximated magnets caused ischemic necrosis of the tissue between the magnets, forming a fistula. After recanalization, a percutaneous transhepatic cholangioscopy (PTCS) catheter was placed through the recanalized fistula. The indwelling PTCS catheter was removed 6 months later, following confirmation of anastomosis patency (▶ **Fig. 1 b**).

The MCA methods in patients #2 [7] and #3 were similar to that for post-LDLT stenosis [6]. Patient #3 had a common bile duct stricture that occurred following cholecystectomy (▶ **Fig. 2 a**). One magnet was delivered through the PTBD tract, and the other magnet was approximated using a duodenoscope (JF240 or TJF240; Olympus Optical, Tokyo, Japan) to form an MCA, leading to successful recanalization (▶ **Fig. 2 b**).

Method 2: PTBD tract and PTBD tract

In patient #4, the left intrahepatic duct (IHD) and right IHD were separately anastomosed to the jejunum, and the stricture was present on the right side. Two PTCS scopes were used: one for the PTBD tract in the right IHD to deliver a magnet, and the other for the left IHD tract to approximate the second magnet at the stricture site [8].

Method 3: PTBD tract and surgically formed fistula

The long afferent loop in patient #5 hindered an endoscopic approach to the anastomosis, and a second PTBD tract was not available because the right IHD and left IHD were not separated, unlike in patient #4. A magnet was delivered through the PTBD tract. Surgical intervention was necessary to form a jejunocutaneous fistula through which a magnet could be delivered. The magnet was fixed to the colonoscope by attachment with a polypectomy snare and was moved to the anastomosis site through the laparoscopically formed jejunocutaneous fistula. The alignment of the magnet was observed and modified under fluoroscopy.

Confirmation of recanalization and removal of magnet

After approximation of the magnets, plain abdominal radiographs were taken at 2-week intervals for 6 – 8 weeks to check the passing of the magnets through the anastomosis site. After recanalization, the magnets usually slid into the jejunum through the newly formed fistula. If close approximation of magnets was maintained for 10 weeks or more, a fistulous tract was assumed to have formed by tissue necrosis, although the magnets may not have moved through the recanalized anastomosis. In this case, the approximated magnets were removed by PTCS via the PTBD tract and the recanalized anastomosis site was visualized.

Maintenance of fistula tract and follow-up

An internal drainage catheter was placed through the recanalized fistula immediately after removal of the approximated magnets. The catheter was exchanged every 2 months and was maintained for 6 months. The recanalization of the anastomotic stricture was endoscopically confirmed with PTCS when the catheter was removed after 6 months. After the removal of the catheter, possible recurrence of BBS was checked by serum chemistry testing every 3 months and biannual ultrasonography during the first year of follow-up.

Results

MCA was attempted in seven cases of BBS. Six were postoperative strictures, and one was post-traumatic. Five of the six postoperative cases were bilioenteric anastomosis strictures, and one stricture had formed after cholecystectomy. The post-traumatic stricture developed secondarily to ischemic injury after right hepatic artery embolization because of liver laceration. A summary of the patients' profiles and clinical outcomes is presented in **Table 1**. The five successfully treated cases comprised three bilioenteric anastomoses and two bile duct stenoses. MCA was performed in a different manner for all the bilioenteric anastomoses. In approaching the obstructed hepaticojejunostomy site, the endoscopic approach was successful in one case (patient #1). In another case (patient #4) [8] use of a second PTBD tract was required, and a jejunocutaneous fistula was formed in yet another (patient #5). In the two cases of bile duct stenosis (patients #2 [7] and #3), magnet delivery using a duodenoscope was possible.

Approximation of the magnets was not possible in two cases: delivery of magnets to the bilioenteric anastomosis failed with endoscopic or percutaneous measures in the two unsuccessfully treated patients, and surgical delivery was also ineffective. MCA failure in these two patients could be ascribed to the length of the stenotic segments, which rendered approximation impossible because of the weaker magnetic force. In addition, the two magnets were aligned with their axes parallel rather than with the end-to-end positioning that is required for stronger magnetic attraction. The BBS in these two patients was surgically recanalized.

The mean time between magnet approximation and removal was 37 days (range 14 – 63 days), and the mean follow-up period after recanalization was 485.2 days (range 80 – 1573 days). There were no complications when the magnets were delivered for approximation or when they were removed with the PTCS scope. The five patients with successful recanalization showed no MCA-related complications or re-stenosis after removal of the indwelling catheter.

Discussion

Our results demonstrate that MCA could be an alternative nonsurgical method in patients with completely obstructive BBS, in whom conventional endoscopic treatment fails because a guidewire cannot be passed. The safety and effectiveness of anastomosis have been verified by animal studies of MCA [9, 10]. The study by Yamanouchi et al. in 1998 was the first to report successful recanalization in humans, and many subsequent case reports have verified the usefulness of MCA and its feasibility as an alternative method by demonstrating favorable outcomes in ameliorating strictures of bilioenteric and duct-to-duct anastomoses [6, 11 – 14]. Moreover, MCA is reportedly useful in post-LDLT anastomotic stricture [6] and malignant obstruction [15] by creating a new fistula tract. The fistula can be formed by necrosis of fibrotic tissue by compression between the two magnets, rather than by dilating the fibrotic area. Therefore, we assumed that the rate of re-stenosis would be low, even with a lack of long-term follow-up data. Re-stenosis after MCA in the context of post-LDLT occurred in one of 12 patients during 331 days of follow-up [6], and in patients with malignant obstruction no recurrent jaundice was observed during the initial 30 days post-procedure [15].

The distance between the two ends of the stricture and the means of magnet delivery are two critical factors and limitations that affect magnet approximation in MCA. A longer distance between the ends of the stricture weakens the magnetic force. This may make it impossible to approximate the magnets or, even after approximation, establish an attractive force that is insufficient to induce ischemic necrosis of tissue. In addition, MCA can fail when the approximated magnets are not end-to-end. MCA failed in patient #7 because of the longer distance between the beginning and end of the strictured areas. In patient #6, the distance between the ends of the stricture was relatively shorter, measuring 15 mm. However, their parallel alignment prevented the magnets from generating a sufficient attractive force and hindered recanalization, even after approximation. The limitation of this procedure is the lack of information regarding the length of stricture for which the MCA can be successful and the lack of assessment for predicting outcome.

Many methods have been developed to deliver magnets to the stricture site, depending on the prior operation and the patient characteristics. ERCP and a PTBD tract have been used for magnet delivery in duct-to-duct anastomotic strictures. The endoscopic approach is preferred in patients with choledochojejunostomy.

Table 1 Magnetic compression anastomosis (MCA) in seven patients with benign biliary stricture: patient and procedure characteristics.

Patient no.	Sex Age, years	Previous operation Reason	Stricture site Stricture length	Time from stricture to MCA, months	Procedures prior to MCA	Magnet delivery	Result	Time to removal of magnets, days	Follow-up after removal of internal catheter, days	Outcome
#1	M 49	PPPD with hepaticojejunostomy Pancreatic neuroendocrine tumor	Hepaticojejunostomy 5 mm	1	PTBD PTCS	PTBD + colonoscopy	Success	36	202	No stenosis
#2 [7][1]	M 45	Right hepatic artery embolization Abdominal trauma	Right intrahepatic duct 4 mm	2	PTBD PTCS ERCP	PTBD + ERCP	Success	63	468	No stenosis
#3	F 38	Cholecystectomy Gallbladder stone	CBD 6 mm	1	PTBD PTCS ERCP	PTBD + ERCP	Success	32	80	No stenosis
#4 [8][1]	M 27	Excision of cyst with Roux-en-Y hepaticojejunostomy Choledochal cyst	Hepaticojejunostomy 5 mm	3	PTBD PTCS	PTBD + PTBD	Success	40	1573	No stenosis
#5	F 63	Whipple procedure with hepaticojejunostomy Pancreatic neuroendocrine tumor	Hepaticojejunostomy 7 mm	1	PTBD PTCS ERCP	PTBD + surgically created fistula	Success	14	103	No stenosis
#6	M 54	Central segmentectomy with choledochojejunostomy Hepatic cystadenocarcinoma	Hepaticojejunostomy 15 mm	49	PTBD PTCS ERCP	PTBD + PTBD PTBD + ERCP	Failure	–	–	Operation
#7	M 71	Cholecystectomy with hepaticojejunostomy CBD stone and gallbladder empyema	Hepaticojejunostomy 17 mm	1	PTBD PTCS	PTBD + surgically created fistula	Failure	–	–	Operation

M, male; F, female; PPPD, pylorus-preserving pancreatoduodenectomy; PTBD, percutaneous transhepatic biliary drainage; PTCS, percutaneous transhepatic cholangioscopy; ERCP, endoscopic retrograde cholangiopancreatography; CBD, common bile duct.
[1] Previously reported.

However, the ERCP approach is difficult in patients with a long afferent loop, and a surgically created jejunocutaneous fistula may be helpful. One study has suggested single-balloon enteroscopy in this situation [11], but this is not a common method.

MCA is a nonsurgical alternative for patients in whom a conventional endoscopic or percutaneous method has failed, and its efficacy has been proven. For effective MCA, an endoscopist must secure the routes of magnet delivery, keep the distance between the magnets short, and be aware of the characteristics of the magnets. Further research should be conducted to discover more effective routes, and pre-MCA assessment should be designed that can predict the outcome of the procedure. Although the number of cases may be limited, we believe that MCA is less traumatic and, more importantly, has a very low recurrence rate compared with other treatments.

Competing interests: None

Institutions
[1] Department of Internal Medicine, Gangnam Severance Hospital, Yonsei University College of Medicine, Seoul, Korea
[2] Department of Bioevaluation Center, Korea Research Institute of Bioscience and Biotechnology, Cheongwon, Korea
[3] Department of Radiology, Gangnam Severance Hospital, Yonsei University College of Medicine, Seoul, Korea
[4] Department of Internal Medicine, Severance Hospital, Yonsei University College of Medicine, Seoul, Korea

References

1 *Laasch HU*, *Martin DF*. Management of benign biliary strictures. Cardiovasc Intervent Radiol 2002; 25: 457 – 466
2 *Shimada H*, *Endo I*, *Shimada K* et al. The current diagnosis and treatment of benign biliary stricture. Surg Today 2012; 42: 1143 – 1153
3 *Born P*, *Rosch T*, *Bruhl K* et al. Long-term results of endoscopic and percutaneous transhepatic treatment of benign biliary strictures. Endoscopy 1999; 31: 725 – 731
4 *Huibregtse K*, *Katon RM*, *Tytgat GN*. Endoscopic treatment of postoperative biliary strictures. Endoscopy 1986; 18: 133 – 137
5 *Yamanouchi EKH*, *Endo I* et al. A new interventional method of anastomosis with magnets: magentic compression anastomosis in five clinical cases [abstract]. Cardiovasc Intervent Radiol 1998; 21: S155
6 *Jang SI*, *Kim JH*, *Won JY* et al. Magnetic compression anastomosis is useful in biliary anastomotic strictures after living donor liver transplantation. Gastrointest Endosc 2011; 74: 1040 – 1048
7 *Rhee KW*, *Park CI*, *Jang SI* et al. A case of magnetic compression anastomosis in benign ischemic biliary stricture from hepatic artery embolization to control hemorrhage due to liver laceration. Korean J Pancreas Biliary Tract 2013; 18: 14 – 19
8 *Lim HC*, *Lee DK*, *Choi HK* et al. Magnet compression anastomosis for bilioenteric anastomotic stricture after removal of a choledochal cyst: a case report. Korean J Gastrointest Endosc 2010; 41: 180 – 184
9 *Cope C*. Evaluation of compression cholecystogastric and cholecystojejunal anastomoses in swine after peroral and surgical introduction of magnets. J Vasc Intervent Radiol 1995; 6: 546 – 552
10 *Gonzales KD*, *Douglas G*, *Pichakron KO* et al. Magnamosis III: delivery of a magnetic compression anastomosis device using minimally invasive endoscopic techniques. J Pediatr Surg 2012; 47: 1291 – 1295
11 *Itoi T*, *Kasuya K*, *Sofuni A* et al. Magnetic compression anastomosis for biliary obstruction: review and experience at Tokyo Medical University Hospital. J Hepatobiliary Pancreat Sci 2011; 18: 357 – 365
12 *Suyama K*, *Takamori H*, *Yamanouchi E* et al. Recanalization of obstructed choledochojejunostomy using the magnet compression anastomosis technique. Am J Gastroenterol 2010; 105: 230 – 231
13 *Itoi T*, *Yamanouchi E*, *Ikeda T* et al. Magnetic compression anastomosis: a novel technique for canalization of severe hilar bile duct strictures. Endoscopy 2005; 37: 1248 – 1251
14 *Takao S*, *Matsuo Y*, *Shinchi H* et al. Magnetic compression anastomosis for benign obstruction of the common bile duct. Endoscopy 2001; 33: 988 – 990
15 *Avaliani M*, *Chigogidze N*, *Nechipai A* et al. Magnetic compression biliary-enteric anastomosis for palliation of obstructive jaundice: initial clinical results. J Vasc Interv Radiol 2009; 20: 614 – 623