SpyGlass single-operator peroral cholangiopancreatoscopy system for the diagnosis and therapy of bile-duct disorders: a clinical feasibility study (with video)

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Background: Clinical implementation of cholangioscopy for direct visual examination of bile ducts, tissue sampling, and therapeutic maneuvers has been slowed by limitations in available technology. With 4-way deflected steering and dedicated irrigation channels, the single-operator SpyGlass peroral cholangiopancreatoscopy system is designed to overcome some of these limitations.

Objective: To evaluate the clinical utility and safety of the SpyGlass system for diagnostic and therapeutic endoscopic procedures in bile ducts.

Design: Prospective observational clinical feasibility study.

Setting: Two tertiary referral centers.

Main Outcome Measurements: Procedural success rate defined as the proportion of SpyGlass procedures in which the diagnostic or therapeutic objectives of the procedure were achieved.

Results: SpyGlass procedures were performed in 35 patients: 22 with indeterminate strictures (63%), 5 with indeterminate filling defects (14%), 5 with stones (14%), 2 with cystic lesions (6%), and 1 patient with an indication for gallbladder stent placement (3%). The rate of procedural success was 91% (95% confidence interval 77%-98%). Twenty patients underwent SpyGlass-directed biopsy, and the specimens procured from 19 patients (95%) were found adequate for histologic evaluation. The preliminary sensitivity and specificity of SpyGlass-directed biopsy to diagnose malignancy were 71% and 100%, respectively. SpyGlass-directed electrohydraulic lithotripsy succeeded in 5 of 5 patients (100%). Procedure-related complications occurred in 2 patients (6%) and resolved uneventfully.

Limitations: No control group was included. Follow-up for determining preliminary sensitivity and specificity was limited.

Conclusions: SpyGlass procedures proved to be clinically feasible, provided adequate samples for histologic diagnosis, and successfully guided stone therapy. The procedures were safe and well tolerated. Prospective multicenter clinical trials of the system are underway. (Gastrointest Endosc 2007;65:832-41.)

ERCP is a standard method for the evaluation of bile-duct disorders. In the diagnosis of malignant biliary strictures, the reported sensitivity of ERCP-directed forceps biopsy ranges widely, from 43% to 81%. Cholangiopancreatoscopy (CP), which facilitates direct visual assessment, visually guided tissue sampling, and therapeutic intervention, holds promise as an advanced technique in cases that elude successful diagnosis or treatment by conventional ERCP or other imaging modalities. Although the percutaneous route can be used, the peroral approach is preferred for accessing the biliary tree, because percutaneous CP is more invasive, requiring either a hepatic puncture, with formation of a bilio-cutaneous fistula, or entry via a surgical T-tube tract. The utility of peroral CP in differentiating between biliary malignant and benign strictures and filling defects has been described in a number of reports. CP-directed forceps biopsy can be of value in diagnosing bile-duct lesions with relatively high sensitivity and specificity. Under direct visualization, subtle

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tissue abnormalities, which might not be evident through use of other imaging modalities, can be discerned. Peroral CP has also been shown useful in therapeutic interventions, eg, the management of complicated bile-duct stones, especially those in the intrahepatic biliary tree and large stones in the common bile duct.\textsuperscript{9,17}

Although cholangioscopes and their accessories have improved greatly in recent years, their remaining short-comings continue to discourage some physicians from adopting peroral CP in clinical practice.\textsuperscript{8} Labor intensiveness has been a major drawback, because CP requires the participation of 2 endoscopists, one to operate the duodenoscope and the other to operate the cholangioscope.

Among the other important limitations of the currently commercially available cholangioscopes are limited tip deflection and suboptimal irrigation capabilities.\textsuperscript{8,18,19} The recently described SpyGlass peroral CP system (SpyGlass Direct Visualization System; Microvasive Endoscopy, Boston Scientific Corp, Natick, Mass) is designed for single-operator examination and 4-way deflected steering, with separate dedicated irrigation channels.\textsuperscript{20} In a laboratory simulator ex vivo, the system significantly improved bile-duct access and increased the biopsy success rate compared with a conventional choledochoscope.\textsuperscript{20} In a porcine mode, the system also proved efficient in obtaining samples that were adequate for histologic evaluation.\textsuperscript{20} We, herein, present the first clinical data characterizing the utility of the system for access, visualization, and guidance during diagnostic and therapeutic endoscopic procedures in bile ducts, including CP-directed forceps biopsy.

**PATIENTS AND METHODS**

The SpyGlass system was evaluated in a prospective observational clinical study conducted at 2 tertiary referral centers. Institutional review board approval was obtained at both centers for collection of data and follow-up. Procedures that used the SpyGlass system were performed in consecutive eligible patients between October 2005 and March 2006.

**Test system**

The SpyGlass system is designed for use during both diagnostic and therapeutic endoscopic procedures. The 3 components of the modular system are the (1) reusable SpyGlass Direct Visualization Probe and Ocular for direct visual guidance and examination in the pancreaticobiliary system, including the hepatic ducts; (2) SpyScope disposable access and delivery catheter capable of accommodating both optical and accessory devices used in the biliary system, including the hepatic ducts; and (3) disposable SpyBite biopsy forceps for tissue acquisition in the pancreaticobiliary system. Technical specifications of the system are detailed elsewhere.\textsuperscript{20}

**Capsule Summary**

**What is already known on this topic**

- Peroral CP may be a helpful adjunct in therapeutic interventions, eg, management of complicated bile-duct stones, but the need for 2 endoscopists is a drawback to its use.

**What this study adds to our knowledge**

- A single-operator peroral CP system is feasible. The initial human nonrandomized study of 35 patients who underwent a variety of diagnostic and therapeutic procedures had an intended procedure success rate of 91%.

**End points**

The primary study end point was a procedural success rate defined as the proportion of SpyGlass procedures in which the diagnostic or therapeutic objectives of the procedure were achieved. In the case of evaluating indeterminate strictures or filling defects with the intent of ruling out malignancy, the success of the procedure was judged by the ability to visualize the stricture and obtain adequate biopsy tissue from the target lesion. The criterion for success in stone therapy was visualization and clearance of the stones. Secondary end points were the adequacy of biopsy specimens for histologic evaluation and the incidence of procedure-related complications.

**Patients**

The study inclusion criteria were either the need to answer biliary diagnostic questions left unresolved at ERCP or to perform biliary therapeutic interventions that had failed during ERCP. Diagnostic indications were predominantly the evaluation of indeterminate strictures to discriminate between benign and malignant tissue and of indeterminate filling defects to differentiate among stones, air bubbles, and masses. The most frequent therapeutic indication was stone therapy. In many cases, diagnostic questions could not be addressed by ERCP, because of an inability to achieve or maintain adequate filling with contrast material at the sites of interest. Tissue sampling at ERCP or by alternative methods before the SpyGlass procedure was not a prerequisite for study entry and, in some instances, had not been performed. All patients with indeterminate strictures or filling defects entered the study by referral from an endoscopist who designated these abnormalities as indeterminate. Although there may have been a suspicion of malignancy, neither the referring endoscopist nor the study investigator was required to make a commitment to a presumptive diagnosis before the SpyGlass procedure.
Procedures

Before the SpyGlass procedure, patients received antibiotic prophylaxis in accord with institutional protocol or at the discretion of the endoscopist. Most common agents administered for antibiotic prophylaxis were levofloxacin, ampicillin, and gentamicin.

All SpyGlass procedures were performed by a single operator, with the SpyScope catheter strapped to the duodenoscope by a silastic belt just below the operating channel. In this configuration, the single endoscopist controlled both of the ratchets or the wheels of the duodenoscope and the knobs of the cholangioscope. The SpyGlass system was introduced through an Olympus duodenoscope (TJF 160 or TFJ 180; Olympus America Inc, Center Valley, Pa). A sphincterotomy was performed as necessary. Ducts were typically inspected during withdrawal of the SpyGlass system. In addition, selected ducts and branches of interest were examined during repeated advancement and withdrawal of the system. In all instances, the objective was to visualize the ducts of interest throughout their entire circumference. The following cholangioscopic features were considered suspicious for malignancy: intraductal nodules, masses, infiltrative or ulcerated strictures, prominent vascularizations (eg, tortuous dilated vessels), ductal papillary mucinous neoplasm was scored as a malignancy.

The methods for procurement of biopsy specimens were similar to those previously described for CP-directed forceps biopsy. When a discreet mass or a tumor vessel was identified, biopsy specimens were obtained from several different parts of the lesion under direct cholangioscopic guidance. In the absence of a discrete lesion, random samples were secured within a stenosis. Biopsy samples were examined by 1 of 4 pathologists, all of whom were experienced in the interpretation of biliary specimens by one or more methods before the SpyGlass procedure. A final diagnosis of bile-duct malignancy was established on the basis of a positive initial SpyGlass-directed biopsy; a repeat cholangioscopy-directed biopsy; or other definitive tissue sampling method, such as CT-guided biopsy, intraoperative biopsy, surgical specimen collection, or autopsy. For purposes of preliminary sensitivity and specificity calculation, a provisional final diagnosis of benign was assigned in patients with a benign biopsy only after ≥6 months' follow-up, without evidence of malignancy. Intraductal papillary mucinous neoplasm was scored as a malignancy, and extrinsic tumor compression without bile-duct tissue involvement was scored as benign.

The Nortech AUTOLITH system (Northgate Technologies, Inc, Elgin, Ill) and a 1.9F probe were used in those patients undergoing electrohydraulic lithotripsy (EHL). Stones identified within a bile duct were immersed in sterile water infused through the dedicated irrigation channels of the SpyScope by means of a foot-pedal-controlled irrigation pump. Thereupon, an EHL probe was introduced through the working channel of the cholangioscope, with the tip positioned directly behind the stone. Shockwaves generated by an electric spark (50-90 W) at the end of the probe were propagated through the aqueous medium to achieve stone fragmentation under visual guidance. Fragmented stones were then flushed out or removed by using a balloon and/or basket.

Statistical analysis

Descriptive statistics consisted of the mean, standard deviation (SD), median, and interquartile range (IQR). The procedural success rate was determined with its exact 95% confidence interval (CI) by using StatXact 7.0 (Cytel Software Corp, Cambridge, Mass) statistical software. Preliminary sensitivity in patients who underwent SpyGlass-directed biopsy for evaluation of malignancy was calculated as the quotient of true positives divided by the sum of true positives and false negatives, and preliminary specificity as true negatives divided by the sum of true negatives and false positives.

RESULTS

Thirty-five patients were included in the study. Patient demographics at baseline and procedure data are summarized in Table 1. Primary sclerosing cholangitis (PSC) was present in 9 patients (26%). Diagnostic evaluation of indeterminate stricture, performed in 22 patients (63%), was the most frequent SpyGlass indication. The most frequent procedures performed at the time of the SpyGlass session were biopsy in 20 patients and stent placement in 13 (Table 1). The median number of such procedures per patient was 2 (IQR, 1-3). Of the 10 patients entering the study with intact sphincters, 8 underwent sphincterotomy at the time of the SpyGlass procedure, and extension of a previous sphincterotomy was performed in 1 patient (Table 1).

In 23 of the 27 patients with indeterminate strictures or filling defects (85%), tissue sampling had been attempted by one or more methods before the SpyGlass procedure. In 1 of the 4 patients with no previous sampling, an attempt at sampling had to be abandoned because of a failure to access the site of interest. Prior tissue-sampling attempts included brushing cytology in 13 patients (57%), biopsy in 3 (13%), and both in 4 (17%). In 8 patients (35%), EUS-guided FNA (EUS-FNA) was performed in addition to brushing cytology, biopsy, or both, whereas 3 (13%) underwent previous EUS-FNA alone.

The diagnostic or therapeutic objectives of the SpyGlass procedure were attained in 32 patients (91%, 95% CI 77%-98%). Access to some areas of interest was precluded by small intrahepatic duct size in 2 patients, and visualization of a short presphincteric stricture was suboptimal in another patient. During 4 of the 32 successful
procedures, technical difficulty was encountered when advancing the SpyBite Biopsy Forceps in 1 case, clearing stone fragments during EHL in a second case, orienting the forceps within the left hepatic duct in a third, and maintaining the desired position of the SpyScope for biopsies in a fourth.

**SpyGlass visualization**

The most frequent primary visual diagnosis assigned during SpyGlass examination was benign stricture/inflammatory changes (Table 2). In the 20 patients who underwent SpyGlass-directed biopsy for evaluation of malignancy, a final or provisional final diagnosis was established, and it was thus feasible to determine sensitivity and specificity. As shown in Table 3, the preliminary sensitivity and specificity of SpyGlass visual diagnosis were 100% (7/7) and 77% (10/13), respectively. All 3 false-positive visual findings were in patients with PSC. Two patients with PSC were correctly visually diagnosed.

In 2 patients, extrinsic tumor compression was observed visually, without apparent malignancy within the bile-duct tissue itself. A third patient, with visually evident extrinsic tumor compression, was not included in the sensitivity and specificity evaluation, because biopsies were not indicated or attempted, and no final diagnosis was established with respect to the bile-duct tissue.

**SpyGlass-directed biopsy**

The indication for SpyGlass-directed biopsy was indeterminate stricture (Fig. 1) in 17 patients (85%), indeterminate filling defect (Fig. 2) in 2 (10%), and cystic disease in 1 (5%). As a result of 112 bites among all 20 patients when we used the SpyBite biopsy forceps, 100 specimens (89%) were collected. Median bites and specimens per patient were 5 (IQR, 4-7) and 4.5 (IQR, 3.8-7), respectively. In 1 patient, intraprocedural breakage of the SpyGlass optical probe after procurement of 2 biopsy
specimens prevented collection of additional samples. The specimens obtained from 19 patients (95%) were judged by the pathologist to be adequate for histologic evaluation. In 1 patient, an attempted biopsy of a presphincteric stricture failed.

A benign result was obtained in 15 of 20 patients biopsied (75%), and, in these 15 patients, the median duration of follow-up was 8.5 months (IQR, 6.5-9.3 months). Six of the 15 patients with a benign biopsy (40%) underwent a total of 12 follow-up tissue-sampling procedures: 1 each in 4 of the patients, 3 in the fifth patient, and 5 in the sixth patient. The median time elapsed from the original Spy-Glass-directed biopsy to the last follow-up tissue sampling procedure was 5.9 months. The types of follow-up tissue sampling procedures consisted of SpyGlass-, ERCP-, and choledochoscope-directed forceps biopsy; ERCP-directed brushing cytology; EUS-FNA; and surgical pathology. These procedures confirmed the initial benign biopsy of 4 patients and demonstrated malignancy in the other 2 cases.

The preliminary sensitivity and specificity of SpyGlass-directed biopsy were 71% (5/7) and 100% (13/13), respectively (Table 3). One false-negative result was obtained during a SpyGlass procedure in which the presphincteric location of the target lesion in the distal common bile duct created technical difficulties, especially after sphincterotomy, in maintaining the desired SpyScope position for biopsies. A second false-negative biopsy result was secured from a patient with confirmed unresectable pancreatic adenocarcinoma.

In the 3 patients with PSC and with false-positive visual findings, SpyGlass-directed biopsies were true negative. True-positive visual findings were recorded in the 2 patients with false-negative biopsies. Hence, the concordance between SpyGlass visual examination and SpyGlass-directed biopsy was 75% (15/20), as indicated in Table 3. Intraductal papillary mucinous neoplasm (Fig. 3, Video 1, available online at www.giejournal.org) was the final diagnosis made in 2 patients and was scored as malignancy. In these 2 patients, intraductal papillary mucinous neoplasm was correctly diagnosed both by visual examination and by biopsy.

**Stone therapy**

SpyGlass-directed EHL succeeded in 5 of 5 patients (100%). Multiple large bile-duct stones (18 mm) were present in 1 of these patients; multiple, large, impacted mid-common bile duct stones in a second patient; and a 35 × 18-mm common bile duct stone with multiple smaller stones in a third. In a fourth patient, a 10-mm common hepatic duct stone was impacted. Prior conventional ERCP stone extraction failed in all 4 of these patients, and mechanical lithotripsy failed in 3. In the fifth patient, >10 intrahepatic bile duct stones had been missed at ERCP.

Complete stone clearance was achieved with no further procedures in 2 of the patients and after repeat SpyGlass-directed EHL in 2 and follow-up ERCP in 1. Four additional patients underwent SpyGlass-directed stone removal without EHL.

**Cystic lesion**

In 2 patients, cystic dilation was successfully evaluated by SpyGlass examination. In 1 patient, it was possible to rule out choledochal cyst after excellent visualization of a locally dilated cystic-duct segment with normal-appearing epithelium in the entire cystic duct and good partial

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**TABLE 3. Preliminary SpyGlass diagnosis of malignancy**

<table>
<thead>
<tr>
<th>Final or provisional final diagnosis</th>
<th>Benign</th>
<th>Malignant</th>
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<tr>
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<td>Total</td>
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<td>Preliminary sensitivity of visual diagnosis = 100% (7/7)</td>
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<tr>
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<td>Malignant</td>
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<td>Total</td>
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<td>Preliminary concordance between visual and biopsy diagnosis = 75% (15/20)</td>
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*Table cells contain counts of patients in each category.

†Final diagnosis of malignant based on tissue sampling and provisional final diagnosis of benign during ≥6 months’ follow-up, without evidence of malignancy.

‡All 3 false-positive visual findings were obtained in patients with PSC.

§One of the 2 false-negative biopsy findings was derived from a SpyGlass procedure in which technical difficulties were experienced and the other from a patient with confirmed unresectable pancreatic adenocarcinoma.
visualization of the gallbladder, which revealed normal gallbladder epithelium. In the second patient, SpyGlass findings were consistent with a choledochal cyst, although both visual examination and SpyGlass-directed biopsy showed no evidence of dysplasia or metaplasia. Downstream stricture, tumor, or stones were excluded.

**Gallbladder stent placement**

Prior ERCP-directed selective cannulation of a cystic duct for gallbladder stent placement failed in a patient with pretransplant cirrhosis, with symptomatic cholelithiasis. During ERCP, multiple attempts by a study investigator to place straight, angled, and hydrophilic wires into the cystic duct and the gallbladder, with a rotating sphincterotome, as well as the use of balloons had been unsuccessful. SpyGlass-directed stent placement was performed to avoid cholecystectomy, an intervention associated with increased morbidity and mortality in patients with cirrhosis.

A Spyscope was advanced 2 cm into the cystic duct, and an angled Jagwire (Microvasive) was inserted, under fluoroscopic guidance, through the Spyscope into the gallbladder. A 7F 15-cm double-pigtail stent was then successfully placed in the gallbladder. After stent placement, the patient experienced relief of gallbladder-disease symptoms.

**Complications**

Two patients (6%) experienced procedure-related complications, namely, ascending cholangitis in 1 patient and cholangitis with intrahepatic abscess in the other. The case of ascending cholangitis, which was marked by jaundice without fever, white blood cell elevation, or positive blood cultures, developed 3 weeks after SpyGlass examination, during which the patient was diagnosed with intraductal papillary mucinous neoplasm. A biliary stent was not placed at the time of the procedure, and the absence of a stent may have allowed ductal occlusion by viscous mucin, thus contributing to the occurrence of cholangitis. Repeat ERCP revealed some purulent material emanating from the biliary orifice. Treatment consisted of plastic-stent placement and intravenous antibiotics. The patient was hospitalized for 4 days and recovered uneventfully.

Preexisting cholangitis was present in the second patient who developed ascending cholangitis and right-lobe intrahepatic abscess 11 days after SpyGlass examination. With CT-guided percutaneous drainage of the infected fluid and 7 days of hospitalization, the patient recovered without further sequelae.

**DISCUSSION**

Accurate differential diagnosis of bile-duct strictures is essential in the planning of therapy and can avoid unnecessary surgery in the case of benign strictures and aid in gauging the potential resectability of tumors. But the differentiation of malignant from benign ductal lesions remains a challenge, despite the continuing refinement of ERCP and EUS techniques, the current primary methods to differentiate and grade tumors. The clinical potential of CP, which permits direct visualization and tissue sampling of the suspected lesions, is still untapped, in large part because of limitations in cholangioscope technology.

With its enhanced maneuverability and dedicated irrigation channels, the SpyGlass system was designed to
address some of these limitations. In this initial clinical evaluation, the technical feasibility of SpyGlass procedures in patients with indications for CP was clearly demonstrated. The procedural success rate exceeded 90%. Biopsy specimens collected by forceps under SpyGlass guidance were adequate for histologic characterization in 95% of cases. All SpyGlass-directed EHL procedures were successful. The study also provided evidence supporting the safety and tolerability of the SpyGlass procedures.

The SpyGlass system is a modular cholangioscope rather than a single unit. This design endows the system with a relatively small turning radius suitable for maneuvering through small ducts, including tertiary intrahepatic ducts. Also, improving maneuverability is the 4-way deflected steering of the tip, which allows unrestricted access to all bile-duct quadrants. In bench simulations, the success rate of the SpyGlass system, in gaining access to target quadrants with a biopsy forceps loaded, was twice that of a conventional control choledochoscope, limited to 2-way deflection.20 The success rate for simulated biopsy with the SpyGlass system was 3 times that with the control choledochoscope. Although direct visualization is believed to enhance the capability for precise targeting of sites for biopsy, its postulated advantages have not yet been fully demonstrated, largely because of the limited maneuverability of previously available cholangioscopes.

The incorporation of dedicated irrigation channels in the SpyGlass system design is a major advance. In laboratory measurements with a biopsy forceps loaded, the dedicated irrigation channels of this system produced irrigation fluid flow rates 4- to 5-fold those attained through the working channel of conventional systems.20 Ample continuous irrigation is essential for keeping the cholangioscopic view clear of blood, stone debris, sludge, or pus during visual inspection and biopsy. Adequate irrigation is also needed to maintain a water-filled medium in the duct during EHL. The dedicated irrigation channels of the SpyGlass system probably contributed to the favorable procedural success rate in the present study.

This clinical study confirmed preclinical evidence that SpyGlass examination can be performed by a single operator.20 In 2-operator systems, cholangioscopes can be damaged when movements of the duodenoscope and the cholangioscope are not tightly coordinated. Beyond obviating additional clinical staff, this single-operator capability may also facilitate synchronization of duodenoscope and cholangioscope movements through a range of positions. However, in addition to sequentially controlling both the duodenoscope and the cholangioscope, the single operator may also be called upon to load a biopsy forceps or an EHL probe. Thus, a learning curve must be traversed to develop proficiency in the use of the system, which is best suited for endoscopists with advanced skills. Because of its relative ease of use and other advantages, the SpyGlass system might potentially expand the population of patients suitable for cholangioscopy; however, this study was not designed to assess the impact of the system on practice utilization.

Other approaches to single-operator cholangioscopy were recently described. In 1 of these, the duodenoscope and the cholangioscope were operated by using the left
This technique was made possible by a breastplate securing the cholangioscope in a socket holder. Another method involved a 2-step procedure, in which a guidewire was placed with a duodenoscope, and, after withdrawal of the duodenoscope, a pediatric ultraslim upper endoscope was introduced over the guidewire. These approaches, together with the development of the SpyGlass system, exemplify current efforts to streamline cholangioscopy. The ultimate goal would be to develop a cholangioscope with 4-way deflection that could be maneuvered through the nose or the mouth into the biliary tract, without a requirement for either a duodenoscope or a guidewire.

Discriminating between malignant and benign bile duct tissue is a frequent challenge. CP might potentially help meet through its dual capabilities of direct visualization and guided biopsy. The preliminary sensitivity of SpyGlass-directed biopsy in this study of a difficult patient subpopulation was 71%, suggesting a potential role for this tissue-sampling approach in detecting bile-duct malignancy. Nevertheless, the present preliminary results were of limited scope, and larger studies are needed to support firmer conclusions as to the diagnostic value of SpyGlass-directed biopsy.

This single-arm feasibility study was not intended to assess the clinical value of the SpyGlass system as a substitute for or as an adjunct to alternative imaging and tissue-sampling modalities such as EUS-FNA. Although the sensitivity of EUS-FNA in the evaluation of pancreatic masses has been consistently high (70%-93%, as elsewhere reviewed), results of applying this modality to bile-duct lesions have been more variable, with reported sensitivity for detecting malignancy of 25%, 45%, 87%, and 89%. One suggested explanation has been the need during EUS-FNA puncture for a visible target mass that may be absent in the vicinity of biliary strictures.

Although, for any suspected neoplasm, a tissue diagnosis is generally an important basis for guiding therapy, direct visualization may itself provide useful supplementary diagnostic information. For instance, the combination of direct visualization with tissue sampling may increase sensitivity in diagnosing malignant bile-duct strictures compared with tissue sampling alone. In cases of extrinsic tumor compression or intramural malignancy, direct visualization may provide evidence difficult to secure by tissue sampling within the bile duct. The relative contributions of direct bile-duct visualization and various tissuesampling techniques have yet to be determined and need to be investigated further. Clinical experience in interpreting SpyGlass visual findings remains limited, and a visual atlas is being developed as an aid to interpretation. Visual criteria for differentiating benign from malignant tissue require further refinement. Advances in techniques, e.g., tissue staining, may also augment the reliability of visual findings.

The utility of direct visualization may be influenced by the type of disease present. In the subset of patients evaluated for sensitivity and specificity, false-positive visual results were obtained in 3 of 5 patients with PSC, which was present in more than a quarter of the study cohort and is associated with increased risk of cholangiocarcinoma. The diagnosis of cholangiocarcinoma in patients with PSC is notable for its difficulty. These patients pose particular diagnostic problems, because the disease tends to be diffuse or multifocal, and, in the absence of a clear mass, it is difficult to identify optimal sites for tissue sampling within the biliary system to rule out cholangiocarcinoma. Moreover, tumors may occur peripherally in an intrahepatic bile duct too small for access by CP. At ERCP, endoscopists typically collect biopsy specimens at the site of the dominant stricture, which is usually situated in the main ducts. It is unclear whether this approach is ideal. With the accumulation of further clinical experience, direct visualization of PSC ducts might prove to be of greater diagnostic value than biopsy. Visual examination might perhaps be performed in conjunction with novel tissue-staining techniques to identify dysplasia in the ductal epithelium.

CP has proven to be valuable in complicated choledocholithiasis, especially in guiding the positioning of the EHL probe. A fluoroscopy-guided EHL probe during ERCP may result in bile-duct injury. In the present study, 4 patients with intrahepatic or large common bile duct stones who had failed conventional ERCP stone removal underwent successful CP-guided EHL. In addition, a patient with multiple intrahepatic stones who went undiagnosed at ERCP was successfully treated by CP-guided
EHL. Intrahepatic stones cannot be easily removed during ERCP and often require surgical intervention. Dedicated irrigation channels that allow strong flow are especially useful for this indication, because the ducts must be kept continuously filled with fluid during EHL.

Several limitations of this study should be noted. No control group was included, so the performance of the SpyGlass system could not be compared directly with that of ERCP alone or a conventional choledochoscope restricted to 2-way deflection. The required follow-up period of ≥6 months for establishing a provisional final diagnosis of benign was relatively short. Last, the present results were obtained by endoscopists with extensive experience in ERCP and cholangioscopic techniques at 2 tertiary referral centers, and the extent to which these findings can be generalized remains uncertain pending further prospective multicenter studies.

The present study was not specifically designed to determine systematically the impact of the SpyGlass procedure on patient management. Nevertheless, the study observations demonstrated the potential for such an impact in certain subsets of patients. Thus, SpyGlass-directed biopsy correctly classified benign and malignant disease in 18 patients, whose management would be altered accordingly. Similarly, successful SpyGlass-directed EHL in 5 patients avoided surgical management or, in poor surgical candidates, recurrent complications of retained stones, necessitating periodic ERCP and stent changes.

This investigation demonstrated the clinical feasibility of single-operator direct visualization with the SpyGlass system, as well as the utility of the system in procuring biopsy samples adequate for histologic diagnosis and in guiding stone therapy. Prospective multicenter clinical trials are currently in progress to evaluate the clinical utility of the system further, including assessment of its impact on diagnosis and clinical management.

Summary
A recently developed single-operator peroral CP system (SpyGlass), with 4-way steering and dedicated irrigation channels, was evaluated in a prospective clinical feasibility study at 2 tertiary centers. For diagnostic and therapeutic procedures performed with the system, including evaluation of indeterminate strictures and filling defects, procurement of biopsy specimens, and stone therapy, the rate of success was 91%. Single-operator SpyGlass procedures were found to be clinically feasible and safe. The system is now being further characterized in prospective multicenter clinical trials.

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DISCLOSURE

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REFERENCES


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