

ENDOSCOPE ACCESSORY

FIELD OF THE INVENTION

[0001] The invention generally relates to the field of surgical devices. In particular, the invention relates to an accessory for use with endoscopes for carrying out minimally invasive surgical procedures, biopsies or other test procedures.

BACKGROUND OF THE INVENTION

[0002] Endoscopes are elongate devices for looking inside the body, which typically include a light source and a means of transmitting an image from a region of interest inside the body to a physician. Many endoscopes also include surgical equipment or include internal channels through which surgical equipment can be inserted to the region of interest to perform surgery or biopsies etc. Current endoscopic submucosal dissection (ESD) procedures using endoscopes with a single working channel are lacking in terms of controllability of tools, triangulation, stability and force transmission.

[0003] To stabilize and support the operative space during endoscopic procedures, carbon dioxide (CO₂) insufflation is usually used. However, CO₂ insufflation can result in bloatedness and patient discomfort post-procedure, and also presents the risk of CO₂ embolism. To enable the possibility of triangulation, dual-channel endoscopes have been developed to provide the ability to have multiple endoscopic tools. However, due to the small distance between the channels, the tools are unable to move independently of the scope. Therefore, the degree of triangulation is inadequate. Furthermore, the additional working channel does not resolve the issue of the lack of force transmission at the distal scope tip. As the movement of the additional tools are controlled by the scope, the force transmitted will be similar to that of the single channel endoscope and the movements of the tools will follow that of the scope.

[0004] There is thus a need for an endoscope accessory that overcomes the drawbacks of the prior art. Furthermore, other desirable features and characteristics will become apparent from the subsequent detailed description and the appended claims, taken in conjunction with the accompanying drawings and this background of the disclosure.

SUMMARY

[0005] In one aspect, the present invention provides an endoscope accessory comprising: (a) a base member comprising a through-opening, the through-opening configured to accommodate an endoscope; (b) a structural member coupled to the base member and enclosing an interior space within the structural member, wherein the structural member

comprises at least one moveable arm configured to move between an open configuration and a closed configuration; and (c) a working tube disposed in the interior space for accommodating a surgical instrument.

5 [0006] In one embodiment, the endoscope accessory as described herein further comprises an overtube having a proximal end and a distal end, wherein the distal end of the overtube is coupled an end of the base member opposite the structural member.

[0007] In one embodiment, the overtube comprises a plurality of rings.

[0008] In one embodiment, the overtube comprises a main channel, the main channel and through-opening aligned with each other, for accommodating the endoscope.

10 [0009] In one embodiment, the overtube comprises a plurality of auxiliary channels for accommodating a plurality of cables.

[0010] In one embodiment, the overtube comprises an inner wall and an outer wall, wherein the inner wall defines the main channel and wherein the plurality of auxiliary channels are disposed in a space between the inner wall and the outer wall.

15 [0011] In one embodiment, the endoscope accessory as described herein further comprises the plurality of cables, wherein at least one of the plurality of cables terminates on the structural member for moving the structural member between the open configuration and the closed configuration, and at least one of the plurality of cables terminates on the working tube for guiding the surgical instrument.

20 [0012] In one embodiment, the base member further comprises a plurality of auxiliary through-openings for accommodating the plurality of cables.

[0013] In one embodiment, the structural member comprises two moveable arms, wherein the two moveable arms oppose each other on either side of the interior space, wherein the two moveable arms are configured to extend outwards away from a longitudinal axis extending
25 along the length of the structural member when the arms are in the open configuration.

[0014] In one embodiment, the endoscope accessory as described herein further comprises an outer sheath for covering the structural member.

[0015] In one embodiment, the movement of the working tube comprises translational movement of the working tube along the x, y and/or z axes and rotational movement of the surgical instrument along the pitch, yaw and/or roll axes.
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[0016] In one embodiment, the surgical instrument is any one selected from the group consisting of a grasper tool, an electrocautery tool, a suturing tool, a snare loop, forceps, scissors, a suction tool, an injection tool, a clipping tool and an irrigation tool.

[0017] In one embodiment, the endoscope accessory as described herein comprises two
35 working tubes.

[0018] In one embodiment, the endoscope accessory as described herein further comprises a transmission interface disposed at the proximal end of the overtube, wherein the transmission interface is configured to actuate the plurality of cables.

[0019] In one embodiment, the transmission interface is configured to be manually driven
5 to actuate the plurality of cables.

[0020] In one embodiment, the transmission interface is operably connected to an actuator and configured to be driven by the actuator.

[0021] In one embodiment, the transmission interface comprises a plurality of driven members for actuating the plurality of cables, wherein each of the plurality of cables is
10 connected to one of the plurality of driven members.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] The invention will be better understood with reference to the detailed description
15 when considered in conjunction with the non-limiting examples and the accompanying drawings, in which:

[0023] **Fig. 1** is a rear top side perspective view of an endoscope accessory in accordance with present embodiments, where the structural member is in an open configuration. In this embodiment, the structural member comprises four arms (two moveable and two non-moveable) and there are two working tubes. The proximal ends of the arms are coupled to the
20 base member, and the distal end of the two moveable arms of the structural member are extended or pivoted outwards away from a longitudinal axis extending along the length of the structural member.

[0024] **Fig. 2** is a front planar view of the endoscope accessory of Figure 1.

25 [0025] **Fig. 3** is a top planar view of the endoscope accessory of Figure 1.

[0026] **Fig. 4** is a side planar view of the endoscope accessory of Figure 1.

[0027] **Fig. 5** is a front planar view of the endoscope accessory where the structural member is in a closed configuration. In this embodiment, the arms of the structural member is substantially parallel to the longitudinal axis extending along the length of the structural
30 member.

[0028] **Fig. 6** is a top planar view of the endoscope accessory of Figure 5.

[0029] **Fig. 7** is a side planar view of the endoscope accessory of Figure 5.

[0030] **Fig. 8** is a top front right perspective view of the endoscope accessory comprising an overtube in accordance with present embodiments.

- [0031] **Fig. 9** is a top front side perspective view of the overtube and transmission interface of the endoscope accessory in accordance with present embodiments.
- [0032] **Fig. 10** is a top front side perspective view of the cuff, overtube and transmission interface of the endoscope accessory in accordance with present embodiments.
- 5 [0033] **Fig. 11** is a top front side perspective view of a working tube of the endoscope accessory in accordance with present embodiments.
- [0034] **Fig. 12** shows an overtube-cuff interface ring of the endoscope accessory in accordance with present embodiments. A) Side planar view. B) Top front side perspective view. C) Front planar view. D) Side planar view.
- 10 [0035] **Fig. 13** shows the first overtube ring. A) Side planar view. B) Top front side perspective view. C) Front planar view. D) Side planar view.
- [0036] **Fig. 14** shows the second overtube ring. A) Side planar view. B) Top front side perspective view. C) Front planar view. D) Side planar view.
- [0037] **Fig. 15** shows a cross-sectional view of the overtube of the endoscope accessory
- 15 when used with the endoscope.

DETAILED DESCRIPTION OF THE PRESENT INVENTION

- [0038] In one aspect, the present invention provides an endoscope accessory comprising:
- 20 (a) a base member comprising a through-opening, the through-opening configured to accommodate an endoscope;
- (b) a structural member coupled to the base member and enclosing an interior space within the structural member, wherein the structural member comprises at least one moveable arm configured to move between an open configuration and a closed configuration; and
- 25 (c) a working tube disposed in the interior space for accommodating a surgical instrument.
- [0039] As shown in Figure 1 and Figure 3, the structural member 24 may be coupled to the base member 1 at a first end 25 of the base member 1. The second end 26 of the base member 1 may be coupled to an overtube 23 as shown in Figure 8.
- [0040] In an embodiment, as shown in Figure 1, the base member 1 may be substantially
- 30 annular in shape and the structural member 24 coupled to the annular base member 1 forms an interior space. The endoscope accessory of this invention is intended to be the end that first enters a cavity of a body or lumen of an organ. As such, the profile of the exterior structural member 24 may be annular to correspond to the base member 1 and its ends may be tapered to ease such entry and movement.

[0041] The structural member 24 may be formed by any arms (as will be described in detail below) or plates that are coupled around the annular end of the base member 1. In an embodiment, four plates are shown in Figure 1. One of the plates is shown in an open configuration in Figure 1.

5 [0042] As shown in the embodiment of Figures 1 to 8, the structural member 24 may comprise four arms (two moveable side arms and two non-moveable top and bottom arms). In an alternative embodiment, all four arms of the structural member 24 may be configured to move between open and closed configurations. The structural member 24 is in the open configuration when the at least one moveable arm 2 is pivoted or extends outwards from a
10 longitudinal axis as shown in Figure 1, where the longitudinal axis extends along the length of the structural member 24. Figures 1 to 4 show the structural member 24 in the open configuration while Figures 5 to 7 show the structural member 24 in the closed configuration. The movement of the moveable arms 2 may be facilitated by the first cuff pin 3, second cuff pin 4 and third cuff pin 8. The cuff bar 7 connects the arms to each other to facilitate opening
15 (i.e. pivoting outwards) and closing of the arms.

[0043] The movement of the arms 2 may be achieved by any suitable means, including any electrical or motorised mechanism where a signal may be transmitted from a controller in the control panel to the arms 2 to drive the arms open and close.

[0044] Figure 11 shows an example of a working tube 5 that has eight entry points (i.e. cable entry points) in two different rows. These cables will be described in detail below. Each row has four entry points spaced out 90 degrees apart from each other. The working tube 5 is disposed in the interior space 27 enclosed by the structural member 24 when the structural member 24 is in the closed configuration. The working tube 5 may protrude from the interior space 27 (i.e. further distally from the distal ends of the arms) when the structural member 24
20 is in the open configuration. The working tube 5 serves as a guide for the surgical instrument, allowing the surgical instrument to move in any desired direction while being supported within the working tube 5. As shown Figure 3, the working tube 5 is connected to cables 17 that control the movement of the working tube 5, enabling precise positioning and manipulation of the surgical instrument.

25 [0045] In one embodiment, as shown in Figure 8, the endoscope accessory as described herein further comprises an overtube 23 having a proximal end and a distal end, wherein the distal end of the overtube is coupled to an end of the base member 1 opposite the structural member 24. For example, the distal end of the overtube is coupled to the second end 26 of the base member 1.

[0046] The overtube 23 may comprise a overtube-cuff interface ring 11, a first overtube ring 12 and a plurality of second overtube rings 13. The overtube-cuff interface ring 11 serves as an interface between the cuff 22 and the other rings of the overtube (i.e. the first overtube ring 12 and the plurality of second overtube rings 13). An embodiment of the overtube-cuff interface ring 11 is shown in Figure 12. In one example, the overtube-cuff interface ring 11 can be screwed onto the cuff 22 to secure the overtube-cuff interface ring 11 in place. The first overtube ring 12 serves as an interface between the second overtube rings 13 and the overtube-cuff interface ring 11. An embodiment of the first overtube ring 12 is shown in Figure 13. The plurality of second overtube rings 13 may span the length of the overtube. The second overtube rings 13 enable the overtube to be flexible. An embodiment of the second overtube ring 13 is shown in Figure 14.

[0047] In one example, the endoscope accessory as described herein is capable of accommodating the endoscope in a manner to allow a distal end of the endoscope to be positioned further distally along the longitudinal axis than the distal end of the structural member 24.

[0048] In one embodiment, the overtube 23 comprises a main channel, the main channel and through-opening aligned with each other, for accommodating the endoscope.

[0049] In one embodiment, the overtube 23 comprises a plurality of auxiliary channels for accommodating a plurality of cables. The auxiliary channels may also accommodate surgical instruments. In one example, the plurality of auxiliary channels of the overtube is substantially parallel to the main channel. In one example, each of the plurality of auxiliary channels is configured to accommodate one of the plurality of cables. The auxiliary channels may also receive surgical instruments, for example through the surgical instrument PTFE tubings 20 shown in Figure 15. The auxiliary channel for receiving the surgical instruments may have a bigger diameter than the auxiliary channels for accommodating the cables for moving the working tube 5.

[0050] In one embodiment, the overtube 23 comprises an inner wall and an outer wall, wherein the inner wall defines the main channel and wherein the plurality of auxiliary channels are disposed in a space between the inner wall and the outer wall.

[0051] An example of the overtube 23 is shown in Figure 15. The endoscope 21 is accommodated in the main channel of the overtube 23. The surgical tube PTFE tubing 20 is accommodated in two of the auxiliary channels shown on the right and left side of Figure 15. Cables 17 are accommodated in the other auxiliary channels of the overtube 23.

[0052] In one embodiment, the endoscope accessory as described herein further comprises the plurality of cables, wherein at least one of the plurality of cables terminates on

the structural member 24 for moving the relevant arms of the structural member between the open configuration and the closed configuration, and wherein at least one of the plurality of cables terminates on the working tube 5 for guiding the surgical instrument. Non-limiting examples of the plurality of cables include a plurality of fishing lines or braided ultra high molecular weight polyethylene (UHMWPE) lines. The cables may be housed within PTFE tubes which act as low-friction guides for the cables. Each PTFE tube may house one cable. In one example, the cables for opening the cuff ("opening cables") are housed in PTFE tubes which are attached (e.g. by gluing) to the first overtube ring 12 such that the first overtube ring 12 acts as a hard stop for these PTFE tubes. In one example, the cables for closing the cuff ("closing cables") are housed in PTFE tubes which terminate at the distal end of the moveable arm 2. In one example, the cables for moving the working tube are housed in PTFE tubes which are attached (e.g. by gluing) to the non-moveable and moveable arms of the cuff.

[0053] In one example, there are four cables for opening the cuff 22 and two cables for closing the cuff 22. The four opening cables may pull four pistons 6 inside the cuff to enable the hinge mechanism to open up. In one example, the two closing cables are positioned towards the distal end of the cuff and go around the cuff. In one example, the closing cables terminate at the distal end of the moveable arm 2. Pulling the closing cables causes the moveable arm(s) to move to the closed configuration.

[0054] In one embodiment, at least one of the plurality of cables terminates on the working tube for moving the working tube, thereby moving the surgical instrument. In one example, each of the non-moveable and moveable arms has two passages. Each passage houses two PTFE tubings for guiding the working tube cables (i.e. cables for moving the working tube 5) through the cuff 22. Each PTFE tubing houses one working tube cable. In the embodiment where there are four arms, there are a total of eight passages and sixteen PTFE tubings for the sixteen cables for moving the working tubes. It would be appreciated that, in view of the multiple cables terminating at each working tube, the pulling/tightening of a relevant cable (and the corresponding loosening of its antagonist equivalent) results in a movement of the working tube 5 in the direction desired. In one example, the cables go from pulleys located at the transmission interface 15 through the overtube 23 and into the cuff 22, terminating on the working tube 5.

[0055] In one example, the working tube cables (i.e. cables for moving the working tubes) and the opening cables (i.e. cables for opening the cuff) which run through the plurality of second overtube rings 13 can cause the overtube 23 to be rigidized when tension is applied to the cables. Optionally, one or more additional cables can be added which terminate on the

distal end of the overtube 23 for moving the overtube 23 between a flexible configuration and a rigid configuration.

[0056] In one embodiment, the base member 1 further comprises a plurality of auxiliary through-openings for accommodating the plurality of cables. The plurality of auxiliary through-openings may be substantially parallel to the through-opening that is configured to accommodate the endoscope. The auxiliary through-openings may be formed as holes in the second overtube rings 13. Optionally, to allow the diameter of the overtube 23 to be smaller, some of the cables may be disposed outside of the second overtube rings 13 and are not threaded through the auxiliary through-openings.

[0057] In one embodiment, the structural member 24 comprises two moveable arms 2, the two moveable arms 2 opposing each other on either side of the interior space, wherein the two moveable arms 2 are configured to extend outwards from the longitudinal axis extending along the length of the structural member 24 when the arms 2 are in the open configuration. In one example, when the structural member 24 is in the closed position, the at least one moveable arm 2 is substantially parallel to the longitudinal axis which extends along the length of the structural member 24. In one example, the structural member 24 comprises two non-movable arms which may be construed as covers, such as the cuff top cover 9 and cuff bottom cover 10. The two moveable arms 2 may be opposing each other.

[0058] In one embodiment, the endoscope accessory as described herein further comprises an outer sheath for covering the structural member 24. A non-limiting example of the outer sheath is a thermoplastic polyurethane (TPU) sheath.

[0059] In one embodiment, the endoscope accessory as described herein further comprises the surgical instrument accommodated in the working tube. The working tube may be capable of receiving the surgical instrument in a manner to allow a distal end of the surgical instrument to be positioned further distally along the longitudinal axis than the distal end of the structural member 24.

[0060] In one example, the number of cables connected to each working tube is between six to eight. In a preferred embodiment, there are 8 cables connected to each working tube.

[0061] In one embodiment, the movement of the working tube comprises translational movement of the working tube along the x, y and/or z axes and rotational movement of the working tube along the pitch, yaw and/or roll axes.

[0062] In one embodiment, the surgical instrument is any one selected from the group consisting of a grasper tool, an electrocautery tool, a suturing tool, a snare loop, forceps, scissors, a suction tool, an injection tool, a clipping tool and an irrigation tool.

[0063] In one embodiment, the endoscope accessory as described herein comprises two working tubes.

[0064] In one example, the endoscope accessory as described herein further comprises an image capturing device disposed on the structural member 24. In one example, the image capturing device is located on the distal end of the cuff, on the cuff top cover 9.

[0065] In one example, the endoscope accessory as described herein further comprises an illumination source disposed on the structural member 24.

[0066] In one example, the endoscope accessory may be single-use.

[0067] In one embodiment, as shown in Figure 9 and Figure 10, the endoscope accessory as described herein further comprises a transmission interface 15 disposed at the proximal end of the overtube 23, wherein the transmission interface is configured to actuate the plurality of cables.

[0068] In one embodiment, the transmission interface is configured to be manually or robotically driven to actuate the plurality of cables.

[0069] In one embodiment, the transmission interface is operably connected to an actuator and configured to be driven by the actuator.

[0070] In one embodiment, the transmission interface comprises a plurality of driven members for actuating the plurality of cables, wherein each of the plurality of cables is connected to one of the plurality of driven members. Non-limiting examples of the driven members include clutches. The transmission interface can be any transmission mechanism that can translate rotational energy to pulling energy to provide tension to the cables. In one example, the transmission interface is in the form of a disc and the driven members are clutches which form an interface between the transmission interface disc and the patient cart. The clutches may be connected to pulleys within the transmission interface disc, and the cables are connected to the pulleys. The turning of the patient cart motor would result in the turning of the patient cart clutch, followed by the turning of the disc clutch, turning of the pulley, and resulting tightening or loosening of the cables depending on which direction the motor turns.

[0071] As used herein, the term "scope" and "endoscope" are used interchangeably. The term "scope" may include other devices for looking and/or operating in the human or animal body, including but not limited to laparoscopes, duodenoscopes, colonoscopes, gastroscopes, hysteroscopes, bronchoscopes and urethrosopes. Endoscopes typically comprise an insertion probe (also known as "endoscopic probe" for insertion into the body cavity). The term "endoscope" may be used to refer to the endoscopic probe.

- [0072] In various examples, the endoscope accessory as described herein may be used with endoscopic probes of various sizes, such as, but not limited to, colonoscopes, gastroscopes, side-viewing scopes, endoscopic ultrasound scopes, adult and pediatric, rigid and flexible scopes, and single and multi-channel scopes. In various examples, the cuff may be suitable for use with non-GI scoping instrumentation.
- [0073] The endoscope accessory as described herein may be used in various advanced endoscopic procedures or surgeries. Non-limiting examples of such endoscope procedures include endoscopic submucosal dissection (ESD), endoscopic full thickness resection (EFTR) and peroral endoscopic myotomy (POEM).
- [0074] The term “user” as used herein may refer to any user or end user of the endoscope accessory of the present embodiments. Non-limiting examples of users include endoscopists, surgeons, specialists, and support staff such as nursing staff and technical staff.
- [0075] Cuff
- [0076] In one embodiment, the base member 1 and the structural member 24 of the endoscope accessory are collectively known as a “cuff”. The base member 1, also known as cuff base or cuff ring, comprises a through-opening (such as a through-hole) for accommodating the endoscope. The endoscope can move in and out of the cuff 22 via the base member 1, and can even move slightly in front of the cuff 22 such that the field of view is not interrupted. The structural member 24 of the cuff of the present embodiments comprises at least one moveable arm and can be in an open or closed configuration. The cuff, structural member or the at least one moveable arm thereof is in an open configuration when the at least one moveable arm is extended or pivoted outwards. The proximal end of the structural member may be coupled to the base member in various ways, such as by a hinge. The term “extending outwards” may include a radial extension in which the arm is substantially parallel to the longitudinal axis, or a pivoting extension where one end of the arm moves away from the longitudinal axis. By “pivoting outwards”, it is meant to refer to the distal end of the at least one moveable arm extending away from the longitudinal axis which extends along the length of the structural member. An embodiment of the cuff in the open configuration, where the structural member comprises two moveable arms and two non-moveable arms, is shown in Figure 1 (rear top side perspective view), Figure 2 (front planar view), Figure 3 (top planar view) and Figure 4 (side planar view). In the orientation shown in the figures, the two arms at the sides are moveable and the top and bottom arms are not moveable. The cuff may be inserted into the human or animal body in the closed configuration. The cuff in the closed configuration is shown in Figure 5 (front planar view), Figure 6 (top planar view), and Figure 7 (side planar view). When the cuff has reached the desired region of interest within the body,

it can be opened to any size within the minimum and maximum width of the cuff. By “width of the cuff”, it is meant to refer to the maximum width of the distal end of the structural member. For example, if the structural member comprises two opposing moveable arms and two opposing non-moveable arms, where the two moveable arms are pivoted outward, the width of the cuff would be the distance between the distal ends of the two moveable arms. The reference to “width” of the cuff may also be taken to refer to a “diameter” of the cuff. Since the structural member is in an open configuration when the at least one moveable arm is pivoted outward, it would be appreciated that reference to the cuff or structural member being in an open configuration is meant to refer to the moveable arm being in an open configuration. The phrase “the structural member is moveable between an open configuration and a closed configuration” is meant to include the cuff being manually-moveable or robotically-moveable to open to any width suitable to the user during the procedure. In one example, the movement of the cuff from the open configuration to the closed configuration is effected by a plurality of cables terminating on the structural member.

[0077] The simple design of the cuff as described herein allows the cuff to be dimensioned with a shorter width and shorter length, allowing the cuff to be easily maneuvered within the patient's body.

[0078] The term “structural member” as used herein is meant to include at least one moveable arm. For example, the structural member 24 can be made up of at least one non-moveable portion and one or more moveable arms. In one embodiment, the structural member includes a total of four arms, with two opposing arms being non-moveable and the other two opposing arms being moveable. It would be appreciated that the “arm” can be panels, plates, walls or any elongated structure such as struts. In one example, the distal end of the arm is tapered. In the context of the example where the structural member includes four arms, with two opposing arms being non-moveable and the other two opposing arms being moveable, the term “interior space” in the phrase “the structural member encloses an interior space” may refer to the area surrounded by the arms. Nevertheless, it should be appreciated that the working space of the cuff of the present embodiments includes not only the interior space, but also the area that is further distally along the longitudinal axis that is made accessible as a result of the cuff being in an open configuration. In other words, the working space includes the area that extends out of the cuff. As such, in use, the endoscope and working tools can be worked not only in the interior space but also the area that is further distally along the longitudinal axis (i.e. further forward of the distal end of the arms).

[0079] In various embodiments, the structural member comprises four arms. In one embodiment, two of the arms are moveable and two are non-moveable. In one embodiment,

the two moveable arms are opposite each other and the two non-moveable arms are opposite each other. In various embodiments, the interior space enclosed by the arms may be a circular, oval or elliptical shape. In various examples, the lengths of the arms may be between 20 to 60 mm.

5 [0080] In some examples, the cuff has a closed configuration. The closed configuration may also be known as the non-deployed, contracted or collapsed configuration. Preferably, the width of the cuff in the closed configuration is between the inner and outer diameters of the overtube 23. In various examples, the inner diameter of the overtube 23 may be 10-16mm and the outer diameter of the overtube 23 may be 15-30mm. For example, when used with
10 gastroscopes or colonoscopes, the width of the cuff in the closed configuration may be between 10-30mm.

[0081] In some examples, the cuff 22 has a open configuration. The deployed configuration may also be known as the deployed or expanded configuration. The width of the cuff in the open configuration may be as large as 80mm. Preferably, the cuff can be opened up to a width
15 of 50-60mm for colonoscopy procedures. As the cuff can be opened up to any degree between the non-deployed width and the maximum deployed width, the open configuration may have a diameter of 10-80mm when used with gastroscopes or colonoscopes.

[0082] The width of the cuff is a measure of the size of the workspace of the cuff. The term "workspace" is meant to include the 3-dimensional interior space inside the cuff (whether in
20 open or closed configuration) as well as the area further forward from the distal end of the structural member, within which the working tube(s) and endoscope will be able to move. The movement of the surgical instruments may be limited to that of the workspace. In various examples, the cuff can be deployed at various different widths between the minimum and maximum widths of the cuff.

25 [0083] In one example, the cuff can be 3D-printed. The cuff can also be manufactured using CNC machining, injection molding, compression molding, or sheet metal bending, metal stamping or a combination of the above-mentioned processes.

[0084] In one example, the cuff may be made of plastic. For example, the cuff may be made of engineered plastic such as polycarbonate (PC) mixed with a percentage of glass fibre reinforcement. Further examples of plastic material include acrylonitrile butadiene styrene
30 (ABS), polylactic acid (PLA), polycarbonate (PC), polytetrafluoroethylene (PTFE) or a mixture of the aforementioned materials. The cuff may also be made of a mixture of stainless steel or aluminium parts.

[0085] Working tube

- [0086] In one embodiment, the endoscope accessory as described herein further comprises the surgical instrument 19 releasably received in the working tube 5. In use, the surgical instrument can be moved forward (i.e. further distally of the distal end of the working tube) and backward while being guided within the working tube. The surgical instrument can even be moved out of the working tube. In another embodiment, the surgical instrument may be releasably connected to the working tube.
- [0087] As used herein, the terms "surgical instrument", "instrument", "treatment instrument", "endoscopic tool", "surgical tool", "tool" and "end effector" are used interchangeably. In one example, the surgical instruments may be more than 2m in length to facilitate insertion into the endoscope accessory. The activation and deactivation of the surgical instrument may be controlled by the handle of the instrument. In one example, the handle of the surgical instrument is plugged into the patient cart which has fixtures to accommodate the shape and size of different surgical instrument. The controllers may have buttons, which when pressed, will mimic the hand motion and move the surgical instruments accordingly in an up/down manner, thereby activating/deactivating them.
- [0088] In one embodiment, the working tube 5 may serve as a guide for the surgical instrument 19 to pass through. For example, the surgical instrument may be moved forwards and backwards while being supported within the working tube. In another embodiment, the working tube may control the movement of the surgical instrument. In one example, the working tube is a metal tube that fits over the proximal end of the surgical instrument to enable control.
- [0089] In one example, the working tube has an outer diameter of 4.5mm, inner diameter of 3mm-3.5mm and a hole spacing of 25mm. The inner diameter of the working tube would depend on the surgical instruments which typically have an outer diameter of 2.8mm. As the working tube would need to accommodate for the outer diameter of the surgical instruments, the working tube may have an inner diameter of between 2.9mm and 3.5mm. The outer diameter of the working tube is preferably as close to the inner diameter of the working tube as possible. In various examples, the outer diameter of the working tube is 3.0-4.5mm. In various examples, the hole spacing on the working tube may be between 10mm and 60mm.
- [0090] In one example, there are eight holes or apertures (cable entry points) on the working tube 5, which make for eight cable mounting points. In the embodiment shown in Figure 11, the eight holes are arranged into two rows of four holes each, with one row at the proximal end of the working tube 5 and another row at the distal end of the working tube 5.

Each row has four holes spaced out 90 degrees apart from each other. The cables may terminate on the working tube by forming a knot between each hole and the proximal or distal end of the working tube 5. In alternative embodiment, there could be sixteen holes arranged into four rows of four holes each, with two rows at the proximal end and two rows at the distal end. In each row, the holes are spaced 120 degrees apart, with each row offset from each other. This results in a knot tied between two side-by-side holes to have a virtual centre point. [0091] In one example, the endoscope accessory includes two working tubes 5, each housing one surgical tool. The working tube 5 is compatible with off-the-shelf surgical tools such as grasper and electrocautery knife. In one example, the total length of the working tube 5 is 45mm. Each working tube 5 may be driven by eight cables. There may be sixteen holes (cable entry points) on the working tube 5, with two holes used for each knot of the fishing line. The holes may be arranged in a manner such that the knot is at a specific position. The cables may be tied onto the working tubes 5 using a clove hitch knot and two thumb knots. It would be appreciated that each working tube may be driven by fewer or more than eight cables. In an embodiment where each working tube is driven by six cables, the degree of freedom is five. In one example, each cable mounting point has three knots. For example, the three knots may be one clove hitch knot and two thumb knots. The number of knots per cable mounting point may range from one to five. A higher number of knots would increase the thickness of the cable at the cable mounting point and thereby increase the strength for withstanding forces.

[0092] Overtube

[0093] As used herein, the term "overtube" and "colonoscopic sheath" may be used interchangeably. The overtube may encase the endoscopic probe partially or completely along its length. The overtube may be flexible or rigid. An example of a flexible overtube is shown in Figure 8. In one embodiment, the overtube is formed by a plurality of rings, such as a series of rings, placed adjacent to each other. The distance between each ring may be of any suitable distance so long as to provide the support and accommodation of the relevant endoscope, tubes and pipes carrying the surgical instrument(s) and cables. Each ring may include any relevant number of holes and their positions correspond to those auxiliary channels disposed on the base member on the end that is coupled with the overtube. As such, when the rings are placed together to form the overtube, the holes form the auxiliary channels for accommodating the cables that run from one end of the overtube to their termination at the working tube or structural member. In another embodiment, there may be cables that run on the external surface of the overtube. The rings on the overtube allow for flexibility as the overtube can follow the curvature of the endoscope. In one embodiment, the overtube can be

rigidized when the endoscope has been inserted to the area of interest. One way of rigidizing the overtube is by tightening the plurality of cables that terminate on the overtube so as to reduce the length of the cables to rigidize the overtube and provide stability for the endoscope accessory. In the example shown in Figure 8, the outer diameter of the overtube is 25mm and overall length is 500mm. The overtube shown in Figure 8 may be made of a single plastic-like material, possibly 3D printed, extruded out or injection molded.

[0094] As used herein, the terms "channel" and "lumen" may be used interchangeably and refer to a hollow compartment formed along the length of the overtube along its longitudinal axis and suitable for serving as a working channel, irrigation, passage of endoscopic tools/instruments, imaging probes or therapeutics. In some examples, the channel may be formed as a longitudinal bore in the single material from which the channel is formed. The main channel and/or auxiliary channels may be formed in the series of rings of the overtube as shown in Figures 12 to 14. In some examples, the material forming the overtube may be flexible.

[0095] The term "working channel" may refer to the main channel or auxiliary channel. In various examples, the working channel(s) may extend along the entire length of the endoscope. In some examples, the working channel(s) may extend along part of the length of the endoscope. In some examples, the working channel(s) may be essentially parallel to the endoscope. In some examples, the working channel(s) may be angled relative to the endoscope, at least along part of its length. As a non-limiting example, the working channel(s) may exit in an upward angle, thereby allowing better retraction.

[0096] In one embodiment, the plurality of auxiliary channels is parallel to the main channel.

[0097] In one embodiment, each of the plurality of auxiliary channels receives one of the plurality of cables.

[0098] In one example, the plurality of auxiliary channels comprises multiple lumen tubes, such as PTFE tubes or Bowden cables. In one example, there are a total of twenty four tubes, with sixteen tubes housing cables for movement of two working tubes (i.e. eight per working tube), four tubes housing cables for opening the cuff, two tubes housing cables for closing the cuff and two tubes housing one surgical instrument each.

[0099] In one example, the surgical instrument may be inserted via an auxiliary channel from the proximal end to the distal end of the overtube.

[0100] In one embodiment, the overtube comprises an inner wall and an outer wall, wherein the inner wall defines the main channel and wherein the plurality of auxiliary channels is disposed in a space between the inner wall and the outer wall. For example, the inner wall

- is an inner jacket that allows the endoscope to pass through and the outer wall is an outer jacket that ensures all tubes (i.e. auxiliary channels) are enclosed within. The main channel may also be known as "colonoscope channel". In one example, the inner jacket is made of a flexible thermoplastic material such as silicone, TPU or PVC, with a special biocompatible hydrophilic coating. When wetted, the endoscope will glide inside the overtube without much friction, enabling the endoscope to move forward and backward easily. In one example, the outer jacket has a very thin TPU sheath which protects the colon tract from entering into the overtube. It also enables the overtube to glide much smoother when in contact with the colon tract.
- 5 [00101] As an alternative to the PTFE tubings, the overtube may include wire coils through which the cables needed to actuate the cuff and working tubes are being routed through. The wire coils may be located inside the auxiliary channels and may extend partially or fully along the length of the auxiliary channels.
- [00102] In a preferred example, the first overtube ring 12 and the cuff serve to terminate the PTFE tubes that house the cables for opening the cuff. The PTFE tubes that house the cables for moving the working tubes 5 terminate on the structural member 24 of the cuff.
- 15 [00103] As an alternative to the hard stop to the PTFE tubes provided by the first overtube ring 12, a cap, also known as end cap, is disposed on the proximal and/or the distal ends of the overtube to restrict the movement of the cables. The cap may secure the inner wall, outer wall and auxiliary channels of the overtube. The cap may have slots to allow the cables to pass through. Each slot may accommodate one or more cables. In one example, the tool channels serve to allow surgical instruments to pass through in the overtube. As used herein, the term "tool channel" is meant to include an auxiliary channel housing the surgical instrument. In the embodiment shown in Figure 15, the tool channel houses the surgical instrument PTFE tubing 20 which in turn receives the surgical instrument 19.
- 20 [00104] In one example, off-the-shelf surgical instruments may be inserted via the tool channels of the overtube and into the working tubes 5. To enable the surgical instruments to be released and changed, the working tubes 5 can be aligned with the tool channels of the overtube.
- 25 [00105] In one example, the diameter of the main channel is 16mm. The diameter of the main channel may also be known as the inner diameter of the overtube. It would be generally understood by a person skilled in the art that a range is possible for the diameter of the main channel 30 and that the diameter of the main channel would depend on the outer diameter of the type of scope to be used with the endoscope accessory. For instance, gastroscopes typically have an outer diameter of 9mm, whereas colonoscopes typically have an outer
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diameter of 13.5-14mm. A main channel of diameter 16mm would allow the overtube to fit a colonoscope, whereas a smaller main channel diameter of 10mm or 11mm can be used to fit a gastroscope. In one example, the diameter of the main channel is between 10mm to 16mm.

[00106] In one example, the diameter of the auxiliary channel is 1.4mm. In one example,
5 the diameter of the auxiliary channel is between 1mm to 4mm so as to accommodate the cables and surgical instruments.

[00107] In one example, the diameter of the overtube is 25mm. It would be generally understood by a person skilled in the art that a range is possible for the diameter of the overtube and that the diameter of the overtube would depend on the outer diameter of the
10 type of scope to be used with the endoscope accessory. For instance, gastroscopes typically have an outer diameter of 9mm, whereas colonoscopes typically have an outer diameter of 13.5-14mm. In one example, the diameter of the overtube is between 10mm to 30mm.

[00108] The overtube is preferably made of biocompatible material. Examples of biocompatible material include but are not limited to polytetrafluoroethylene (PTFE), polyether
15 block amide copolymers such as PEBAX, fluorinated ethylene propylene (FEP), thermoplastic polyurethane (TPU) and perfluoroalkoxy (PFA).

[00109] Cables

[00110] In one embodiment, the plurality of cables comprises a plurality of braided UHMWPE lines. In various examples, the plurality of cables may comprise a plurality of metal
20 wires, metal cables, or any cables that do not stretch.

[00111] In various embodiments, the plurality of cables is connected to a transmission interface which is manually driven or driven by a cable actuation mechanism. In one example, the cable actuation mechanism is a Cable Driven Parallel Mechanism (CDPM). Advantageously, CDPM allows larger and more controlled forces to be transmitted to the
25 surgical instrument, allowing the surgical instrument to lift larger loads, as well as have increased precision of movement to perform ESD. This enables the en-bloc dissection of bigger lesions instead of piecemeal, reducing occurrence of relapse due to seeding of cells. In various embodiments, the plurality of cables is connected to a transmission interface which is manually driven or driven by a cable actuation mechanism. As used herein, the terms
30 "actuator", "actuation mechanism" and "actuation unit" are used interchangeably. The term "actuator" is meant to include any device that receives energy (such as in the form of electrical, hydraulic or pneumatic energy) and converts the energy into mechanical force or motion (such as linear or rotary motion). In one example, the cable actuation mechanism is a Cable Driven Parallel Mechanism (CDPM). Advantageously, CDPM allows larger and more controlled
35 forces to be transmitted to the surgical instrument, allowing the surgical instrument to lift larger

loads, as well as have increased precision of movement to perform ESD. This enables the en-bloc dissection of bigger lesions instead of piecemeal, reducing occurrence of relapse due to seeding of cells.

[00112] As will be understood by the person skilled in the art, any other method to actuate the cables, such as pulleys, can be used.

[00113] The cables from the actuation system are routed through the auxiliary channels in the overtube through the plurality of auxiliary through-openings in the base member 1 to the structural member 24 and working tube 5. For example, to open the cuff, some of the cables may terminate on the moveable arm(s) of the structural member. In one example, to open the cuff, four opening cables pull on 4 pistons inside the cuff which will then enable the hinge mechanism to open up. To close the cuff, two cables may be positioned towards the distal tip of the cuff and go around the cuff. To move the surgical instrument, the cables may be terminated on a working tube 5.

[00114] The term "cable entry point" as used herein may refer to an aperture or through hole feature that allows the entry of cables from a structure. The cable entry points may be present on the working tubes 5. In various examples, the working tubes 5 may have sixteen cable entry points (eight cable mounting points) each. The base member 1, and structural member 24 may have a plurality of auxiliary through-holes to accommodate the cables. The term "through-hole" is meant to include a passage, channel or groove for accommodating one or more cables. For example, a pair of cable entry points may be used as one cable mounting point. As used herein, the terms "cable entry points" and "cable mounting point" are used interchangeably. For example, the cables would enter from the cable entry points as well as terminating/mounting at the entry point with a knot. In one example, the auxiliary through-holes in the structural member 24 are passages. In one example, each of the two non-moveable and two moveable arms of the structural member has two passages. Each passage houses two PTFE tubings, and each PTFE tubing houses one working tube cable (i.e. cable for moving the working tube). In total, there would be eight passages in the four arms, sixteen PTFE tubings, and sixteen working tube cables. It is generally known in the art that different techniques may be used to terminate a cable at the cable mounting point. For example, polymer fiber cables or braided UHMWPE cable can terminate by knots provided in the cables, whereas metal fiber cables may terminate by crimp connections, spot welding and/or barbed connections. Preferably, at least one of the plurality of cables terminates at the at least one mounting point by a knot provided in the cable. Examples of knots include clove hitch knots and thumb knots. Advantageously, a clove hitch knot allows the cable to move without moving the knot.

[00115] In one embodiment, the at least one of the plurality of cables terminates at the at least one cable mounting point by a knot provided in the cable.

[00116] In one example, the cables which terminate onto the working tubes 5 are used to actuate them in a controlled manner.

5 [00117] In one example, the working tubes 5, each of which are connected to eight cables, are able to achieve six degrees of freedom (DOF), including translational motion in the x, y and z directions, rotational movement along the pitch, yaw and roll axes. The total DOF can be seven or eight if the DOF of the tools were to be included, i.e. activation/opening or deactivation/closing of the tool. Owing to their antagonistic nature and configuration, the
10 cables are able to exert high forces in six DOF while simultaneously ensuring control and stability of the surgical instruments. Advantageously, the configuration of the plurality of cables connected to each working tube 5 allows the working tube to move in any desired direction, including outwards outside and beyond the interior space of the structural member 24. The ability of such movement of the working tube 5 allows surgical instruments that are disposed
15 within the working tube 5 to reach places outside and beyond the interior space of the endoscope accessory. This is advantageous as it allows a user greater flexibility to maneuver within a tight space of a body cavity or lumen of an organ.

[00118] In any event, this invention (when used with an endoscope) allows additional channels for a user to carry out an endoscopy to view the inside of a lumen or cavity and, at
20 the same time, carry out any required or desired surgical procedure without having to free up channels used by other tools. In addition, the surgical instruments used in conjunction with this endoscope accessory may be controlled independent of the endoscope. This allows greater maneuverability and control of tools used in an endoscope procedure.

[00119] Advantageously, the endoscope accessory of this invention may be used with any
25 endoscope and surgical instrument commercially available.

[00120] In one embodiment, six cables are connected to the working tube 5. This achieves five DOF. The number of cables connected to the working tube 5 can be more than six. For example, eight cables per working tube 5 would give six DOF. By suitable manipulation of the cables, any desired angle and position of the surgical instrument can be achieved.

30 [00121] In one embodiment, the movement of the working tube, and thereby surgical instrument, comprises translational movement of the working tube along the x, y or z axes.

[00122] Advantageously, the present invention reduces the difficulty of performing endoscopic submucosal dissection (ESD) in multiple ways. Firstly, the one or more working tubes 5 provides for one or more additional endoscopic tools. For instance, in the embodiment
35 where the number of working tubes 5 is two, the user will be able to work with two endoscopic

tools, in addition to a possible 3rd endoscopic tool from the working channel of the endoscope. This translates to faster procedures due to the ability to operate multiple endoscopic tools at the same time. This also allows for a shorter learning curve compared to traditional ESDs. Secondly, the cable-actuated working tubes 5 provides for up to six degrees of freedom (DOF) control of the one or more additional endoscopic tools. The arrangement of working tubes 5 also allows strong forces to be applied to the endoscopic tools, and allows well-controlled, stable movement. This enables improved control and therefore lowers the risk of perforations, leading to safer procedures. Thirdly, the cuff which can be held in the open configuration provides for support and stabilization of the working site. Fourthly, the independent scope and tool movement provided by the separate main and auxiliary channels in the overtube allows the elimination of coupled scope and tool movement found in conventional ESD.

[00123] Creation and maintenance of a submucosal space or tunnel is laborious and risky. Using the expandable cuff of the endoscope accessory as described herein to mechanically expose and confidently maintain this working space presents a practical solution. Alternatively, the endoscope accessory may also be used to suction or invaginate tissue for resection as well as protecting it for safe specimen extraction. Finally, there are numerous imaging opportunities of the cuff design allowing the endoscope accessory to function well as an image acquisition and display device, ranging from multiple mobile camera positioning, improved illumination of the operative field and real time in-situ image-guided dissection using the cuff as a probe, for example a wide radial-array ultrasound probe.

[00124] In one embodiment, the expandable cuff further comprises an outer sheath.

[00125] As used herein, the term "outer sheath" is meant to include a layer of material configured to completely or partially encase or cover the cuff. For example, the outer sheath may cover the outer face of the structural member to minimise contact of the structural member with tissues. The outer sheath forms a protective layer surrounding the cuff and serves as a barrier between the cuff components and the patient's tissue. In various examples, the outer sheath may cover the cuff and overtube. The outer sheath may be composed of one piece covering the cuff and another piece covering the overtube, or it may be composed of one piece covering both the cuff and overtube. In various examples, the outer sheath may be made of thermoplastic polyurethane (TPU), polytetrafluoroethylene (PTFE), polyether block amide copolymer such as PEBAX, silicone, or a combination of these materials.

[00126] In one embodiment, the endoscope accessory as described herein further comprises an image capturing device disposed on the expandable cuff. For example, a camera can be housed at the proximal end of the structural member, such as on the "topmost" arm, to give a bird's eye view of the area of interest.

- [00127] Advantageously, the endoscope accessory as described herein provides improved triangulation compared to existing dual-channel endoscopes as the present endoscope accessory allows the tools to be moved independently of the scope. The term "triangulation" is meant to include the arrangement of having the camera in between two surgical instruments (in the case where the number of working tubes 5 is two) and relates to the size of the workspace in which the placement of the camera versus that of the instruments is crucial. Triangulation also takes into account the importance of the independent motion of the camera and that of each instrument.
- [00128] In one embodiment, the endoscope accessory as described herein further comprises an illumination source disposed on the expandable cuff. For example, lights can be housed at the proximal end of the structural member to give even lighting of the area of interest. In another example, site illumination can be provided through reflection/diffusion of the scope's existing light source (similarly to an umbrella flash reflector).
- [00129] In one embodiment, the endoscope accessory as described herein is single-use.
- 15 [00130] Advantageously, the endoscope accessory can be fully composed of mechanical components, thus eliminating the risk of patient injury caused by stray electrical currents. In other words, the base member, structural member, working tube(s), overtube and transmission interface can be fully composed of mechanical components.
- [00131] Advantageously, the endoscope accessory as described herein can be used with existing endoscopes. For example, existing endoscopes can be modified to include the endoscope accessory of the present embodiments as an add-on. In addition, the present endoscope accessory can use off-the-shelf endoscopic tools. This is advantageous compared to robotic systems which create their own endoscopy systems. Such robotic systems aim to have their own endoscopes and tools, necessitating increased cost and time of development which leads to an increased cost of the end product. Since the tools in such robotic systems are expensive, they need to be made reusable and re-sterilizable. Furthermore, such robotic systems would need to compete with existing endoscopy systems which already dominate the endoscopy industry.
- 25 [00132] In various examples, the endoscope accessory of the present embodiments can be used with flexible or rigid endoscopes. The endoscope accessory can be used in a method of performing surgery, comprising inserting the endoscope accessory into the human or animal body and deploying the cuff, then operating the surgical instruments by controlling the cables.
- [00133] System
- [00134] It would generally be appreciated by the skilled person that tension applied to the relevant cables would enable movement of the moveable arm(s) and the working tube(s). By
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“tension”, it is meant to include any tightening or stretching of the relevant cables by applying a force, for example a pulling action. In various embodiments, the tightening of a relevant cable (and the corresponding loosening of its antagonist equivalent) results in a movement of the structural member wall and/or working tube in the direction desired.

5 [00135] The endoscope accessory as described herein may include a transmission interface 15 disposed at the proximal end of the overtube, wherein the transmission interface is configured to actuate the plurality of cables. The transmission interface may serve as the intermediary between the actuation motors on the patient cart and the plurality of cables. The transmission interface 15 comprises a plurality of driven members for actuating the plurality of
10 cables, wherein each of the plurality of cables is connected to one of the plurality of driven members. Examples of the driven members are clutches. For example, the transmission interface 15 may include a plurality of male clutches connected to the cables, with the corresponding female clutches present on the controller cart. The cart may have torque sensors that measure the twist tension in the cables to control the tension of the cables. The
15 male clutches on the transmission interface 15 may also be operated manually via knobs, allowing for fine-tuned adjustments to the cable lengths. In one example, the knobs can be manually tightened/loosened pre- and post-operation, and robotically tightened or loosened during operation. In one example, the male clutches may be in the form of small protruding squares and the female clutches may have square-shaped grooves for fitting over the male
20 clutches.

[00136] The endoscope accessory of the present embodiments may be connected to an actuation unit and one or more controllers. In some examples, the actuation units and controllers can be used multiple times whereas the overtube 23, cuff 22, working tubes 5, cables, surgical instruments 19 and transmission interface 15 may be disposable (single-use).

25 [00137] The endoscope accessory of the present embodiments may be used with existing endoscopes. The endoscopes may come with their own endoscopy system which may include a monitor, light source, camera and controls. The backend system comprises an user console and a patient cart. The user console includes 2 controllers for the user to move the 2 working tubes as well as activate/deactivate each working tube’s surgical instrument. In one example,
30 the console may include a screen for graphical user interface (GUI) purpose and/or to enable the user to see the visual feedback from the endoscopy system, as well as a PC to house the software system. The user console is physically connected via cables to the patient cart. The patient cart is comprised of motors, motion controllers, power supplies, custom PCBAs, amongst other parts to move the cables according to the controller’s movement, which will
35 then move the working tubes.

- [00138] In various examples, the controllers may be designed with a serial arm concept. Moving the controller in space would effect the same movement of the end effector. In various examples, the serial arm has three potentiometers to identify the position of the end effector in X,Y,Z planes. In various examples, the end effector has another three potentiometers, which
- 5 control the pitch, yaw and roll of the working tubes 5. This also contains two buttons to control the action of the tool itself, e.g. opening or closing the grasper, or activation or deactivation of the electrocautery knife. The activation and deactivation of the end effector can be gradual and controlled.
- [00139] The controller may include a dorsal strap for fitting around the user's hands to keep
- 10 the controller supported. This gives the user the impression that the controller is weightless.
- [00140] In one example, the actuation unit controls the movement of the working tubes 5 by pulling and thus changing the length of cables attached to the working tubes 5 at various points. This may be done with a cable driven parallel mechanism (CDPM). The actuation unit may serve to pull the different cables (i.e. causing lengthwise displacement of the cables) to
- 15 enable the working tubes 5 to move in the desired direction(s). It also monitors the tension on each cable to ensure that the cable does not snap from excessive loads.
- [00141] In one example, the actuation unit may control the movement of the cuff, overtube and working tubes via a transmission interface. The transmission interface may be in the form of a disc having a plurality of male clutches connected to the cables, with the corresponding
- 20 female clutches present on the controller cart. In this embodiment, torque sensors on the cart measures the twist tension in the cables to control the tension of the cables. The male clutches on the disc may also be operated manually. For example, the male clutches can be in the form of knobs which can be turned manually to lengthen or shorten the cables. The disc may also comprise gaskets to minimize leakage of CO₂ from CO₂ insufflation.
- 25 [00142] Any suitable transmission interface for manipulating the plurality of cables to achieve the desired outcome or movement of the working tubes and arms of the structural member may be used.
- [00143] In one example, the actuation unit includes opposing banks of eight and nine linear actuators respectively. These linear actuators correspond to the seventeen lines required for
- 30 the movement of two working tubes 5, as well as expansion and closing of the surgical cuff attachment. In another example, the actuation unit includes twenty-two linear actuators, with eleven on each side, so as to provide sixteen lines required for the movement of two working tubes 5, as well as four lines for the expansion and two lines for closing the cuff instead of one. In yet another example, the actuation unit includes an additional two lines per working

tube 5 for controlling the roll of the working tubes 5. This corresponds to twenty one or twenty two linear actuators.

[00144] In one example, the linear actuators are ball screw set ups, where a motor controls each ball screw to produce linear motion of slider blocks along the horizontal axis. The slider
5 blocks are supported by two additional guide rails, with plain bearings on the interface between the slider block and the guide rail. The ball screws have also a thrust bearing on each end to ease axial frictional loads and to support the ball screws. The motors are coupled to the ball screws through Oldham couplings, which alleviate axial misalignments for smoother motion. A load cell is mounted onto each slider block. The cables from the working tubes 5 terminate
10 on to said load cells, allowing for monitoring of the tension on each cable in real time. The data lines on the load cells are organised and protected from bending wear by utilising drag chains. Limit switches mounted on the ends of the ball screw supports define the maximum stroke position for each of the linear actuators. On the distal support, there are also hard stops for the Bowden cables, which are in-line with each linear actuator.

[00145] The transmission interface may be coupled to a control panel that is similar to a control panel for an endoscope. Such a control panel, connected to a power supply, may include a monitor screen for viewing images captured by the endoscope that is coupled or
15 used with the endoscope accessory of this invention, any suitable image management (including a recording means) or enhancement module for adjusting the images captured, any water or air supply that is necessary for carrying out the endoscopy procedure or any surgical
20 procedures carried out with the aid of the surgical instruments, controllers for controllers the surgical tools or instruments etc. In one example, for control of the endoscopic tools, there are also linear actuators positioned on the side of the patient cart. The linear actuators consist of a leadscrew and a pair of guide rails for each actuator. These actuators are similar to the
25 actuators mentioned above, with force sensing capability, as well as maximum displacement sensors. To interface with the endoscopic tools, they have a universal compliant mechanism, that allows users to simply clip in their desired tool at the operating cart to transform them into robotically controlled tools.

[00146] The invention illustratively described herein may suitably be practiced in the
30 absence of any element or elements, limitation or limitations, not specifically disclosed herein. Thus, for example, the terms "comprising", "including", "containing", etc. shall be read expansively and without limitation. Additionally, the terms and expressions employed herein have been used as terms of description and not of limitation, and there is no intention in the use of such terms and expressions of excluding any equivalents of the features shown and
35 described or portions thereof, but it is recognized that various modifications are possible within

- the scope of the invention claimed. Thus, it should be understood that although the present invention has been specifically disclosed by preferred embodiments and optional features, modification and variation of the inventions embodied therein herein disclosed may be resorted to by those skilled in the art, and that such modifications and variations are
- 5 considered to be within the scope of this invention.
- [00147] The invention has been described broadly and generically herein. Each of the narrower species and subgeneric groupings falling within the generic disclosure also form part of the invention. This includes the generic description of the invention with a proviso or negative limitation removing any subject matter from the genus, regardless of whether or not
- 10 the excised material is specifically recited herein.
- [00148] While embodiments of the invention have been particularly shown and described with reference to specific embodiments, it should be understood by those skilled in the art that various changes in form and detail may be made therein without departing from the scope of the invention as defined by the appended claims. The scope of the invention is thus indicated
- 15 by the appended claims and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced.

CLAIMS

1. An endoscope accessory comprising:
 - (a) a base member comprising a through-opening, the through-opening
5 configured to accommodate an endoscope;
 - (b) a structural member coupled to the base member and enclosing an interior space within the structural member, wherein the structural member comprises at least one moveable arm configured to move between an open configuration and a closed configuration; and
 - 10 (c) a working tube disposed in the interior space for accommodating a surgical instrument.
2. The endoscope accessory of claim 1, further comprising an overtube having a proximal end and a distal end, wherein the distal end of the overtube is coupled to an end of the
15 base member opposite the structural member.
3. The endoscope accessory of claim 2, wherein the overtube is formed by a plurality of rings.
- 20 4. The endoscope accessory of claim 2 or 3, wherein the overtube comprises a main channel, the main channel and through-opening aligned with each other, for accommodating the endoscope.
- 25 5. The endoscope accessory of any one of claims 2 to 4, wherein the overtube comprises a plurality of auxiliary channels for accommodating a plurality of cables.
6. The endoscope accessory of claim 5, wherein the overtube comprises an inner wall and an outer wall, wherein the inner wall defines the main channel and wherein the plurality of auxiliary channels are disposed in a space between the inner wall and the
30 outer wall.
7. The endoscope accessory of claim 5 or 6, further comprising the plurality of cables, wherein at least one of the plurality of cables terminates on the structural member for moving the structural member between the open configuration and the closed configuration, and wherein at least one of the plurality of cables terminates on the
35 working tube for guiding the surgical instrument.

8. The endoscope accessory of any one of claims 1 to 7, wherein the base member further comprises a plurality of auxiliary through-openings for accommodating the plurality of cables.
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9. The endoscope accessory of any one of claims 1 to 8, wherein the structural member comprises two moveable arms, the two moveable arms opposing each other on either side of the interior space, wherein the two moveable arms are configured to extend outwards away a longitudinal axis extending along the length of the structural member
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- when the arms are in the open configuration.
10. The endoscope accessory of any one of claims 1 to 9, wherein the endoscope accessory further comprises an outer sheath for covering the structural member.
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11. The endoscope accessory of any one of claims 1 to 10, wherein the movement of the working tube comprises movement of the working tube along x, y and/or z axes and rotational movement of the working tube along pitch, yaw and/or roll axes.
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12. The endoscope accessory of any one of claims 1 to 11, wherein the surgical instrument is any one selected from the group consisting of a grasper tool, an electrocautery tool, a suturing tool, a snare loop, forceps, scissors, a suction tool, an injection tool, a clipping tool and an irrigation tool.
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13. The endoscope accessory of any one of claims 1 to 12, comprising two working tubes.
14. The endoscope accessory of any one of claims 4 to 13, further comprising a transmission interface disposed at the proximal end of the overtube, wherein the transmission interface is configured to actuate the plurality of cables.
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15. The endoscope accessory of claim 14, wherein the transmission interface is configured to be manually driven to actuate the plurality of cables.
16. The endoscope accessory of claim 14, wherein the transmission interface is operably connected to an actuator and configured to be driven by the actuator.
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17. The endoscope accessory of any one of claims 14 to 16, wherein the transmission interface comprises a plurality of driven members for actuating the plurality of cables, wherein each of the plurality of cables is connected to one of the plurality of driven members.
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