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(54) A METHOD, AN OPTICAL PROBE AND A CONFOCAL MICROSCOPY SYSTEM FOR INSPECTING A SOLID ORGAN

VERFAHREN, OPTISCHE SONDE UND KONFOKALES MIKROSKOPIESYSTEM ZUR ÜBERPRÜFUNG EINES FESTEN ORGANS

PROCÉDÉ, SONDE OPTIQUE ET SYSTÈME DE MICROSCOPIE CONFOCALE POUR INSPECTER UN ORGANE SOLIDE

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Description

BACKGROUND

Field of the Present Disclosure

[0001] The disclosure generally relates to organ inspection. More specifically, it relates to organ inspection of living subjects for diagnosing purpose and/or therapeutic applications.

Background Art

[0002] In the following description, a solid organ is defined as an organ that does not contain a cavity or lumen and that is not gaseous. A solid organ may for example consist of parenchyma and stroma, the latter often arranged as trabeculae or surrounding groups of parenchymatous cells to provide support (e.g. liver, kidney). A solid organ may also comprise cysts. Histological examination of suspected lesions and structural alterations in solid organs, e.g. in liver cirrhosis or staging of pancreatic malignant disease, is a continuous challenge. Radiology only offers a partial answer to this issue because Magnetic Resonance Imaging (MRI), helical Computed Tomography (CT) scan, endoscopic ultrasonography and Positron Emission Tomography (PET) only allow a low accuracy diagnosis with significant over and understaging status. To confirm definite diagnosis, standard histopathology through biopsies remains the current standard practice.

[0003] In order to get a tissue sample on living subjects, endoscopy procedures are generally preferred. As shown on Figure 1A, for imaging the gastrointestinal tract (GI tract), an endoscope 1 may be inserted in a subject 7 through upper or lower endoscopy. A specific endoscopy procedure, called Endoscopic UltraSound-guided Fine Needle Aspiration (EUS-FNA) is designed to provide ultrasound images of accessory full organs of the GI tract, such as the liver, the pancreas and sentinel lymph nodes. Referring now to Figure 1B, which illustrates an EUS-FNA procedure, the endoscope 1 may access a stomach 71 at the level of a junction with a duodenum 72 through upper endoscopy. A distal tip of the endoscope 1 may comprise an ultrasound module 11 for targeting a mass 74 of a pancreas 73 with an endoscopic needle 23 inserted into a working channel of the endoscope 1.

[0004] In the present description and subsequent claims, the term "needle" is used to indicate a hollow conduit that has a tip intended to puncture organs. Preferably, the tip is beveled. In the present description and subsequent claims, the expression "endoscopic needle" is used to indicate a hollow conduit adapted to be inserted in the working channel of an endoscope. In selected embbodiments, the endoscopic needle has a beveled tip.

[0005] The range of the ultrasound is marked on Figure 1B with dashed lines. The pancreas 73 may then be punctured and penetrated by the endoscopic needle 23 in order to obtain a biopsy for diagnosis purposes. EUS-FNA procedures are common in the field of endoscopy and are used for diagnostic of lesions as well as therapeutic actions. EUS-FNA main applications include:

- Pancreatic solid or cystic lesions. Solid masses or cysts can grow in the pancreas and they need to be punctured to diagnose whether they are malignant tumors or benign lesions. Liquid cysts, due to pancreatitis for instance, may also be punctured via EUS-FNA in order to be drained.

- Staging of cancers, by assessing the content of the surrounding lymph nodes. Indeed in many cancers, including lung cancer, pancreatic cancer, gastric cancer or rectum cancer, metastases are often found in the lymph nodes. Therefore, puncturing the lymph nodes allows diagnosing if cancer has spread.

[0006] Other less common applications of EUS-FNA include lesions in the liver or submucosal lesions in the GI tract. EUS-FNA procedures work by using an echoendoscope (standard endoscope with an ultrasound module at its tip) to localize a suspected lesion via ultrasound images of the area surrounding the GI or respiratory tract (in the case of lesion in the respiratory tract, the procedure is called EUS-TBNA for Endoscopic UltraSound-guided TransBronchial Needle Aspiration). Then a fine endoscopic needle is inserted in the endoscope's working channel and punctures the surrounding wall (either GI tract wall, or bronchial tree) in order to reach the targeted lesion. This puncture is monitored thanks to real-time ultrasound images in order to guide the needle to the lesion while avoiding any dangerous vessel puncture. The endoscopic needles used for the puncture have varying diameters, but the most used are referred to in the art as 19G and 22G needles, whose inner diameter is about 890 μm and 560 μm respectively. US patent document US2008/064925 discloses a portable system for endoscopic procedures.

[0007] However, cytology has also major limitations including: incremental cost, risk, time needed to perform a diagnosis, lack of in vivo information such as blood flow, and limited ability to predict disease course. Fine needle aspirations are particularly limited by sampling errors due to the limited number of aspirations and delayed diagnosis because of time consuming sampling processing.

[0008] The Applicant proposes hereunder a method, an optical probe and a confocal microscopy system for inspecting solid organs capable of overcoming the aforementioned limitations and in particular to accelerate the time needed for diagnosis and/or therapy.

SUMMARY OF THE CLAIMED SUBJECT MATTER

[0009] In at least one aspect, embodiments disclosed herein relate to a method for inspecting a solid organ in

a subject. The method may include the steps of introducing a needle in a predetermined area of the solid organ, inserting an optical probe through a lumen of the needle, and imaging the predetermined area by means of the optical probe.

[0010] Preferably, the step of introducing a needle in a predetermined area of the solid organ is performed before the step of inserting an optical probe through a lumen of the needle. According to an alternative embodiment, the step of introducing a needle in a predetermined area of the solid organ is performed after the step of inserting an optical probe through a lumen of the needle.

[0011] Preferably, the step of introducing the needle in the solid organ comprises puncturing the solid organ, preferably with a tip of the needle, which is preferably beveled.

[0012] According to a preferred embodiment, the step of introducing the needle in the solid organ comprises puncturing the solid organ using a stylet which is preferably preliminary inserted in the lumen of the needle, the stylet being preferably driven to protrude out of the needle and being preferably removed from the lumen before the step of inserting the optical probe through the lumen of the needle.

[0013] Preferably, the needle is percutaneously inserted in the organ.

[0014] Preferably, the solid organ is one selected from the group comprising, preferably consisting of a pancreas, a liver, a spleen, a lymph node, a prostate, a kidney, breast and ovaries.

[0015] According to a preferred embodiment, the needle is passed through a working channel of an endoscope which is preferably inserted in the subject through a natural orifice to approach the solid organ.

[0016] Preferably, the endoscope is passed through an internal incision of internal tissues to access the solid organ.

[0017] Preferably, the needle is guided using an ultrasound module. Preferably, the ultrasound module is arranged at a tip of the endoscope.

[0018] Preferably, the needle is passed through an incision of internal tissues to access the solid organ.

[0019] Preferably, the needle is guided using any of an ultrasound module, a scanner, a computed tomography scan system, a magnetic resonance imagery system or a fluoroscopy imagery system.

[0020] In at least one aspect, embodiments disclosed herein relate to an optical probe for inspecting a solid organ in a subject, the optical probe being intended to be positioned in the solid organ through a needle. The optical probe preferably comprises an optical fiber bundle; a ferule for protecting the distal tip of the optical fiber bundle, the ferule preferably comprising a shank and a head; a sheath preferably wrapping the fiber bundle and the shank. The head of the ferule has a length adapted for the optical probe to image the solid organ while keeping the sheath inside the needle.

[0021] Preferably, the optical probe further comprises an objective connected coaxially at a distal tip of the optical fiber bundle, and the ferule preferably connects the objective to the distal tip of the optical fiber bundle.

[0022] Preferably, the shank and the head of the ferule are coaxially mounted together. Preferably, both the shank and the head of the ferule have a tubular shape defining a lumen. Preferably, the optical fiber bundle and the objective are enclosed in said lumen.

[0023] Preferably, the optical probe further comprises an external junction between the shank and the head, the external junction being chamfered.

[0024] Preferably the shank, the head and the external junction are integrally made, preferably integrally molded with one another.

[0025] The optical probe according preferably further comprises glue preferably provided on the external junction between the head and the shank of the ferule.

[0026] Preferably, the head of the ferule extends to the tip of the objective to be in contact with the organ to image.

[0027] Preferably, the head of the ferule extends to the tip of the optical fiber bundle to be in contact with the organ to image.

[0028] Preferably, the optical fiber bundle, the ferule and the sheath each have an external diameter of preferably less than 0.9 mm, preferably less than 0.8 mm, preferably less than 0.7 mm.

[0029] Preferably, the length of the ferule is less than 8 mm, preferably less than 7 mm, preferably less than 6 mm. Preferably, the axial length of the ferule is less than 8 mm, preferably less than 7 mm, preferably less than 6 mm.

[0030] Preferably, the external diameter of the head of the ferule is substantially equal to the external diameter of the sheath.

[0031] Preferably, the optical probe further comprises a locking mechanism preventing the head of protruding out of the needle. Preferably, the locking mechanism is intended to prevent the head of protruding out of the needle more than of a predetermined length.

[0032] Preferably, an internal surface of the sheath is adapted to stick on the shank.

[0033] Preferably, the optical probe further comprises at least one hollow section, preferably a hollow volume to be filled for example with air or other suitable gas for enhancing ultrasound visualization of the optical probe.

[0034] In at least one aspect, embodiments disclosed herein relate to a confocal microscopy system for inspecting a solid organ in a subject preferably comprising a confocal microscope, and an optical probe as described above.

[0035] Other aspects and advantages of the present disclosure will be apparent from the following description and the appended claims.

BRIEF DESCRIPTION OF DRAWINGS

[0036]

Figure 1A illustrates a lower endoscopy and an upper endoscopy on a human body according to the prior art. Figure 1B illustrates a standard Endoscopic UltraSound-guided Fine Needle Aspiration technique (EUS-FNA) according to the prior art.

Figures 2 shows an endoscopic needle system according to the prior art.

Figure 3 illustrates an ultrasound view obtained via EUS-FNA in a pancreas according to an embodiment of the present disclosure.

Figure 4 illustrates a distal tip of an optical probe according to an embodiment of the present disclosure.

Figure 5 illustrate a distal tip of an optical probe according to an embodiment of the present disclosure.

Figures 6A, 6B and 6C illustrate three positions of an optical probe according to embodiments of the present disclosure inserted in a needle according to the prior art.

Figure 7 illustrates a confocal microscopy system according to an embodiment of the present disclosure.

Figures 8A and 8B are respectively confocal images of pancreatic and hepatic blood vessels obtained using a method and the confocal microscopy system of Figure 7 according to embodiments of the present disclosure.

Figures 9A, 9B and 9C are respectively confocal images of pancreatic, hepatic and splenic cells obtained using a method and the confocal microscopy system of Figure 7 according to embodiments of the present disclosure.

DETAILED DESCRIPTION

[0037] Specific embodiments of the present disclosure will now be described in detail with reference to the accompanying Figures. Like elements in the various Figures may be denoted by like numerals.

[0038] In a method for inspecting solid organs according to the present disclosure, a needle may be introduced in a solid organ of a subject. An optical probe inserted in a lumen of the needle may be brought in contact of a predetermined area of the organ to image the predetermined area. The optical probe may be used together with a confocal microscopy system. Imaging the organ according to this method may enable to obtain microscopic pictures of the predetermined area and may help establishing a diagnosis in real time. The solid organ may be one selected from the group consisting of a pancreas, a liver, a spleen, a lymph node, breast, ovaries, a kidney or a prostate.

[0039] The step of introducing the needle in the solid organ may comprise puncturing the solid organ, preferably with a tip of the needle. In order to facilitate the puncturing, the tip of the needle intended to puncture the organ is preferably beveled. The needle may be percutaneously inserted in the organ to image. Alternatively, the needle may be an endoscopic needle and may be passed through a working channel of an endoscope inserted in the subject for example through upper or lower GI endoscopy procedures, bronchoscopy and other endoscopic procedures (for example transrectal ultrasound, cystoscopy, etc.) in order to approach the solid organ to image. The endoscope may further be passed through an internal incision for the needle to directly access the solid organ. The needle may puncture a surrounding wall before accessing the organ to image. The step of inserting the optical probe in the needle may be performed before or after the step of puncturing the organ with the needle. The optical probe may be positioned to protrude out of the needle and may be locked on a given position using a locking mechanism.

[0040] After the puncture of the surrounding organs (for instance the stomach or duodenum in the case of a pancreatic lesion), dirt resulting from surrounding organ residuals may remain in the lumen of the needle. A stylet may be used to push the dirt out of the lumen. Advantageously, when the step of inserting the optical probe follows the puncture, the stylet may be loaded in the lumen of the needle during the organ puncture. The dirt may also be pushed out of the needle by the optical probe. Advantageously, when the step of inserting the optical probe in the needle precedes the puncture, the optical probe performs pushing out of the dirt.

[0041] In another embodiment, the solid organ may be punctured by a stylet preloaded in the lumen of the needle. The stylet may have a beveled edge to ease the organ puncture. The stylet may be driven out of the lumen of the needle to puncture a predetermined area of the solid organ. The needle may thereafter be introduced in the solid organ at the predetermined area. The stylet may be removed for the optical probe to be inserted in said lumen.

[0042] The needle may be guided to the predetermined area using ultrasound, scanner, MRI or the like in order to avoid dangerous vessel puncture. An ultrasound module may be arranged at a tip of an endoscope in order to visualize the needle when it is used through the working channel of the endoscope. The device used to perform the puncture (i.e. the needle or the stylet) may puncture the organ under direct visualization or ultrasound guidance by advancing carefully into the organ. Advantageously, when the optical probe is used together with a fluorescence fiber microscope, fluorescein may be injected intravenously for intensifying contrast enhancement. The optical probe may then be manipulated in order for a distal tip of the optical probe to touch the inner tissue

of the organ.

[0043] Figure 2 shows an endoscopic needle system 2 that may be used for fine needle aspiration. The endoscopic needle system 2 may comprise a handle 21, a protective needle sheath 22, and an endoscopic needle 23. A stylet 24 may be inserted through an opening in a lumen of the needle. The opening may be located at an end of the handle 21. A syringe connection that may also be placed on the opening may enable to connect a syringe for aspiration of a tissue when the endoscopic needle system is used for performing tissue aspiration through EUS-FNA procedure. In order to connect the syringe, the stylet may first be removed. According to an embodiment of the present disclosure, an optical probe may be inserted through the opening in the lumen of the needle. The needle 23 may be enclosed in the sheath 22 and the handle 21 may also comprise a control system to enable controlled protrusion of the needle 23 out of the needle sheath 22. When an optical probe is inserted in the lumen of the needle 23, the position of the optical probe in the lumen may be manually adjusted by an operator. The distal tip of the needle may be beveled in order to facilitate the puncture of a predetermined organ. Preferred features of the needle may be for example: inner diameter (ID) from about 0.30 mm to 1 mm; outer diameter (OD) from about 0.6 mm to about 1.2 mm. Particularly preferred needles are the 22G needle (ID = 0.56 mm; OD = 0.71 mm) and the 19G needle (ID = 0.89 mm; OD = 1.07 mm). Those having ordinary skill will appreciate that alternative needle gauges and sizes may be used as well.

[0044] The sheath 22 together with the needle 23 may be inserted into an endoscope to approach an organ. The step of puncturing the organ may be performed under ultrasound guidance. Figure 3 illustrates an ultrasound picture of a pancreas taken via an endoscope arranged with a linear ultrasound module 11 at its tip during a puncture of a pancreas by an endoscopic needle 23.

[0045] Referring to Figure 7, an optical probe 3 according to an embodiment of the present disclosure may comprise an optical fiber bundle made of several thousands of optical fibers protected by a sheath. The fibers may, for example, have a core diameter of 2 μm and a mean core spacing of 3.3 μm. A proximal end of the optical probe may be connected for example to a real-time scanning confocal microscope 4 (such as Cellvizio® from Mauna Kea Technologies). A proximal end may also be connected to any type of fiber microscopes. Observations at cellular or micro-vascular levels with high sensitivity may also be made possible. The proximal confocal microscope 4 may include an illumination source, which may be a LASER source, capable of exciting endogenous or exogenous fluorophores. The proximal confocal microscope 4 may also include a detection channel, which permits collecting and measuring a fluorescence signal. In an embodiment, the confocal microscope is a reflection microscope collecting and measuring backscattered light. The distal objective of the optical probe 3 conjugates the distal end of the fiber bundle with a specific image plane, at a specific working distance when the optical probe is in contact with a biological tissue. When illuminated one after another by the proximal scanner, each fiber of the bundle becomes an illumination source of a small volume within the tissue. This illumination may excite endogenous or exogenous fluorescence. In addition to functioning as a source of light, the illumination fiber also collects the fluorescence signal and transmits it to the proximal scanner. There, the return beam is spatially filtered and directed to the detection channel. As a result, the optical probe and its proximal scanner perform a confocal exploration of the tissue. The resulting images may be stored and processed on a processing and storage device 6 and may also be displayed on a display device 5.

[0046] Referring now to Figure 4, an optical probe 3 may comprise an optical fiber bundle 31, a miniaturized objective 32 coaxially mounted at a distal tip of the optical fiber bundle 31 and a ferule 33 for connecting the objective 32 to the distal tip of the optical fiber bundle 31. The ferule 33 may comprise a shank 331 and a head 332. A sheath 34 may wrap a portion of the fiber bundle 31 and the shank 331. The head 332 may extend to the tip of the objective 32 to be in contact of the organ to image and may be polished in order to limit its invasiveness. The shank 331 and the head 332 of the ferule 33 may both have a tubular shape and be coaxially arranged. The shank 331 and the head 332 may be integrally formed. The fiber bundle 31 and the objective 32 may fit in a lumen formed by arranging the shank 331 and the head 332 coaxially. The shank 331 and the head 332 may have same internal diameter. An external junction 333 between the shank 331 and the head 332 may be chamfered. Advantageously, the chamfered external junction may be covered with glue to prevent from dirt accumulation at the junction 333.

[0047] In an embodiment, the optical probe 3 may not comprise an objective and the distal tip of the fiber bundle 31 may be brought directly into contact of an organ to image. In this embodiment, the head 332 may protect the fiber bundle 31 and may extend to the distal tip of the fiber bundle 31.

[0048] As shown in Figure 5, the optical probe 3 may comprise at least one hollow volume 334 filled with air in order to enhance ultrasound visualization of the optical probe 3. Advantageously, the air in the hollow volume may be replaced by any fluid or solid enhancing ultrasound visualization of the optical probe. The head and the shank may have a tubular shape. The external diameter of the shank 331 may substantially be equal to the internal diameter of the head 332. An internal surface of the head 332 may comprise a cavity so that the hollow volume 334 may result from assembling the shank into a lumen of the head 332.

[0049] Referring to Figure 6A, the optical probe 3 may be inserted in a lumen of the needle 23. The optical probe 3 may be moved toward the tip of the needle 23 (Figure

6B) in order to protrude out of the tip of the needle (Figure 6C) for imaging a predetermined area of an organ (not shown on Figures 6A-C). The needle 23 may be beveled to ease the puncture of the organ. The head 332 of the optical probe may have a longitudinal length adapted for the sheath 34 to stay enclosed in the needle 23 when the tip of the head 332 is moved beyond the tip of the needle 23 in order to be put in contact with the organ. In other words, the head 332 may have an axial length such that the sheath 34 stays before the end section of the needle (preferably before the beginning of the bevel) when the tip of the head 332 projects out of the end section of the needle (after the end of the bevel, i.e. the free end of the needle 23). The head 332 may be pushed beyond the end of the bevel of about 0 to 5 mm. The bevel of the needle 23 may form an angle of about 20° to 90° relatively to a longitudinal axis of the needle 23. Preferably, the bevel of the needle 23 may be of about 20°. The head 332 may have a length of about 1 to 8 mm. The length of the head 332 of the optical probe 3 may be defined as the axial length of the head 332. Preferably, the bevel of the needle 23 may have a length greater than 2 mm. The length of the bevel may be defined as the axial length between the beginning of the bevel and the end of the bevel, i.e. the free end of the needle 23. In other words, the length of the bevel may be equal to the projection, on the longitudinal axis of the needle 23, of the beveled edge of the needle 23. The length of the head 332 of the optical probe 3 is preferably greater than the length of the bevel of the needle 23.

[0050] Experiments with first ferules having a longitudinal length of about 4 mm and second ferules having a longitudinal length of about 8mm have shown that the first ferules ease the extraction of the probe 3 from the needle 23 especially when the needle 23 is bent, for example upon accessing lesions through the duodenum.

[0051] A safe contact between the probe 3 and the needle 23 is provided by the presence of the ferule 33 which avoids the probe 3 to be cut by the bevel of the needle 23. When the probe 3 is inserted in the needle 23, a predetermined limit of advancement of the probe 3 beyond the end of the bevel may be determined. In an embodiment, this limit position may be reached when the probe 3 protrudes from the distal tip of the needle 23 of more than 2 mm. Having the probe 3 protruding out of the bevel from 2 mm may enable to position the tip of the probe 3 in better contact with the tissue to inspect and therefore enables to obtain a good image quality. Preferably, the length of the head 332 of the optical probe 3 is superior to the length of the bevel of the needle 23 increased by the predetermined limit of advancement of the probe 3 beyond the end of the bevel.

[0052] Preferably, the head of the optical probe 3 may have a length of about 3 mm. This may advantageously improve the resistance of the optical probe 3 by preventing the sheath 34 to rub against the bevel of the needle 23. The length of the ferule may be advantageously kept lower than 12 mm for the flexibility of the endoscope and the needle to stay satisfactory.

[0053] Figures 8A-B and Figures 9A-C illustrate images of solid organs obtained according to embodiments of the present disclosure. Figures 8A and 8B show blood vessels 731 and 751 respectively observed in a pancreas and in a liver.

[0054] Figure 9A has been acquired in a pancreas and shows pancreatic acini 732 which are part of the exocrine part of the pancreas. Figure 9B has been acquired in a liver. The liver is a very vascularized organ, divided into small hexagonal structures called lobules which are themselves composed of hepatocytes 752 separated by sinusoids. Figure 9C has been acquired in a spleen and enables to distinguish between the red pulp 762 and white pulp 761 of the spleen.

[0055] While the disclosure has been described with respect to a limited number of embodiments, those skilled in the art, having benefit of this disclosure, will appreciate that other embodiments can be devised which do not depart from the scope of the disclosure as disclosed herein. Accordingly, the scope of the disclosure will be limited only by the attached claims.

Claims

1. An optical probe to image a solid organ in a subject, the optical probe being intended to be positioned in the solid organ through a needle, the optical probe comprising:

   an optical fiber bundle (31) for transmitting light of an illumination source towards the solid organ through the distal end of the optical fiber bundle and for transmitting a return light beam coming from the solid organ;
   a ferule (33) to protect the distal tip of the optical fiber bundle, the ferule (33) comprising a shank (331) and a head (332);
   a sheath (34) wrapping the fiber bundle (31) and the shank (331);

   wherein

   the head (332) of the ferule (33) has a length adapted for the optical probe to image the solid organ while keeping the sheath (34) inside the needle.

2. The optical probe according to claim 1, further comprising an objective (32) connected coaxially at a distal tip of the optical fiber bundle (31), wherein the ferule (33) connects the objective (32) to the distal tip of the optical fiber bundle (31).

3. The optical probe according to claim 2, wherein:

   the shank (331) and the head (332) of the ferule

(33) are coaxially mounted and both have a tubular shape defining a lumen, and
the optical fiber bundle (31) and the objective (32) are enclosed in the lumen.

4. The optical probe according to claim 3, further comprising an external junction (333) between the shank (331) and the head (332), the external junction (333) being chamfered.

5. The optical probe according to claim 4, wherein the shank (331), the head (332) and the external junction (333) are integrally molded.

6. The optical probe according to claim 4 further comprising glue provided on the chamfered external junction between the head (332) and the shank (331) of the ferule (33).

7. The optical probe according to claim 2, wherein the head (332) of the ferule (33) extends to the tip of the objective (32) to be in contact with the organ to image.

8. The optical probe according to claim 1, wherein the head (332) of the ferule (33) extends to the tip of the optical fiber bundle (31) to be in contact with the organ to image.

9. The optical probe according to claim 3, wherein the optical fiber bundle (31), the ferule (33) and the sheath (34) each have an external diameter of less than 0.9 mm.

10. The optical probe according to claim 1, wherein the length of the ferule (33) is less than 8 mm.

11. The optical probe according to claim 3, wherein the external diameter of the head (332) of the ferule (33) is substantially equal to the external diameter of the sheath (34).

12. The optical probe according to claim 1, further comprising a locking mechanism preventing the head of protruding out of the needle more than of a predetermined length.

13. The optical probe according to claim 1, wherein an internal surface of the sheath (34) is adapted to stick on the shank (331).

14. The optical probe according to claim 1, further comprising at least one hollow section to be filled with air for enhancing ultrasound visualization of the optical probe.

15. A confocal microscopy system for inspecting a solid organ in a subject comprising:

a confocal microscope, and
an optical probe according to any of claims 1 to 14.

16. A confocal microscopy system according to claim 15, comprising

a proximal scanner for illuminating one after another the fibers of the optical fiber bundle of the optical probe in order to excite an endogenous or exogenous fluorescence of a tissue of the solid organ and for collecting a fluorescence signal coming from the solid organ which is transmitted through the optical fiber bundle of the optical probe.

17. A method to image a solid organ in a subject using an optical probe according to any of claims 1 to 14, the method comprising:

transmitting a light of an illumination source through the optical fiber bundle of the optical probe towards the solid organ,
collecting a return light beam coming from the solid organ and transmitted through the optical fiber bundle of the optical probe,
acquiring an image of the solid organ from the return light beam.

18. A method according to claim 17, further comprising illuminating, by a proximal scanner, one after another the fibers of the optical fiber bundle of the optical probe in order to excite an endogenous or exogenous fluorescence of a tissue of the solid organ,
wherein the return light beam is a fluorescence signal.

Patentansprüche

1. Optische Sonde zum Abbilden eines soliden Organs in einem Subjekt, wobei die optische Sonde mithilfe einer Nadel im soliden Organ positioniert werden soll und die optische Sonde Folgendes umfasst:

ein Lichtleitfaserbündel (31) zum Aussenden von Licht einer Lichtquelle durch das distale Ende des Lichtleitfaserbündels in Richtung des soliden Organs und zum Senden eines zurückkehrenden Lichtstrahls, der vom soliden Organ kommt;
eine Hülse (33) zum Schutz der distalen Spitze des Lichtleitfaserbündels, wobei die Hülse (33) Folgendes umfasst:

einen Schaft (331) und einen Kopf (332);

eine Umhüllung (34), die das Faserbündel (31)

und den Schaft (331) umgibt;

wobei

der Kopf (332) der Hülse (33) eine Länge aufweist, die so angepasst ist, dass die optische Sonde das solide Organ abbildet, während die Umhüllung (34) innerhalb der Nadel bleibt.

2. Optische Sonde nach Anspruch 1, die außerdem ein Objektiv (32) umfasst, das koaxial an einer distalen Spitze des Lichtleitfaserbündels (31) verbunden ist, wobei die Hülse (33) das Objektiv (32) mit der distalen Spitze des Lichtleitfaserbündels (31) verbindet.

3. Optische Sonde nach Anspruch 2, wobei:

der Schaft (331) und der Kopf (332) der Hülse (33) koaxial angebracht sind und beide eine Schlauchform aufweisen, die ein Lumen definiert, und
das Lichtleitfaserbündel (31) und das Objektiv (32) im Lumen eingeschlossen sind.

4. Optische Sonde nach Anspruch 3, die außerdem einen externen Anschluss (333) zwischen dem Schaft (331) und dem Kopf (332) umfasst, wobei der externe Anschluss (333) abgeschrägt ist.

5. Optische Sonde nach Anspruch 4, wobei der Schaft (331), der Kopf (332) und der externe Anschluss (333) in einem Stück gegossen sind.

6. Optische Sonde nach Anspruch 4, die des Weiteren Klebstoff umfasst, der auf dem abgeschrägten externen Anschluss zwischen dem Kopf (332) und dem Schaft (331) der Hülse (33) bereitgestellt wird.

7. Optische Sonde nach Anspruch 2, wobei der Kopf (332) der Hülse (33) sich bis zur Spitze der Objektivs (32) erstreckt, um mit dem abzubildenden Organ in Kontakt zu sein.

8. Optische Sonde nach Anspruch 1, wobei der Kopf (332) der Hülse (33) sich bis zur Spitze des Lichtleitfaserbündels (31) erstreckt, um mit dem abzubildenden Organ in Kontakt zu sein.

9. Optische Sonde nach Anspruch 3, wobei das Lichtleitfaserbündel (31), die Hülse (33) und die Umhüllung (34) jeweils einen Außendurchmesser von weniger als 0,9 mm aufweisen.

10. Optische Sonde nach Anspruch 1, wobei die Länge der Hülse (33) weniger als 8 mm beträgt.

11. Optische Sonde nach Anspruch 3, wobei der Außendurchmesser des Kopfs (332) der Hülse (33) im Wesentlichen dem Außendurchmesser der Umhüllung (34) entspricht.

12. Optische Sonde nach Anspruch 1, die außerdem eine Arretierung umfasst, die verhindert, dass der Kopf weiter aus der Nadel hervorragt als eine vorgegebene Länge.

13. Optische Sonde nach Anspruch 1, wobei eine innere Oberfläche der Umhüllung (34) so ausgeführt ist, dass sie auf dem Schaft (331) haftet.

14. Optische Sonde nach Anspruch 1, die weiterhin mindestens einen Hohlbereich umfasst, der mit Luft gefüllt wird, um die Ultraschallvisualisierung der optischen Sonde zu verbessern.

15. Konfokales Mikroskopiesystem zur Untersuchung eines soliden Organs in einem Subjekt, das Folgendes umfasst:

ein konfokales Mikroskop, und
eine optische Sonde gemäß einem der Ansprüche 1 bis 14.

16. Konfokales Mikroskopiesystem nach Anspruch 15, welches

einen proximalen Scanner umfasst, um damit nacheinander die Fasern des Lichtleitfaserbündels der optischen Sonde zu beleuchten, sodass eine endogene oder exogene Fluoreszenz eines Gewebes des soliden Organs angeregt wird und um ein Fluoreszenzsignal zu empfangen, das vom soliden Organ kommt und durch das Lichtleitfaserbündel der optischen Sonde übertragen wird.

17. Verfahren zur Abbildung eines soliden Organs in einem Subjekt mithilfe einer optischen Sonde nach einem der Ansprüche 1 bis 14, wobei das Verfahren Folgendes umfasst:

Aussenden eines Lichts einer Lichtquelle durch das Lichtleitfaserbündel der optischen Sonde in Richtung des soliden Organs,
Empfangen eines zurückkehrenden Lichtstrahls, der vom soliden Organ kommt und durch das Lichtleitfaserbündel der optischen Sonde übertragen wird,
Erhalt einer Abbildung des soliden Organs vom zurückkehrenden Lichtstrahl.

18. Verfahren nach Anspruch 17, das außerdem Folgendes umfasst:

Beleuchtung der Fasern des Lichtleitfaserbündels der optischen Sonde nacheinander mithilfe

eines proximalen Scanners, um eine endogene oder exogene Fluoreszenz eines Gewebes des soliden Organs anzuregen,
wobei der zurückkehrende Lichtstrahl ein Fluoreszenzsignal ist.

Revendications

1. Sonde optique pour former une image d'un organe solide dans un sujet, la sonde optique étant destinée à être positionnée dans l'organe solide à travers une aiguille, la sonde optique comprenant :

un faisceau de fibres optiques (31) pour transmettre la lumière d'une source d'éclairement en direction de l'organe solide à travers l'extrémité distale du faisceau de fibres optiques et pour transmettre un faisceau lumineux de retour venant de l'organe solide ;
une ferrule (33) pour protéger la pointe distale du faisceau de fibres optiques, la ferrule (33) comprenant une tige (331) et une tête (332) ;
une gaine (34) enveloppant le faisceau de fibres (31) et la tige (331) ;
dans laquelle
la tête (332) de la ferrule (33) présente une longueur adaptée pour que la sonde optique forme une image de l'organe solide tout en maintenant la gaine (34) à l'intérieur de l'aiguille.

2. Sonde optique selon la revendication 1, comprenant en outre un objectif (32) raccordé coaxialement sur une pointe distale du faisceau de fibres optiques (31), dans laquelle la ferrule (33) raccorde l'objectif (32) à la pointe distale du faisceau de fibres optiques (31).

3. Sonde optique selon la revendication 2, dans laquelle :

la tige (331) et la tête (332) de la ferrule (33) sont montées coaxialement et ont toutes deux une forme tubulaire définissant un conduit, et
le faisceau de fibres optiques (31) et l'objectif (32) sont enfermés dans le conduit.

4. Sonde optique selon la revendication 3, comprenant en outre une jonction externe (333) entre la tige (331) et la tête (332), la jonction externe (333) étant chanfreinée.

5. Sonde optique selon la revendication 4, dans laquelle la tige (331), la tête (332) et la jonction externe (333) sont intégralement moulées.

6. Sonde optique selon la revendication 4, comprenant en outre de la colle prévue sur la jonction externe chanfreinée entre la tête (332) et la tige (331) de la ferrule (33).

7. Sonde optique selon la revendication 2, dans laquelle la tête (332) de la ferrule (33) s'étend vers la pointe de l'objectif (32) pour être en contact avec l'organe dont une image doit être formée.

8. Sonde optique selon la revendication 1, dans laquelle la tête (332) de la ferrule (33) s'étend vers la pointe du faisceau de fibres optiques (31) pour être en contact avec l'organe dont une image doit être formée.

9. Sonde optique selon la revendication 3, dans laquelle le faisceau de fibres optiques (31), la ferrule (33) et la gaine (34) ont chacun un diamètre extérieur inférieur à 0,9 mm.

10. Sonde optique selon la revendication 1, dans laquelle la longueur de la ferrule (33) est inférieure à 8 mm.

11. Sonde optique selon la revendication 3, dans laquelle le diamètre extérieur de la tête (332) de la ferrule (33) est essentiellement égal au diamètre extérieur de la gaine (34).

12. Sonde optique selon la revendication 1, comprenant en outre un mécanisme de verrouillage évitant que la tête ne sorte hors de l'aiguille de plus d'une longueur prédéterminée.

13. Sonde optique selon la revendication 1, dans laquelle une surface interne de la gaine (34) est adaptée pour coller sur la tige (331).

14. Sonde optique selon la revendication 1, comprenant en outre au moins une section creuse destinée à être remplie d'air pour augmenter la visualisation par ultrasons de la sonde optique.

15. Système de microscopie confocale pour inspecter un organe solide dans un sujet, comprenant :

un microscope confocal, et
une sonde optique selon l'une quelconque des revendications 1 à 14.

16. Système de microscopie confocale selon la revendication 15, comprenant
un scanner proximal pour éclairer l'une après l'autre les fibres du faisceau de fibres optiques de la sonde optique afin d'exciter une fluorescence endogène ou exogène d'un tissu de l'organe solide et pour collecter un signal de fluorescence venant de l'organe solide qui est transmis à travers le faisceau de fibres optiques de la sonde optique.

17. Procédé de formation d'image d'un organe solide

dans un sujet employant une sonde optique selon l'une quelconque des revendications 1 à 14, le procédé comprenant :

la transmission d'une lumière d'une source d'éclairement à travers le faisceau de fibres optiques de la sonde optique en direction de l'organe solide,
la collecte d'un faisceau de lumière de retour venant de l'organe solide et transmise à travers le faisceau de fibres optiques de la sonde optique,
l'acquisition d'une image de l'organe solide à partir du faisceau de lumière de retour.

18. Procédé selon la revendication 17, comprenant en outre :

l'éclairement, par un scanner proximal, l'une après l'autre des fibres du faisceau de fibres optiques de la sonde optique afin d'exciter une fluorescence endogène ou exogène d'un tissu de l'organe solide,
dans lequel le faisceau de lumière de retour est un signal de fluorescence.

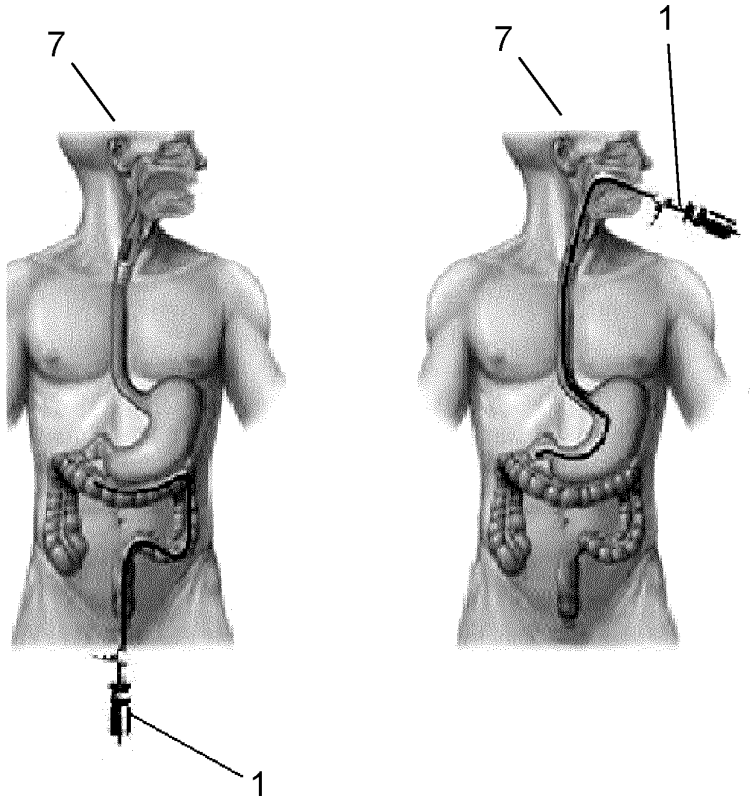

FIG.1A

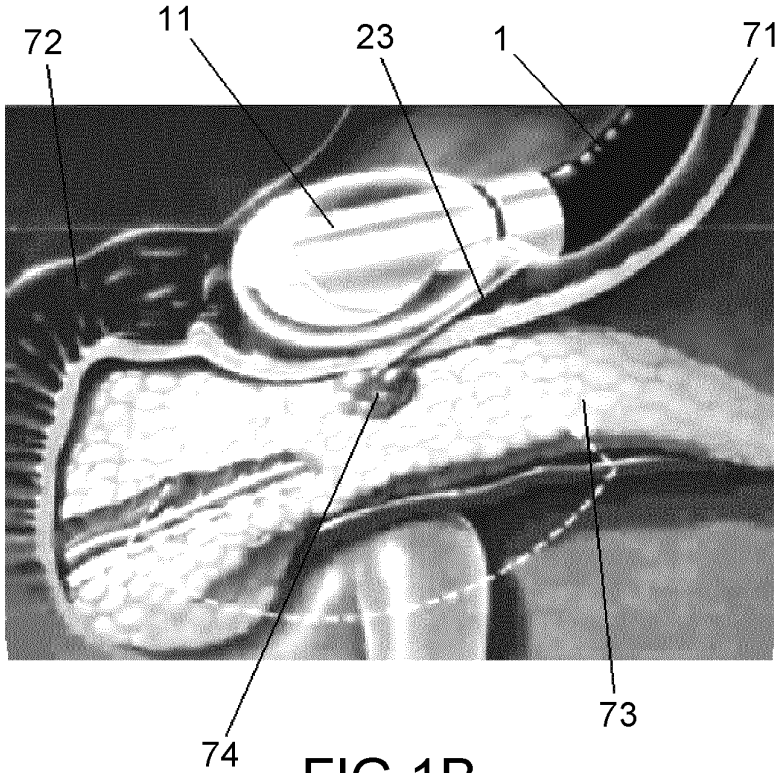

FIG.1B

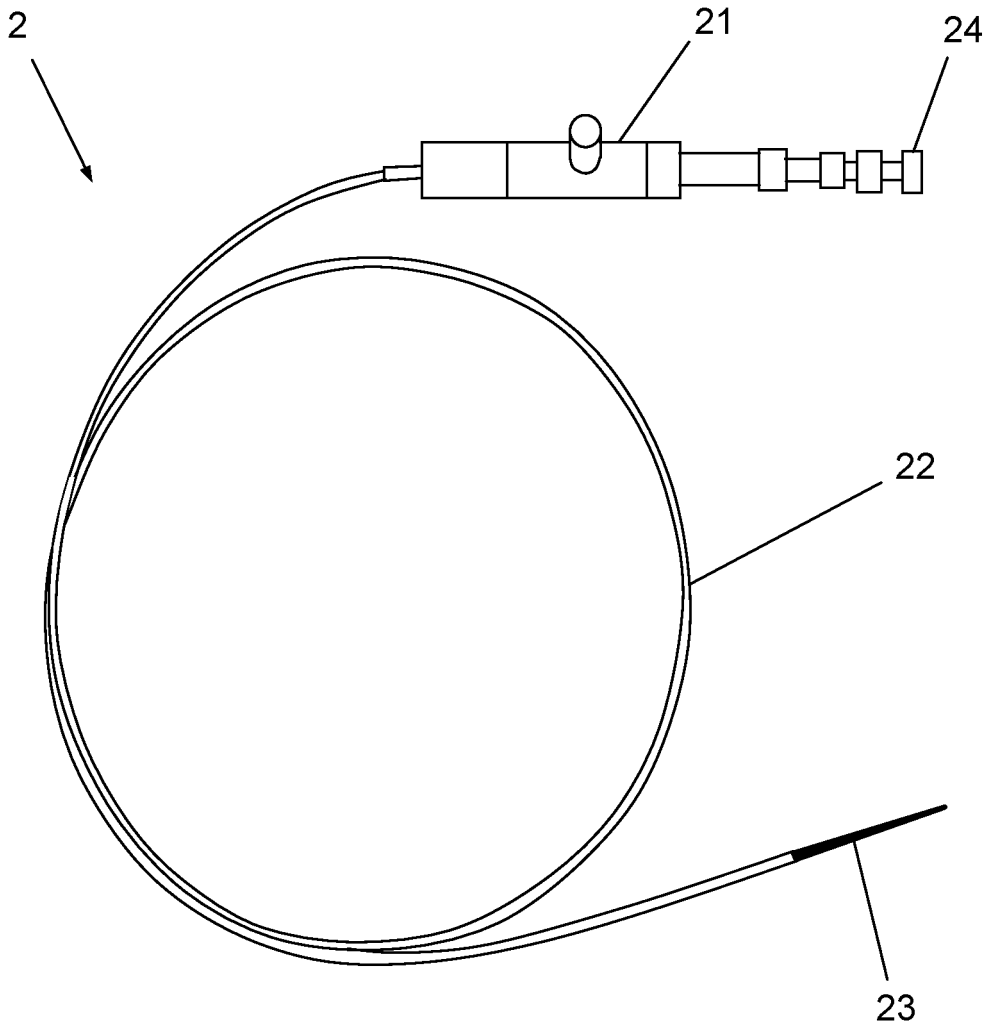

FIG.2

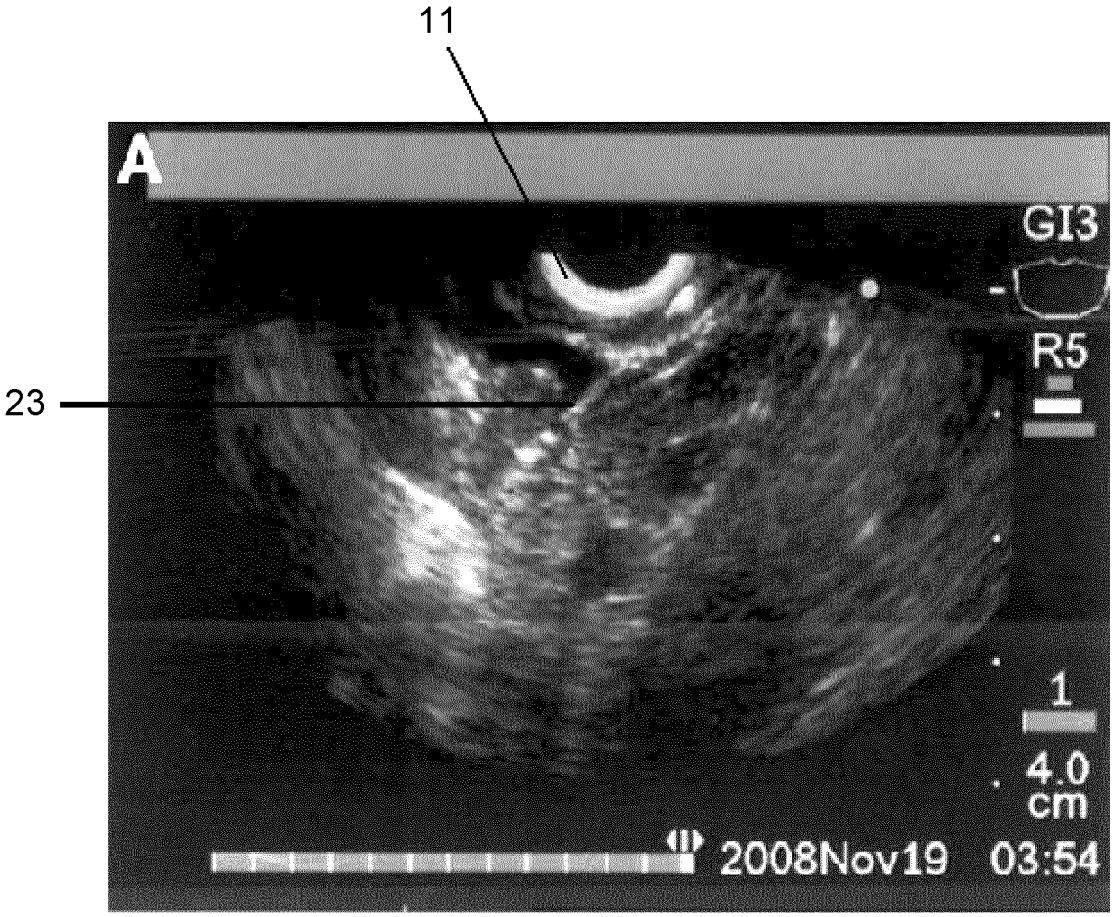

FIG.3

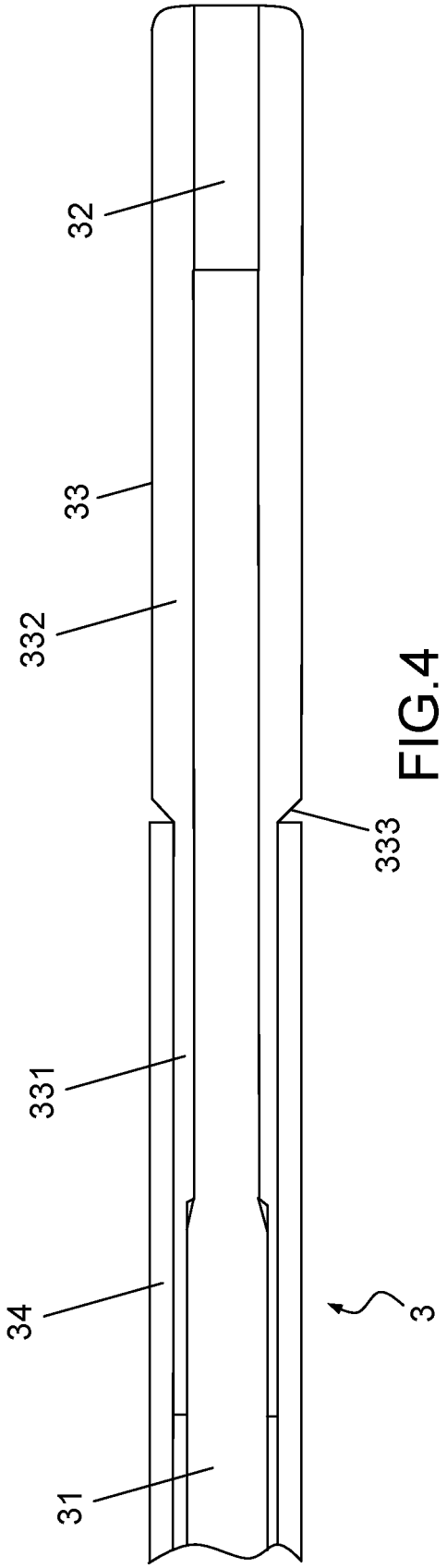

FIG.4

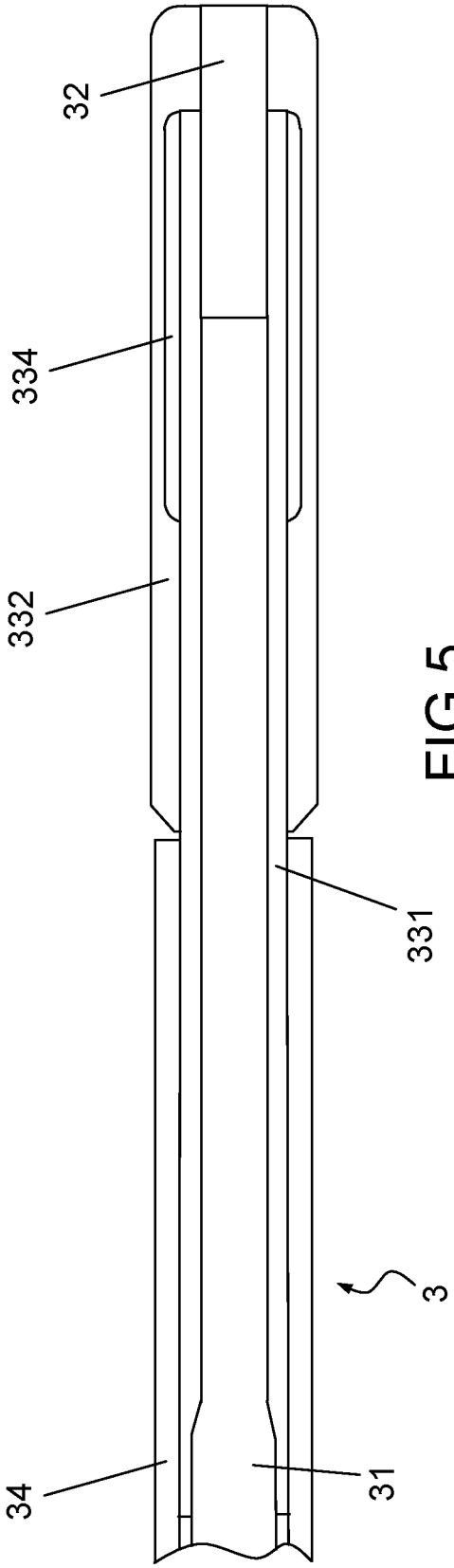

FIG.5

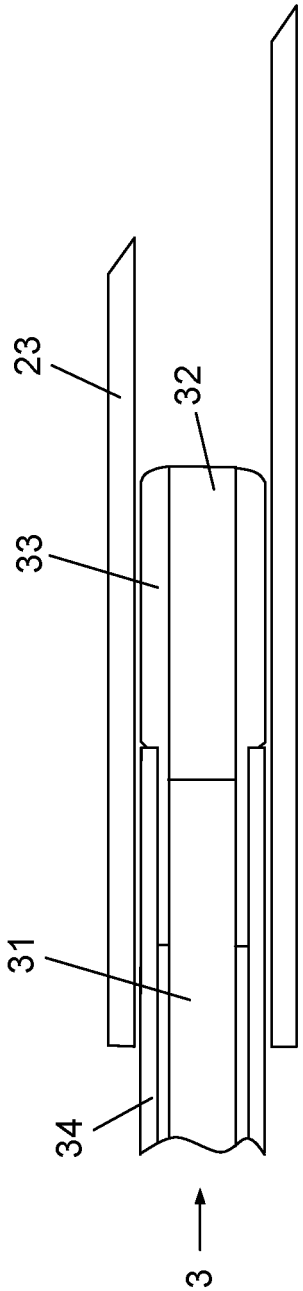

FIG.6A

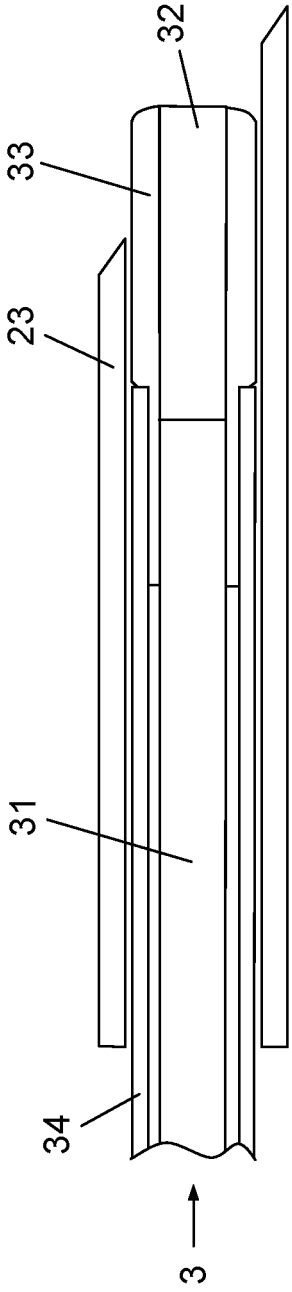

FIG.6B

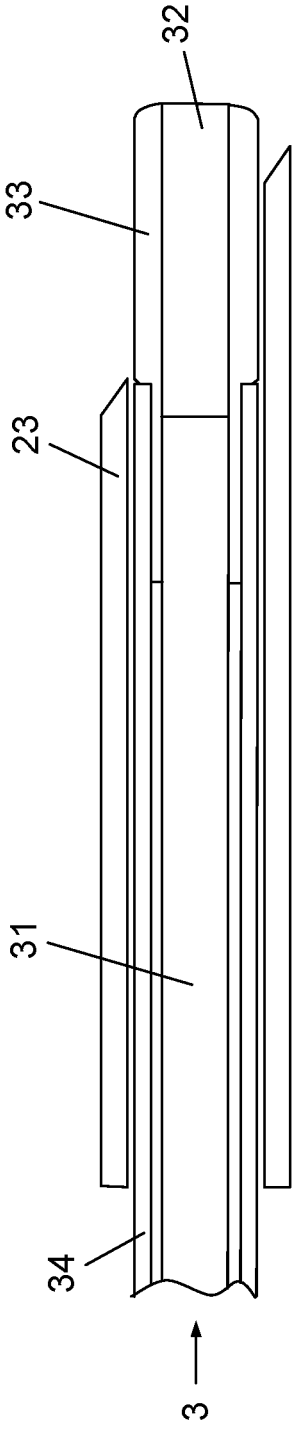

FIG.6C

FIG.6

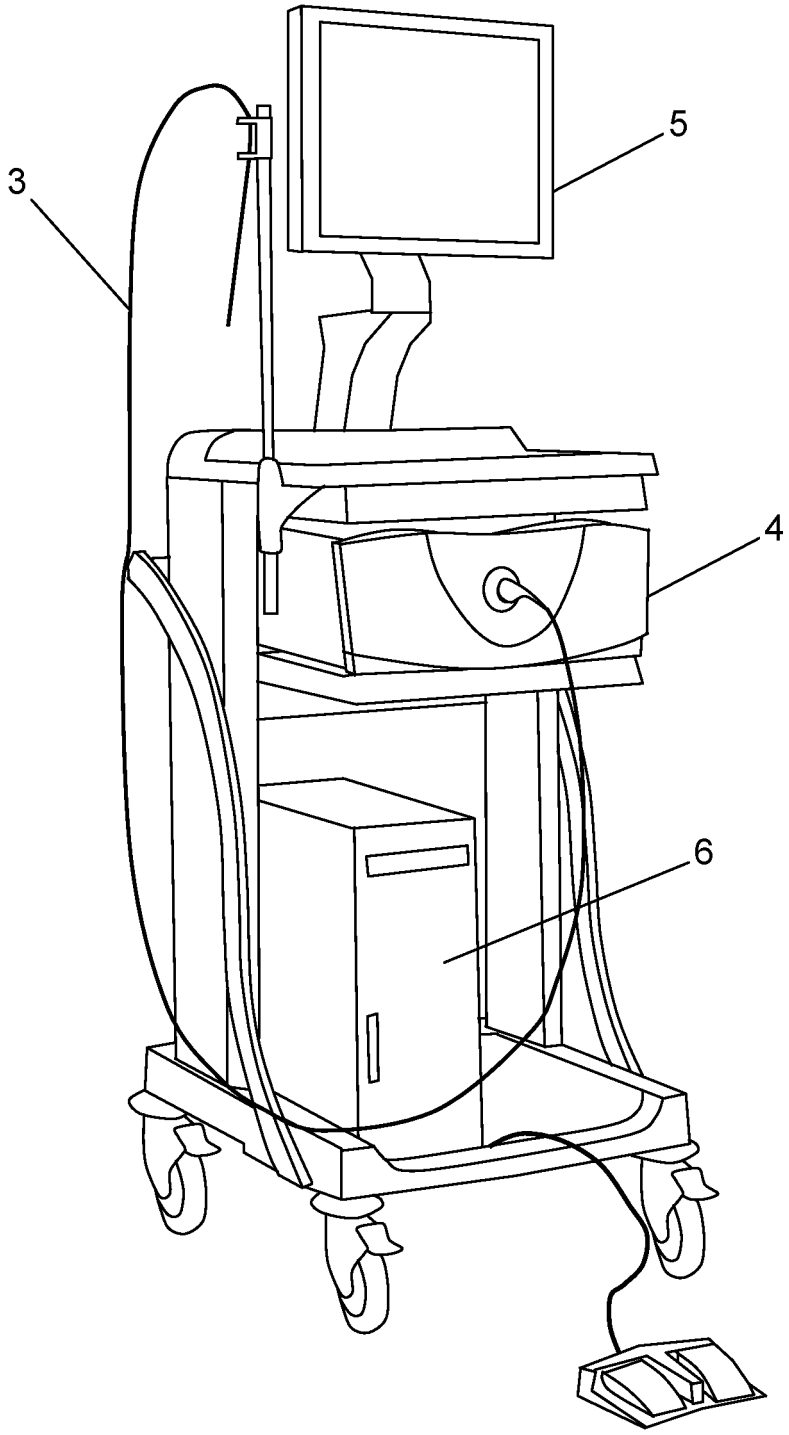

FIG.7

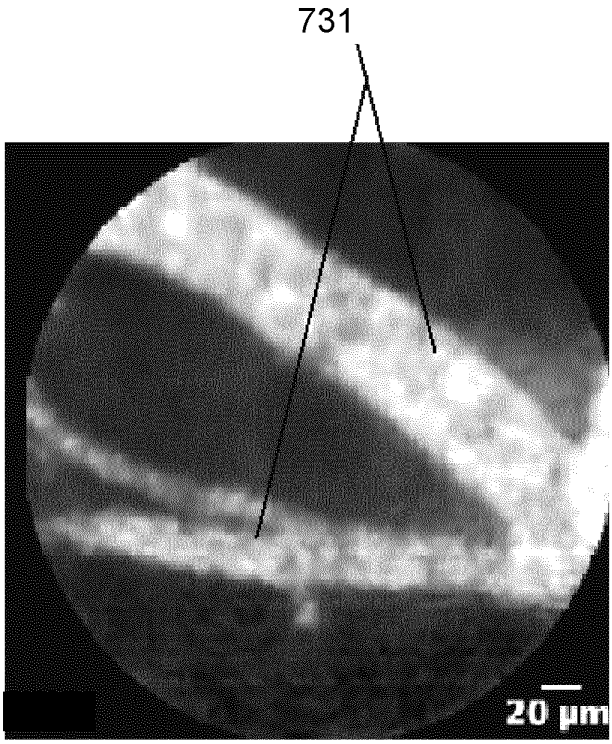

FIG.8A

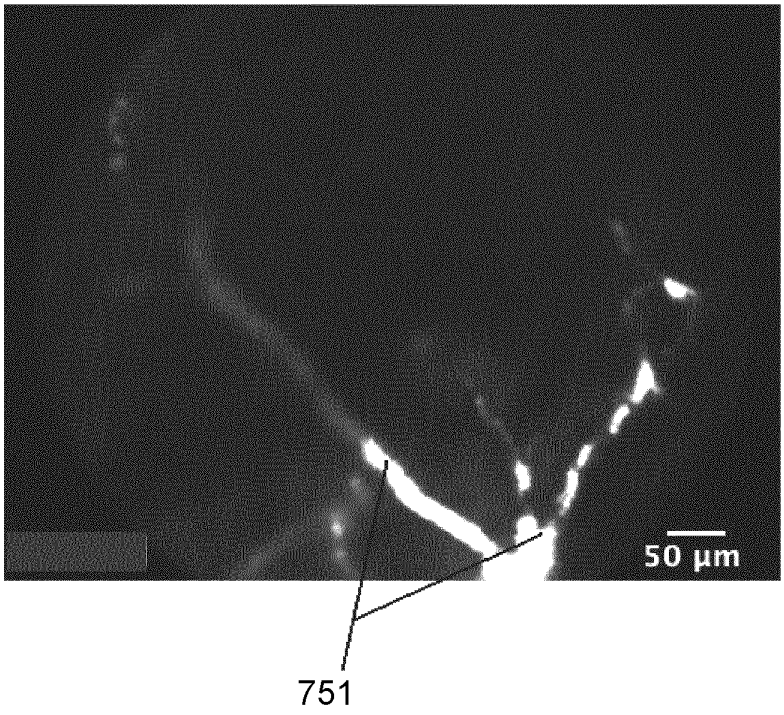

FIG.8B

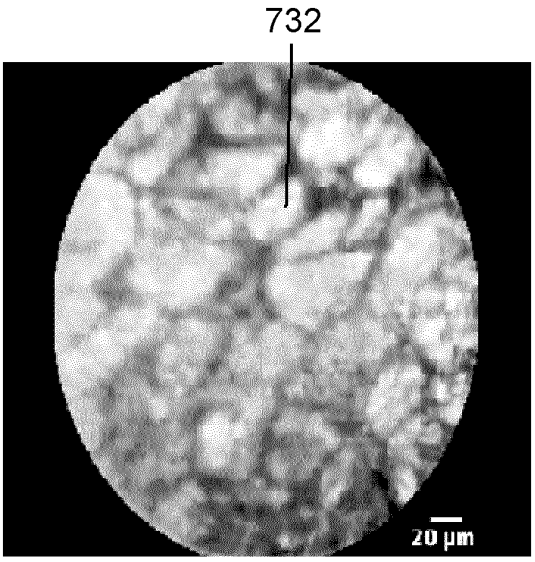

FIG.9A

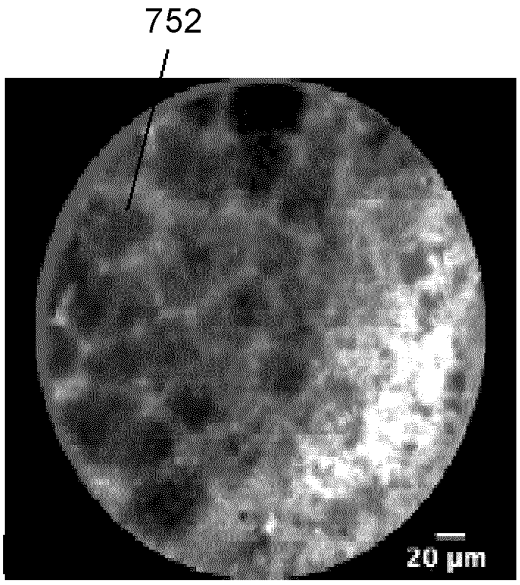

FIG.9B

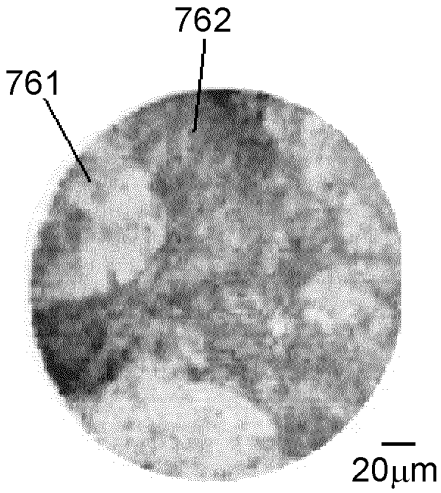

FIG.9C

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 2008064925 A **[0006]**

专利名称(译)	用于检查实体器官的方法，光学探针和共焦显微镜系统		
公开(公告)号	EP2477530B1	公开(公告)日	2017-05-10
申请号	EP2010785187	申请日	2010-09-17
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申请(专利权)人(译)	莫纳克亚TECHNOLOGIES		
当前申请(专利权)人(译)	莫纳克亚TECHNOLOGIES		
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IPC分类号	A61B5/00		
CPC分类号	A61B5/415 A61B5/0068 A61B5/0071 A61B5/0084 A61B5/416 A61B5/418 A61B5/6848		
优先权	61/243425 2009-09-17 US		
其他公开文献	EP2477530A1		
外部链接	Espacenet		

摘要(译)

检查对象中的实体器官的方法包括：将针头引入实体器官的预定区域中;将光学探针插入通过针头的内腔;以及使用光学探头对预定区域成像。 1.一种用于检查对象中的实体器官的光学探针，所述光学探针旨在通过针定位在所述实体器官中，所述光学探针包括光纤束，保护所述光纤束的远侧末端的箍，所述箍部包括柄部和头部，以及包裹所述纤维束和所述柄部的护套，其中所述箍部的头部具有适于所述光学探头成像所述实体器官同时将所述护套保持在所述针内的长度。

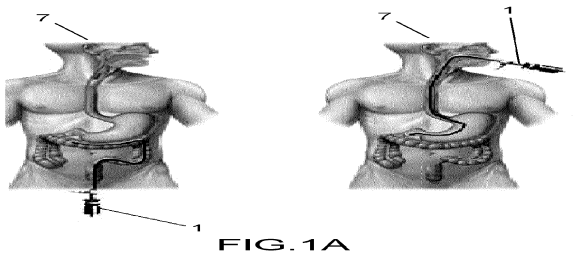

FIG.1A

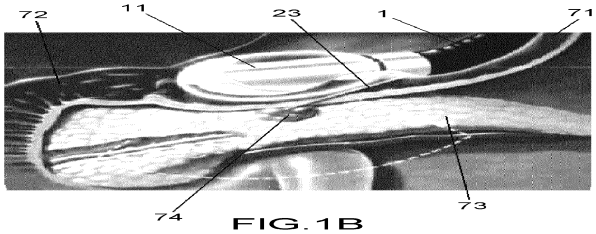

FIG.1B