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United States Patent Application Publication 20250255470
Kind Code A1
Publication Date August 14, 2025
Inventor(s) Powers; Jessica et al.

FLUOROPHORE IMAGING DEVICES, SYSTEMS, AND METHODS FOR AN ENDOSCOPIC PROCEDURE

Abstract

Fluorescent imaging systems for performing an endoscopic procedure, such as a retrograde cholangiopancreatography (ERCP) procedure may include a first light source for emitting light in the visible spectrum, or light in the near infrared (NIR) spectrum, or both. A light source bandpass filter may block the emitted light in the visible spectrum, or in the NIR spectrum, or both. A first sensor may be capable of detecting the light in the visible spectrum, or the light in the NIR spectrum, or both. A sensor bandpass filter may block the detected light in the visible spectrum, or in the NIR spectrum, or both. The first or a second light source, or the first or a second sensor, or combinations thereof, may be removably disposed on a duodenoscope.

Inventors: **Powers; Jessica (Somerville, MA), Caldwell; Jacob (Frewsburg, NY), Cho; Sungmin R. (Baltimore, MD), Yazdi; Youseph (Ellicott City, MD), Durr; Nicholas J. (Baltimore, MD), Pasricha; Pankaj J. (Ellicott City, MD), Weiler; Chad (Columbia, MD), Nimgaonkar; Ashish (Ellicott City, MD)**

Applicant: **Boston Scientific Scimed, Inc.** (Maple Grove, MN); **The Johns Hopkins University** (Baltimore, MD)

Family ID: **1000008561525**

Assignee: **Boston Scientific Scimed, Inc. (Maple Grove, MN); The Johns Hopkins University (Baltimore, MD)**

Appl. No.: **19/190860**

Filed: **April 28, 2025**

Related U.S. Application Data

parent US continuation 18117775 20230306 parent-grant-document US 12310562 child US 19190860
parent US continuation 16240032 20190104 parent-grant-document US 11627870 child US

18117775
us-provisional-application US 62614266 20180105

Publication Classification

Int. Cl.: **A61B1/04** (20060101); **A61B1/00** (20060101); **A61B1/018** (20060101); **A61B1/05** (20060101); **A61B1/06** (20060101); **A61B1/07** (20060101); **A61B1/273** (20060101)

U.S. Cl.:

CPC **A61B1/043** (20130101); **A61B1/00096** (20130101); **A61B1/00101** (20130101); **A61B1/00137** (20130101); **A61B1/00177** (20130101); **A61B1/00186** (20130101); **A61B1/018** (20130101); **A61B1/0646** (20130101); **A61B1/2736** (20130101); A61B1/00165 (20130101); A61B1/05 (20130101); A61B1/0661 (20130101); A61B1/07 (20130101)

Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS [0001] This application is a continuation of U.S. Nonprovisional patent application Ser. No. 18/117,775, filed on Mar. 6, 2023, which is a continuation of U.S. Nonprovisional patent application Ser. No. 16/240,032, filed on Jan. 4, 2019, now U.S. Pat. No. 11,627,870, which claims the benefit of U.S. Provisional Patent Application No. 62/614,266, filed Jan. 5, 2018, each of which is incorporated by reference herein in its entirety.

FIELD
[0002] The present disclosure relates generally to fluorophore imaging devices, systems, and methods for an endoscopic procedure, and more particularly for use of indocyanine green (ICG) to image the bile duct through the duodenum of a patient during an endoscopic retrograde cholangiopancreatography (ERCP) procedure.
BACKGROUND
[0003] In an endoscopic procedure, e.g., ERCP procedure, selective cannulation provides access to either the biliary duct or the pancreatic duct of a patient through the duodenal papilla. Orientation of the ducts may not be easily visualized by the medical professional, such that endoscopic tools may be incorrectly positioned and/or oriented. Cannulation may be difficult sometimes requiring a medical professional to make several attempts to access the biliary duct for therapeutic intervention, including, for example, exceeding a predefined time limit and/or exceeding a predefined number of unsuccessful attempts.
[0004] Contrast imaging may be used to visualize orientation of the ducts under fluoroscopy. However, the contrast is typically used only after cannulation, as the contrast agent is a known irritant of the ducts, and may place a patient at risk for post-ERCP pancreatitis.
[0005] It is with respect to these and other considerations that the present improvements may be useful.
SUMMARY
[0006] This Summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This Summary is not intended to necessarily identify key features or essential features of the claimed subject matter, nor is it intended as an aid in determining the scope of the claimed subject matter.
[0007] According to an exemplary embodiment of the present disclosure, a fluorophore imaging device may include an attachment removably coupleable to a distal end of a duodenoscope. The

attachment may include a first filter that may be alignable with a light source of the duodenoscope and a second filter that may be alignable with an imaging device of the duodenoscope. The attachment may be coupled to the distal end of the duodenoscope by a ring such that a working channel of the duodenoscope may be accessible when the attachment is coupled to the duodenoscope.

[0008] In various of the foregoing and other embodiments of the present disclosure, an extension portion may be extendable from the ring longitudinally along the duodenoscope for connection with a filter portion. The attachment may include a first portion and a second portion. The first and second portion may be lockable with each other to fix the attachment to the distal end of the duodenoscope. The attachment may have a curvature to extend distally of a distal tip of the duodenoscope to fix the attachment to the distal end of the duodenoscope. The curvature may be a J-shape, U-shape, C-shape, or hook, or combinations thereof.

[0009] According to an exemplary embodiment of the present disclosure, a fluorescent imaging system for performing an endoscopic retrograde cholangiopancreatography (ERCP) procedure may include a first light source for emitting light in the visible spectrum, or light in the near infrared (NIR) spectrum, or both. A light source bandpass filter may be included for blocking the emitted light in the visible spectrum, or in the NIR spectrum, or both. A first sensor may be capable of detecting the light in the visible spectrum, or the light in the NIR spectrum, or both. A sensor bandpass filter may be included for blocking the detected light in the visible spectrum, or in the NIR spectrum, or both.

[0010] In various of the foregoing and other embodiments of the present disclosure, in response to applying the light source bandpass filter to the emitted light from the first light source, the emitted light may be blockable in the visible spectrum, or in the NIR spectrum, or both. In response to applying the sensor bandpass filter to the detected light by the first sensor, the detected light may be blockable in the visible spectrum, or in the NIR spectrum, or both. The first light source may be capable of emitting light in the visible spectrum. A second light source may be capable of emitting light in the near infrared (NIR) spectrum. The light source bandpass filter may be capable of blocking the emitted light in the NIR spectrum. The first sensor may be capable of detecting the light in the visible spectrum. A second sensor may be capable of detecting light in the NIR spectrum. The sensor bandpass filter may be capable of blocking the detected light in the NIR spectrum. The first or second light source, or the first or second sensor, or combinations thereof, may be disposed on a duodenoscope. The light source bandpass filter may be permanently applied to the second light source, and the sensor bandpass filter may be permanently applied to the second sensor. The fluorescent imaging is indocyanine green (ICG) fluorescent imaging.

[0011] According to an exemplary embodiment of the present disclosure, a method for imaging an endoscopic procedure may include injecting a fluorophore in an area of the endoscopic procedure. The area may be imaged to generate a fluorescent signal indicating the area of the endoscopic procedure. A best fit curve of the area of the endoscopic procedure may be established. The best fit curve may be overlaid on the fluorescent signal.

[0012] In various of the foregoing and other embodiments of the present disclosure, the best fit curve may be established by determining a center of a papilla of a patient for locating a common bile duct, and by extending the best fit curve through the fluorescent signal. The best fit curve may include a confidence interval as a thickness of the best fit curve. As the best fit curve is extended through the fluorescent signal, the corresponding thickness may indicate an error level at each data point. The best fit curve may have a thickness indicating a diameter of the area of endoscopic procedure. The area of endoscopic procedure may be at least one of a biliary duct, a pancreatic duct, a duodenum, or a duodenal papilla, or combinations thereof.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] Non-limiting embodiments of the present disclosure are described by way of example with reference to the accompanying figures, which are schematic and not intended to be drawn to scale. In the figures, each identical or nearly identical component illustrated is typically represented by a single numeral. For purposes of clarity, not every component is labeled in every figure, nor is every component of each embodiment shown where illustration is not necessary to allow those of ordinary skill in the art to understand the disclosure. In the figures:

[0014] FIG. **1** illustrates gastrointestinal anatomy of a human patient;

[0015] FIGS. **2**A-**2**B illustrate an exemplary embodiment of a fluorophore imaging device in accordance with the present disclosure;

[0016] FIGS. **3**A-**3**B illustrate another exemplary embodiment of a fluorophore imaging device in accordance with the present disclosure;

[0017] FIG. **4** illustrates an exemplary embodiment of a fluorescent imaging system in accordance with the present disclosure;

[0018] FIGS. **5**A-**5**C illustrate exemplary embodiments of image displays in accordance with the present disclosure; and

[0019] FIG. **6** illustrates an exemplary embodiment of an endoscopic accessory in accordance with the present disclosure.

DETAILED DESCRIPTION

[0020] The present disclosure is not limited to the particular embodiments described herein. The terminology used herein is for the purpose of describing particular embodiments only, and is not intended to be limiting beyond the scope of the appended claims. Unless otherwise defined, all technical terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which the disclosure belongs.

[0021] As used herein, the singular forms “a,” “an,” and “the” are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms “comprises” and/or “comprising,” or “includes” and/or “including” when used herein, specify the presence of stated features, regions, steps elements and/or components, but do not preclude the presence or addition of one or more other features, regions, integers, steps, operations, elements, components and/or groups thereof.

[0022] The devices, systems, and methods described herein are intended to overcome the disadvantages with using contrast imaging in an endoscopic, e.g., ERCP, procedure in a known manner. For example, contrast is typically not injected into the biliary tree (including the pancreatic duct and/or other ducts, including but not limited to hepatic ducts and common bile duct as shown in FIG. **1**) until after cannulation is complete so as to reduce patient risk for pancreatitis. However, cannulation of the biliary or pancreatic duct may be difficult without being able to visualize and orient endoscopic tools to the duct.

[0023] In accordance with an exemplary embodiment of the disclosure, a fluorophore may be used instead to fluoresce desired regions in an endoscopic procedure, e.g., for purposes of cannulating the papilla to access the biliary and/or pancreatic ducts. In embodiments, devices, systems, and methods may utilize fluorophore for imaging in an endoscopic procedure as described herein and in co-pending application filed concurrently herewith, entitled “Fluorophore Imaging Devices, Systems, and Methods for an Endoscopic Procedure” to Rout et al. (Attorney Docket No. 8150.0504), which is herein incorporated by reference in its entirety.

[0024] In some embodiments, indocyanine green (ICG) may be utilized, or another alternative fluorophore having characteristics similar to ICG (e.g., similar excitation and emission spectra), which may be injected intravenously, and secreted into bile. A fluorophore may be selected having characteristics similar to ICG at least partially based on near infrared (NIR) wavelengths. For example, lower wavelength spectra may have lower tissue penetration depth and lower signal-tonoise ratio due to tissue natural autofluorescence. Tissue autofluorescence may be particularly low in the NIR region, such that ICG (and other fluorophore having similar characteristics) may be desirable over other known fluorophore.

[0025] A fluorophore, such as ICG, may bind to plasma proteins, e.g., bile, upon which the protein bound fluorophore (e.g., ICG) may emit light. ICG, as an exemplary fluorophore, may be advantageous over known contrast imaging in that it may be injected into a patient intravenously, which is then excreted exclusively by the liver into bile. The ICG may be detectable within approximately 15 minutes of the injection, and may be present in the patient's system for detection for approximately two hours. As such, an injection of ICG may provide fluorescent images of a patient's biliary tract without necessitating gaining prior access to the bile duct. Near infrared (NIR) fluorescence imaging devices and systems in accordance with exemplary embodiments of the present disclosure may allow for fluorescence-based visualization of the ducts within a patient's biliary tree following an intravenous injection of fluorophore. For example, a medical professional may be able to visualize the orientation of a patient's bile duct on the duodenal wall, which may aide in orienting a sphincterotome or other endoscopic tool in the same direction.

[0026] Referring now to FIGS. **2**A-**3**B, exemplary embodiments of fluorophore imaging (e.g., ICG fluorescence imaging) devices and systems for an endoscopic procedure (e.g., an ERCP procedure) are shown. In an ERCP procedure, an endoscope, or duodenoscope **105**, may be inserted into an intestinal region of a patient, e.g., into the duodenum of a patient adjacent the biliary papilla. A distal end **110** of the duodenoscope **105** may include several accessories, for example, a light source **115** and a sensor **120**. In embodiments, the light source **115** may be a light emitting diode (LED), laser diode, or any method of emitting light that includes light at a 780 nm wavelength. In embodiments, the sensor **120** may be an imaging device such as a camera or other detection system. The sensor, or camera, may have a non-zero quantum efficiency in the NIR region, e.g., equal to or greater than approximately 10%, in a waveband between approximately 800 nm and 850 nm (e.g., approximately 830 nm). In embodiments, the camera may be a charge-coupled device (CCD) and/or complementary metal-oxide semiconductor (CMOS). The distal end **110** of the duodenoscope **105** may also include an elevator **125** so that a medical professional may manipulate additional accessory devices in the intestinal region of the patient at various angles to the shaft of the duodenoscope via the elevator **125**.

[0027] An attachment **130**, as shown in FIGS. **2**A-**2**B, may be removably attachable to the distal end **110** of the duodenoscope **105**. In embodiments, the attachment **130** may be configured to align one or more filters with the light source **115**, the sensor **120**, or both. The attachment **130** may include a ring **135** disposed at a proximal end **130***a* of the attachment **130**. The ring **135** may extend around a circumference “C” of the distal end **110** of the duodenoscope **105**, and the duodenoscope may have a diameter “d.sub.D.” The ring **135** may have a diameter “d.sub.A” and be sized as a slip fit relative to the circumference C, e.g., a circumference of the ring **135** may be larger than the circumference C of the distal end **110** of the duodenoscope **105** so that the attachment **130** may be removably attachable to the duodenoscope **105**. The ring **135** may fully extend around the distal end **110** of the duodenoscope **105**, and may be formed as a single piece, or may be formed as two or more pieces connectable to each other to couple the attachment **130** to the duodenoscope **105** (see FIGS. **3**A-**3**B).

[0028] The attachment **130** may further include an extension portion **140**. The extension portion **140** may extend from the proximal end **130***a* of the attachment **130** to the distal end **130***b* of the attachment **130**, e.g., longitudinally relative to the distal end **110** of the duodenoscope **105**, and may be coupled to the ring **135**. The extension portion **140** may be substantially flat, and/or may include a curvature **145** to match the curvature (e.g., of the circumference C) of the distal end **110** of the duodenoscope **105**.

[0029] At the distal end **130***b* of the attachment **130**, the extension portion **140** may include a distal curvature **150**, which may be configured to extend distally of a distal tip **155** of the duodenoscope

105. The distal curvature **150** may be configured so that the extension portion **140** and the distal curvature **150** form a “J” shape, a “U” shape, and/or a “C” shape, e.g., so that the extension portion **140** and the distal curvature form a hook around the distal tip **155** of the duodenoscope **105**. The curvature **150** may have a radius “r.sub.E”, which may be substantially similar to the corresponding curvature of the distal tip **155** of the duodenoscope **105**. In embodiments, the distal curvature **150** may additionally include a curvature **160** to match the curvature (e.g., of the circumference C) of the duodenoscope **105**, and/or the curvature **145** of the extension portion **140**. In some embodiments, the distal curvature **150** may be formed substantially flat, so that the distal tip **155** of the duodenoscope **105** may nest and/or contact the curvature radius r.sub.E.

[0030] The extension portion **140** and the distal curvature **150** may have a thickness “t”, which may cover a small portion of the circumference C of the duodenoscope **105**. “Small portion” may be understood to be approximately 3° to approximately 30°. By covering only a small portion of the distal end **110** of the duodenoscope with components of the attachment **130**, the duodenoscope **105** may be operable in a manner substantially the same or the same as without the attachment **130**. For example, the attachment **130** may not interfere with the elevator, or other channels or ports, so that accessories may be deliverable out of the distal end **110** of the duodenoscope **105** during an endoscopic procedure, and channel accessibility may be maintained while the attachment **130** is coupled to the duodenoscope **105**. In some embodiments, the extension portion and the distal curvature **150** may have a width “w”, which may be minimalized so that the attachment **130** may not affect the patient insertion process.

[0031] The distal curvature **150** may be coupled to the extension portion **140**, and also may be coupled to a filter portion **165**. In embodiments, the distal curvature **150** may extend from the extension portion **140** approximately 180° so that the filter portion **165** may be extendable from an opposite side of the distal curvature **150** substantially parallel to the extension portion **140** and extending in a direction proximal relative to the distal curvature **150**.

[0032] The filter portion **165** may have the same thickness “t” and width “w” as the extension portion **140** and/or the distal curvature **150**. The thickness “t” may be determined such that the filter portion **165** is extendable only over the light source **115** and/or the sensor **120**, thereby leaving the elevator **125** uncovered to allow for accessory devices to extend from and/or be retracted into a working channel of the duodenoscope **105**. The width “w” may be minimalized so that patient insertion processes remain unaffected. In embodiments, the filter portion **165** may be formed as a flat surface, e.g., to extend over the distal end **110** of the duodenoscope, where the light source **115**, the sensor **120**, and/or the elevator **125** may be disposed. In some embodiments, the filter portion **165** may have a curvature **170** formed to match the curvature (e.g., a portion of the circumference C) of the duodenoscope **105**, the curvature **160** of the distal curvature **150**, and/or the curvature **145** of the extension portion **140**. The curvatures **170**, **160**, **145** may match at least a portion of the circumference C of duodenoscope **105**, e.g., as a slip fit, which may minimize material from becoming trapped between the attachment **130** and the duodenoscope **105**.

[0033] The filter portion **165** may include a first filter **175** and a second filter **180**. When the attachment **130** is connected to the distal end **110** of the duodenoscope **105**, the first and second filters **175**, **180** may be in alignment with the light source **115** and/or the sensor **120** of the duodenoscope **105**. In embodiments, the first filter **175** may be alignable with the light source **115**, and the second filter **180** may be alignable with the sensor **120**, although it is understood that the first filter **175** may be alignable with the sensor **120**, and the second filter **180** may be alignable with the light source **115**. Although the attachment **130** shows the first filter **175** and the second filter **180** adjacent each other, it is understood that the positioning of the first and second filters **175**, **180** may be anywhere on the attachment **130** to be alignable with the light source **115** and the sensor **120** of the duodenoscope **105**.

[0034] In embodiments, the first filter **175** may be an excitation filter, and the second filter **180** may be an emission filter. An excitation filter may be used to only transmit a narrow waveband from the light source **115** as an excitation signal, to excite fluorophore (e.g., of the ICG fluorescent) injected in or otherwise provided to an area of the endoscopic procedure. In embodiments, the waveband may be between approximately 760 nm and 790 nm. For example, an excitation filter may be a 769 nm center-wavelength bandpass filter, with 41 nm bandwidth and high transmission (e.g., up to approximately 90%) of light in the passing region, and high blocking outside the passing region (e.g., optical density approximately equal to or greater than 5). In embodiments, the first filter **175**, or excitation filter, may be alignable with the light source **115** of the duodenoscope **105**.

[0035] The second filter **180**, e.g., an emission filter, may be used to isolate a signal emitted by the fluorophore from the excitation light source **115** with included first filter **175** as well as external sources centered near the excitation wavelength 780 nm. In some embodiments, an emission filter for ICG imaging may transmit wavelength between approximately 810 nm and 840 nm. For example, an emission filter may be an 832 nm center-wavelength bandpass filter with 38 nm bandwidth and high transmission (e.g., up to approximately 90%) of light in the passing region, and high blocking outside of the passing region (e.g., optical density approximately equal to or greater than 5). In embodiments, the second filter **180**, or emission filter, may be alignable with the sensor **120** of the duodenoscope **105**.

[0036] In embodiments, the attachment **130** may be connected to the duodenoscope **105** at the distal end **110**, e.g., by positioning the distal end **110** through the ring **135** of the attachment **130**, and aligning the filter portion **165** relative to the light source **115**, the sensor **120**, the elevator **125**, or combinations thereof. In embodiments, the attachment **130** may be connectable so that the first and/or second filters **175**, **180** may be movable relative to the light source **115**, the sensor **120**, and/or the elevator **125**. In some embodiments, the attachment **130** may be rotatable about the duodenoscope (e.g., as indicated by arrow "A") to move the filters in and/or out of alignment, e.g., the ring **135**, extension portion **140**, distal curvature **150**, and filter portion **165** may rotate relative to the duodenoscope **105**. An inner surface **195** of the ring **135** may be a flat surface relative to the circumference C of the duodenoscope **105**, and since the diameter da of the attachment **130** may be larger than the diameter d.sub.D of the duodenoscope **105**, the attachment **130** may be rotatable. In some embodiments, the surface **195** may be tapered, e.g., extending from the distal end **130***b* of the attachment **130** towards the proximal end **130***a* of the attachment **130**. The ring **135** may engage with the duodenoscope **105** so that a tapered surface **195** may allow for a tighter fit between the duodenoscope **105** and the attachment **130**, and movement (e.g., rotation) may occur only when the attachment **130** is intentionally rotated. In some embodiments, the attachment **130** may be fixed to the duodenoscope **105** such that rotation of the attachment **130** does not occur.

[0037] In some embodiments, the attachment **130** may remain substantially stationary relative to the duodenoscope **105** while the first and/or second filters **175**, **180** may be controllable externally to move in and/or out of alignment with the light source **115** and sensor **120**. For example, the first and/or second filters **175**, **180** may be extendable and retractable across a respective opening **185**, **190** of the attachment **130**. The filters **175**, **180** may be controlled by mechanisms or other actuators, configured so as to maintain a minimized thickness of the attachment **130**.

[0038] In some embodiments, the attachment **130** may include fasteners or other mechanisms to removably couple the attachment **130** and the duodenoscope **105**. The attachment **130** may be coupleable to the circumference C of the duodenoscope **105**, although in some embodiments, the attachment **130** may be attachable to an internal surface of the duodenoscope, e.g., through the elevator **125**. In some embodiments, an accessory may extend through a working channel of the duodenoscope **105** and out of the elevator **125** to clamp the attachment **130** in a desired position relative to the duodenoscope. The accessory may additionally and/or alternatively move the attachment **130** in and/or out of alignment with the light source **115** and/or sensor **120**.

[0039] Referring now to FIGS. **3**A-**3**B, another embodiment of a fluorophore imaging device and system is shown. An attachment **330** may be coupleable to a distal end **110** of a duodenoscope **105**, e.g., for performing an endoscopic procedure (e.g., an ERCP procedure). A proximal end **330***a* may be coupleable around the circumference C of the duodenoscope **105**, and a distal end **330***b* may be extendable around the distal tip **155** of the duodenoscope **105**. The attachment **330** may include a first portion **332***a* and a second portion **332***b*, which may be configured to be coupled together around the distal end **110** of the duodenoscope **105**. The first portion **332***a* may be configured so that the light source **115** and/or the sensor **120** are unobstructed. Filters, e.g., filters **375**, **380**, may be disposed on the first portion that may be alignable with the respective light source **115** and/or the sensor **120**, as described above with respect to attachment **130** and first and second filters **175**, **180**. In some embodiments, the attachment **330** may include any number “n” of portions **335***n*, configured to couple together to form the attachment **330**.

[0040] The attachment **330** may include a ring **335**, formable from a first ring portion **335***a* disposed on the first portion **332***a* and a second ring portion **335***b* disposed on the second portion **332***b*. The first ring portion **335***a* may have a first end **337***a* and extend around substantially circularly to a second end **337***b*. The second ring portion **335***b* may have a first end **338***a* and extend around substantially circularly to a second end **338***b*. In embodiments, the first and second ring portions **335***a*, **335***b* may each be approximately a half-circle, e.g., each extending around approximately half of the circumference C of the duodenoscope **105**, so that the ring **335** may extend around the circumference C of the distal end **110** of the duodenoscope **105**. The ring **335**, e.g., the first and second ring portions **335***a*, **335***b* together, may have a diameter “d.sub.B” and be sized as a slip fit relative to the diameter d.sub.D, e.g., the diameter of the ring **335** may be larger than the diameter of the distal end **110** of the duodenoscope so that the attachment **330** may be removably attachable to the duodenoscope **105**.

[0041] The attachment **330** may include an extension portion **340**, which may include a first extension portion **340***a* disposed on the first portion **332***a* and extending from the first ring portion **335***a*, and a second extension portion **340***b* disposed on the second portion **332***b* and extending from the second ring portion **335***b*. The first and second extension portions **340***a*, **340***b* may each extend longitudinally along the duodenoscope **105** toward the distal tip **155**. In some embodiments, the first extension portion **340***a* may extend longitudinally in a distal direction from the first end **337***a* of the first ring portion **335***a*, around the distal tip **155** of the duodenoscope **105** and extend longitudinally to connect at the second end **337***b*. The second extension portion **340***b* may extend longitudinally in a distal direction from the first end **338***a* of the second ring portion **335***b*, around the distal tip **155** of the duodenoscope **105** and extend longitudinally to connect at the second end **338***b*. The extension portions **340***a*, **340***b* may be positioned at the respect first and second ends **337***a*, **338***a*, **337***b*, **338***b* so that only side portions of the duodenoscope **105** are covered, leaving the light source **115**, sensor **120**, or elevator **125**, or combinations thereof, open. It is understood that similar to the extension portion **140** of attachment **130**, the first and/or second extension portions **340***a*, **340***b* of the attachment **330** may have a curvature **345** to match a portion of the circumference C of the duodenoscope **105**.

[0042] The first and second extension portions **345***a*, **345***b* may extend around the distal tip **155** of the duodenoscope **105**, e.g., at respective first and second distal curvature portions **350***a*, **350***b* to form curvature portion **350**. The distal portions **350***a*, **350***b* may be configured to extend distally of the distal tip **155** of the duodenoscope **105** around the side portions of the duodenoscope **105**, and may have a radius “r.sub.C”, which may be substantially similar to the corresponding curvature of the distal tip **155** of the duodenoscope **105**. While the distal curvature **150** may extend around the distal tip **155** to the filter portion **165** over the upper portion of the duodenoscope **105** including the light source **115**, the sensor **120**, the elevator **125**, or combinations thereof, the distal portions **350***a*, **350***b* may avoid extending over the light source **115**, the sensor **120**, the elevator **125**, or combinations thereof.

[0043] The first and second portions **332***a*, **332***b* may be coupleable to each other by a plurality of fasteners **343** disposed along the first and/or second extension portions **340***a*, **340***b*. In some embodiments, the fasteners **343** may be teeth which may interlock with each other to join the first and second portions **332***a*, **332***b*, as shown in FIG. **3**B, although the fasteners **343** may be clips, clamps, hook-and-eye closures, or other mechanisms to attach/detach and/or lock the first and second portions **332***a*, **332***b* to each other. In embodiments, the fasteners **343** may be fully disposed around the first and/or second extension portions **340***a*, **340***b*, although in some embodiments, the fasteners **343** may lock the first and second portions **332***a*, **332***b* only at selected areas around the first and/or second extension portions **340***a*, **340***b*, e.g., in equally spaced intervals. The first and second extension portions **340***a*, **340***b* and the fasteners **343** may allow the attachment **330** to be fixed to the distal end **110** of the duodenoscope **105** and remain stationary during an endoscopic procedure. In some embodiments, the filters **375**, **380** may be configured to be retractable within the attachment **330**. For example, a connector **367** may receive one or both of the filters **375**, **380**, for when the medical professional may not desire to filter wavelengths of the light source **115** and/or the sensor **120**. Mechanisms may actuate the filters **375**, **380** to align with the respective light source and/or sensor **120** when the medical professional desires to filter the wavelengths. Any mechanisms may be employed in the attachment **330** that do not substantially extend a thickness of the attachment **330**, so that the duodenoscope **105** and the attachment **330** may still navigate through a patient.

[0044] The attachment **330** may include a connector **367** extendable from the first extension portion **340***a*, or the second extension portion **340***b*. In embodiments, the connector **367** may have a curvature substantially matching at least a portion of the circumference C of the duodenoscope **105**. The connector **367** may be disposed on either the first or second portion **332***a*, **332***b*, such that when the attachment **330** is connected to the duodenoscope **105**, the light source **115**, the sensor **120**, the elevator **125**, or combinations thereof may remain uncovered and/or unobstructed. In some embodiments, the connector **367** may extend between the light source **115** and/or the sensor **120**. It is envisioned that the connector **367** may be optionally included on the attachment **330**. Embodiments without a connector **367** may allow for unobstructed access to the light source **115**, sensor **120**, and/or elevator **125**. In embodiments without the connector **367**, the first and/or second extension portions **340***a*, **340***b* may define windows to receive a respective first and/or second filter **375**, **380** for positioning over the light source **115** and/or sensor **120**, while allowing open access to the elevator **125**. As described above with respect to FIGS. **2**A-**2**B, a thickness “t” and width “w” of the extension portion **340** and/or the connector **367** may be minimalized so that patient insertion processes remain unaffected.

[0045] During an endoscopic procedure, e.g., an ERCP procedure, an endoscope, or a duodenoscope **105**, may be inserted into a patient, e.g., through a patient's mouth through the stomach and into the duodenum. The duodenoscope may be positioned along the duodenal wall at the biliary tree, and fluorescent (e.g., ICG fluorescent) may be provided to the area for imaging. In embodiments, the fluorescent may be provided before or after, or simultaneous, to the endoscope being inserted into the patient. The fluorescent may need time, e.g., approximately 15 minutes for ICG fluorescent, to bind to bile to fluoresce during the procedure. When the duodenoscope is in position and the fluorescent has had sufficient binding time, a medical professional may manipulate a distal end of the duodenoscope. For example, the duodenoscope may be positionable so that a light source, or sensor, or both, allow a medical professional to view the bile duct at the duodenal wall (see e.g., FIG. **1**). According to exemplary embodiments of the present disclosure, filters may be alignable with the light source, or the sensor, or both, so that the medical professional may view the area under white light, as well as filtered imaging (e.g., under fluorescence). For example, the first filter **175**, or excitation filter, may be alignable with the light source, and the second filter **180**, or emission filter, may be alignable with the sensor **120**. The medical professional may be able to toggle between white light (e.g., visible light between approximately 400 nm and 700 nm) and filtered imaging as desired. Under white light (e.g., visible light), the filters may not be used, so that the medical professional may view the area as illuminated by the light source (see FIG. **5**A).

When filtered, the contrast (e.g., ICG fluorescent) in the area may fluoresce, illuminating a path of the ducts (e.g., the bile duct), so that the medical professional may guide an accessory device (e.g., a guidewire) into the duct (see FIG. **5**B). When the duct is illuminated by the fluorescent (e.g., ICG fluorescent), the medical professional may have a clear view of a path for cannulation.

[0046] In some embodiments, the medical professional may control the filters on the attachments **130**, **330** remotely, e.g., by an imaging system such as an ICG fluorescence imaging system. The medical professional may control the filters by electrical toggle. An electrical toggle may be magnetically induced, voltage induced, or another electrical mechanism for switching between "on" (e.g., aligning the first and/or second filters **175**, **180** to the light source **115** and sensor **120**, respectively), and "off" (e.g., moving the first and/or second filters **175**, **180** out of alignment from the light source **115** and sensor **120**, respectively). It is understood that the user, or medical professional, may have control over the electrical toggle, to switch between white-light imaging and NIR fluorescence imaging during an endoscopic procedure, such as an ERCP procedure.

[0047] Referring now to FIG. **4**, an imaging system **410** may be operably connectable to a duodenoscope **105**, **405**. In some embodiments, the imaging system **410** may be a single component, although it is understood that the components may be individual components for connection with each other and the duodenoscope **105**. For example, the imaging system **410** may include a light source **415′**, a first bandpass filter **425** (e.g., an excitation filter), a sensor **420′**, and a second bandpass filter **430** (e.g., an emission filter), and may be disposed remotely from the patient. A fiber optic cable, or bundles, may be connectable to the imaging system **410**, and extendable a length for insertion through a duodenoscope, e.g., duodenoscope **105**, **405**. In this manner, the imaging system **410** may allow a medical professional to efficiently cannulate and verify proper access during an endoscopic procedure, such as an ERCP procedure. It is also understood that in embodiments, the light source **415** and/or the sensor **420** may be disposed in the duodenoscope **105**, **405**, e.g., at the distal end **110** of the duodenoscope **105** as shown in FIGS. **2**A-**3**B.

[0048] In some embodiments, the imaging system **410** may include several components, including but not limited to a controller **460**, a memory **440**, and/or a processing device **435**, a power source **445**, a display **450**, or user input interface **455**, or combinations thereof, for performing an endoscopic procedure. It is understood that, as above, the components may be included in a single system, or may be provided in separate components for connection with each other and/or the duodenoscope **105**, **405**.

[0049] In some embodiments, a first or second bandpass filter **425**, **430** may be remote to the duodenoscope **105**, **405**, such that signals may be sent through the bandpass filters **425**, **430**, to allow signals of a predetermined frequency range through the filter, and to not allow signals outside of the predetermined frequency range. In some embodiments, bandpass filters **425**, **430** may include a low pass filter and a high pass filter, to isolate the predetermined frequency range. In this manner, the light source **415**, **415′** may emit light, including light in the visible spectrum (e.g., white light), but also light in the NIR spectrum, e.g., such that light at a wavelength of approximately 780 nm is continuously supplied by the duodenoscope **105**, **405** and/or the imaging system **410**. The first and second bandpass filters **425**, **430** may be connectable with the light source **415** and/or the sensor **420**, and may include one or more light sources and/or sensors, and may be disposed remotely and/or in the duodenoscope **105**, **405**.

[0050] A first bandpass filter **425** may be a light source bandpass filter, and may be operatively connected to the light source **415**, **415′** such that when blocking visible light is desirable, e.g., during cannulation attempts, the first bandpass filter **425** may filter out the visible light to only allow the light wavelength in the NIR spectrum through. In some embodiments, a removable lowpass filter may additionally be included, having approximately a 700 nm wavelength cutoff point for when cannulation is not occurring, e.g., to be included to block 780 nm light except during cannulation, e.g., to minimize photobleaching of the ICG.

[0051] A second bandpass filter **430** may be a sensor bandpass filter, and configured for receiving signals of the detected light by the sensor **420**, **420′**, which may detect light at both the visible spectrum as well as the NIR spectrum continuously. The second bandpass filter **430** may be applied to the signal to filter out visible light, such that during cannulation attempts, only light in the NIR spectrum, e.g., at approximately the 830 nm wavelength, may be detectable by the sensor **420**, **420′** and visible light in blocked. A medical professional may apply and/or remove the first and second bandpass filters **425**, **430** as desired during an endoscopic procedure, e.g., by the imaging system **410**.
[0052] In some embodiments, the imaging system **410** and/or the duodenoscope **105**, **405** may include additional light sources **415** and/or sensors **420**. A first light source **415*a*** may be configured to emit light in the visible spectrum (e.g., white light) and a second light source **415*b*** may be configured to emit light in the NIR spectrum (e.g., approximately 780 nm wavelength). The second light source **415*b*** may include a first bandpass filter **425**. Similarly, a first sensor **420*a*** may be configured for detecting light in the visible spectrum, and a second sensor **420*b*** for detecting light in the NIR spectrum (e.g., approximately 830 nm wavelength). The second sensor **420*b*** may include a second bandpass filter **430**. It is understood that description herein of the light source **415** may be applicable to the first and/or second lights sources **415*a***, **415*b***, and the description herein of the sensor **420** may be applicable to the first and/or second sensors **420*a***, **420*b***. A medical professional may control the first and second bandpass filters **425**, **430** to filter signals to block light in the visible spectrum during cannulation, and/or light in the NIR spectrum. In some embodiments, a single light source **415** as described above may be used with a first and second sensors **420*a***, **420*b***, and in other embodiments, a first and second light source **415*a***, **415*b*** may be used with a single sensor **420** as described above.
[0053] In some embodiments, a duodenoscope **105**, **405** may be configured with a first light source **415*a*** to emit light only in the visible spectrum, and a first sensor **420*a*** to detect light only in the visible spectrum. In some embodiments, additional sensors and/or light sources may be included in an imaging system **410** and/or the duodenoscope **105**, **405**. For example, the first sensor **420*a*** may be configured to detect light in the visible wavelength, and a second sensor **420*b*** may be included to detect light in the NIR spectrum. A light source may be included to emit light through 780 nm wavelengths, and/or may include a first light source **415*a*** to provide the visible light source wavelengths, and a second light source **415*b*** to provide light in the NIR spectrum, e.g., approximately 780 nm wavelengths. A medical professional may toggle between the two settings at their discretion during cannulation. It is understood that in some embodiments, the light source **415** and/or the sensor **420** may be exchangeable in the duodenoscope **105**, **405** and/or the imaging system **410**.
[0054] In some embodiments, a light source **415** and/or a sensor **420** may be disposed as an accessory extending through a working channel of a duodenoscope **105**. Referring now to FIG. **6**, the first and/or second light source **415*a***, **415*b*** may be disposed on a distal end **610** of the accessory **605** as light source **615**. The first and/or second sensor **420*a***, **420*b*** may be disposed on the distal end **610** of the accessory **605** as sensor **620**. The accessory **605** may include fiber optics or LED capabilities as the light source **615**, and may be capable of emitting light at a wavelength of up to approximately 780 nm, e.g., NIR light. A sensor **620**, e.g., a camera, may collect, or detect up to 830 nm light. In embodiments, the sensor **620** may detect visible light, although when a filter is in alignment with the sensor **620**, only emission wavelength may be detectable so that background signals from light sourced from other than a fluorescence signal may be reduced. The medical professional may manually control the accessory **605** for extension and/or retraction, and turning the light source on and off as desired for performing the endoscopic procedure. The accessory **605** may be used in standard endoscopes and/or duodenoscopes, e.g., duodenoscope **105**, such as described above, and may include a light source **115** and/or a sensor **120**.
[0055] The imaging system **410** may also allow the medical professional to view an image of the

gastrointestinal area of the patient. For example, during an ERCP procedure, the fluorophore (e.g., ICG fluorescent) may be injected into a patient to allow for the biliary and/or pancreatic duct to be visible by a medical professional when filtering the light by the first and/or second filters **175**, **180**, **425**, **430**. As shown in FIGS. **5**A-**5**B, the an area of the duodenum, indicated at reference numeral **505**, may be visible under white light at **500** (FIG. **5**A), and the bile duct, as indicated at reference numeral **515**, may be visible through a filtered image **520** by the fluorescence (e.g., ICG fluorescent) and the first and/or second filter **175**, **180**, **425**, **430**, so that the medical professional may visualize the orientation of the bile duct for insertion of a guidewire during the ERCP procedure. As shown in FIGS. **5**A-**5**B, this visualization may allow a medical professional to position a sphincterotome or cannula **510** for accessing the bile duct **515**. The cannula **510** may include one or multiple channels for a guidewire for insertion and/or to inject contrast. However, the raw fluorescent signal to provide the image shown in FIG. **5**B may provide limited information to the medical professional for directing cannulation. As the light travels through tissue the light may spread such that it may be difficult to determine the boundaries of the bile duct.

[0056] Referring now to FIG. **5**C, an image overlay may be provided so that the medical professional may have a more accurate visualization for cannulation. As shown in reference numeral **525**, a pathway **530** may indicate visualization for cannulation, utilizing the fluorescent image provided in FIG. **5**B. The pathway **530** may represent a direction of the bile duct, e.g., calculated from the fluorescent image signal of FIG. **5**B. In embodiments, image system **410** may perform calculations based on the fluoresced bile duct **515**, e.g., by determining a best fit curve of the fluorescent signal. The best fit curve may be a center line, or center curve, of the signal, and may be calculated by determining a center of a duodenal papilla of a patient for locating a common bile duct, and extending the best fit curve through the fluorescent signal. The center of the duodenal papilla may be a first end of the common bile duct, or the last point needed to provide data. Data points may be collected from the fluorescent signal to calculate the best fit curve, which may indicate the location of the bile duct in the image which provides context for the medical professional to perform the medical procedure. The duodenal papilla may leak bile injected with ICG, such that fluorescent saturation occurs at the duodenal papilla and may be easily visible by the medical professional by the fluorescent image signal as an initial location or data point.

[0057] The image system **410** may include a memory **440**, which may store one or more programs or algorithms, and may be operably connected to the processing device **435** and/or the controller **460** for using the stored programs and/or algorithms to calculate the best fit curve based on the fluorescent signal. The medical professional may run the programs or algorithms after collecting the fluorescent signal (FIG. **5**B) through the user input interface **455** of the image system **410**, and may output the resulting best fit curve as an overlay image on the display **450**.

[0058] An overlay image may include the pathway **530**. The pathway may include the best fit curve determined by the programs or algorithms, and may also include a confidence interval. In some embodiments, the confidence interval may be visualized as a thickness of the best fit curve. For example, as the best fit curve is extended through the fluorescent signal, the corresponding thickness may indicate an error level at each data point. As shown in FIG. **5**C, the pathway **530** is a wedge-like shape, e.g., starting at a focal point at the duodenal papilla, which may have a high confidence level by virtue of the ICG injected bile concentrated at the duodenal papilla. As the fluorescent signal extends through the bile duct, the error level may increase at each data point, to account for light spread through tissue as described above. The programs and/or algorithms may account for the light spread, e.g., as light may spread in a Gaussian pattern, although the confidence interval may still be reduced as the fluorescent signal extends further into the bile duct. It is understood that the bile duct extends from the duodenal papilla, and there is additional tissue between the bile duct and the duodenal wall, which may increase the light spread. In some embodiments, instead of a wedge-like shape including the confidence interval of the fluorescent signal, the pathway **530** may be an image including the best fit curve with a thickness indicating a diameter of the area of endoscopic procedure. For example, the pathway **530** may show a thickness of a bile duct, so that the medical professional may have a visualization of the location of the bile duct. Programs or algorithms may receive an input of the raw fluorescence signal and may determine boundaries of the bile duct based on the gradient in signal intensity proceeding away from the center line/curve.

[0059] In some embodiments, the pathway **530** may further include additional visual indicators for the medical professional. In response to confidence levels that are lower in a specified area, e.g., a region of thick connective tissue, or tumor, where the signal may be lost or otherwise inconsistent such that a Gaussian signal is not present, different colors may be used to indicate the reduced area of confidence. In some embodiments, a portion of the pathway **530** may include a first color (e.g., green) to indicate high probability that the corresponding portion of the bile duct is located as indicated by the pathway. Additional colors (e.g., yellow, red) may indicate other portions of the pathway **530** to indicate lower probabilities that the corresponding portions of the bile duct are located as indicated by the pathway.

[0060] The overlay processes using programs and algorithms described above may be implemented by a processor component executing instructions stored on an article of manufacture, such as a storage medium. A storage medium may comprise any non-transitory computer-readable medium or machine-readable medium, such as an optical, magnetic or semiconductor storage. The storage medium may store various types of computer executable instructions, such as instructions to implement one or more disclosed processes. Examples of a computer readable or machine readable storage medium may include any tangible media capable of storing electronic data, including volatile memory or non-volatile memory, removable or non-removable memory, erasable or non-erasable memory, writeable or re-writeable memory, and so forth. Examples of computer executable instructions may include any suitable type of code, such as source code, compiled code, interpreted code, executable code, static code, dynamic code, object-oriented code, visual code, and the like. The embodiments are not limited in this context.

[0061] One or more aspects of at least one embodiment described herein may be implemented by representative instructions stored on a machine-readable medium which represents various logic within the processor, which when read by a machine causes the machine to fabricate logic to perform the techniques described herein. Such representations, known as “IP cores” may be stored on a tangible, machine readable medium and supplied to various customers or manufacturing facilities to load into the fabrication machines that actually make the logic or processor. Some embodiments may be implemented, for example, using a machine-readable medium or article which may store an instruction or a set of instructions that, if executed by a machine, may cause the machine to perform a method and/or operations in accordance with the embodiments. Such a machine may include, for example, any suitable processing platform, computing platform, computing device, processing device, computing system, processing system, computer, processor, or the like, and may be implemented using any suitable combination of hardware and/or software. The machine-readable medium or article may include, for example, any suitable type of memory unit, memory device, memory article, memory medium, storage device, storage article, storage medium and/or storage unit, for example, memory, removable or non-removable media, erasable or non-erasable media, writeable or re-writeable media, digital or analog media, hard disk, floppy disk, Compact Disk Read Only Memory (CD-ROM), Compact Disk Recordable (CD-R), Compact Disk Rewriteable (CD-RW), optical disk, magnetic media, magneto-optical media, removable memory cards or disks, various types of Digital Versatile Disk (DVD), a tape, a cassette, or the like. The instructions may include any suitable type of code, such as source code, compiled code, interpreted code, executable code, static code, dynamic code, encrypted code, and the like, implemented using any suitable high-level, low-level, object-oriented, visual, compiled and/or interpreted programming language.

[0062] Numerous specific details have been set forth herein to provide a thorough understanding of

the embodiments. It will be understood by those skilled in the art, however, that the embodiments may be practiced without these specific details. In other instances, well-known operations, components, and circuits have not been described in detail so as not to obscure the embodiments. It can be appreciated that the specific structural and functional details disclosed herein may be representative and do not necessarily limit the scope of the embodiments.
[0063] Some embodiments may be described using the expression “coupled” and “connected” along with their derivatives. These terms are not intended as synonyms for each other. For example, some embodiments may be described using the terms “connected” and/or “coupled” to indicate that two or more elements are in direct physical or electrical contact with each other. The term “coupled,” however, may also mean that two or more elements are not in direct contact with each other, but yet still co-operate or interact with each other.
[0064] Unless specifically stated otherwise, it may be appreciated that terms such as “processing,” “computing,” “calculating,” “determining,” or the like, refer to the action and/or processes of a computer or computing system, or similar electronic computing device, that manipulates and/or transforms data represented as physical quantities (e.g., electronic) within the computing system's registers and/or memories into other data similarly represented as physical quantities within the computing system's memories, registers or other such information storage, transmission or display devices. The embodiments are not limited in this context.
[0065] It should be noted that the methods described herein do not have to be executed in the order described, or in any particular order. Moreover, various activities described with respect to the methods identified herein can be executed in serial or parallel fashion.
[0066] Although specific embodiments have been illustrated and described herein, it should be appreciated that any arrangement calculated to achieve the same purpose may be substituted for the specific embodiments shown. This disclosure is intended to cover any and all adaptations or variations of various embodiments. It is to be understood that the above description has been made in an illustrative fashion, and not a restrictive one. Combinations of the above embodiments, and other embodiments not specifically described herein will be apparent to those of skill in the art upon reviewing the above description. Thus, the scope of various embodiments includes any other applications in which the above compositions, structures, and methods are used.
[0067] Although the subject matter has been described in language specific to structural features and/or methodological acts, it is to be understood that the subject matter defined in the appended claims is not necessarily limited to the specific features or acts described above. Rather, the specific features and acts described above are disclosed as example forms of implementing the claims.

Claims

1. A fluorescent imaging system for performing an endoscopic retrograde cholangiopancreatography (ERCP) procedure, comprising: a duodenoscope; a first light source for emitting light in the visible spectrum, or light in the near infrared (NIR) spectrum, or both; a light source bandpass filter for blocking the emitted light in the visible spectrum, or in the NIR spectrum, or both; a first sensor capable of detecting the light in the visible spectrum, or the light in the NIR spectrum, or both; and a sensor bandpass filter for blocking the detected light in the visible spectrum, or in the NIR spectrum, or both.
2. The fluorescent imaging system according to claim 1, wherein in response to applying the light source bandpass filter to the emitted light from the first light source, the emitted light is blockable in the visible spectrum, or in the NIR spectrum, or both.
3. The fluorescent imaging system according to claim 1, wherein in response to applying the sensor bandpass filter to the detected light by the first sensor, the detected light is blockable in the visible spectrum, or in the NIR spectrum, or both.
4. The fluorescent imaging system according to claim 1, wherein the first light source is capable of

emitting light in the visible spectrum and in the NIR spectrum and wherein the first sensor is capable of detecting light in the visible spectrum and in the NIR spectrum.

5. The fluorescent imaging system according to claim 1, wherein the light source bandpass filter is capable of blocking the emitted light in the visible spectrum and wherein the sensor bandpass filter is capable of blocking the detected light in the visible spectrum.

6. The fluorescent imaging system according to claim 1, wherein the first light source is capable of emitting light in the visible spectrum.

7. The fluorescent imaging system according to claim 6, further comprising: a second light source capable of emitting light in the near infrared (NIR) spectrum, wherein the light source bandpass filter is capable of blocking the emitted light in NIR spectrum.

8. The fluorescent imaging system according to claim 7, further comprising: a second sensor capable of detecting light in the NIR spectrum, wherein the sensor bandpass filter is capable of blocking the detected light in the NIR spectrum.

9. The fluorescent imaging system according to claim 8, wherein the first or second light source, or the first or second sensor, or combinations thereof, are disposed on the duodenoscope.

10. A fluorescent imaging system for performing an endoscopic retrograde cholangiopancreatography (ERCP) procedure, comprising: a duodenoscope comprising a first light source and a first imaging device that face from a side of the duodenoscope at a location along a length of the duodenoscope, the first light source for emitting light in the visible spectrum and the first sensor capable of detecting the light in the visible spectrum; a light source bandpass filter for blocking the emitted light in the visible spectrum, or in the NIR spectrum, or both; and a sensor bandpass filter for blocking the detected light in the visible spectrum, or in the NIR spectrum, or both.

11. The fluorescent imaging system according to claim 10, further comprising: a second light source capable of emitting light in the near infrared (NIR) spectrum; wherein the light source bandpass filter is capable of blocking the emitted light in NIR spectrum.

12. The fluorescent imaging system according to claim 11, further comprising: a second sensor capable of detecting light in the NIR spectrum; wherein the sensor bandpass filter is capable of blocking the detected light in the NIR spectrum.

13. The fluorescent imaging system according to claim 12, wherein second light source, or the second sensor, or both are disposed on the duodenoscope.

14. The fluorescent imaging system according to claim 13, wherein the fluorescent imaging system is configured to image an area of an endoscopic procedure in which a fluorophore is injected to generate a fluorescent signal indicating the area of the endoscopic procedure, establish a best fit curve of the area of the endoscopic procedure and overlaying the best fit curve on the fluorescent signal.

15. A fluorophore imaging device, comprising: an attachment removably coupleable to a distal end of a duodenoscope comprising a light source and an imaging device that face from a side of the duodenoscope along a length of the duodenoscope, the attachment including a first filter alignable with the light source of the duodenoscope, and a second filter alignable with the imaging device of the duodenoscope; wherein a working channel of the duodenoscope is accessible when the attachment is coupled to the duodenoscope.

16. The fluorophore imaging device according to claim 15, wherein the attachment is coupled to the distal end of the duodenoscope by a ring.

17. The fluorophore imaging device according to claim 16, wherein an extension portion is extendable from the ring longitudinally along the duodenoscope for connection with a filter portion.

18. The fluorophore imaging device according to claim 15, wherein the attachment includes a first portion and a second portion, the first and second portions being lockable with each other to rotationally fix the attachment to the distal end of the duodenoscope.

19. The fluorophore imaging device according to claim 15, wherein the attachment has a curvature to extend distally of a distal tip of the duodenoscope to fix the attachment to the distal end of the duodenoscope.
20. The fluorophore imaging device according to claim 19, wherein the curvature is a J-shape, U-shape, C-shape, or hook, or combinations thereof.