United States Patent	12390205
Kind Code	B2
Date of Patent	August 19, 2025
Inventor(s)	Bhowmick; Nabarun et al.

Medical device handle assemblies and methods of using the same

Abstract

A medical device that includes a handle including a plurality of actuators. The handle defines a longitudinal axis extending through a distal end of the handle. The device includes a shaft extending from the handle and an end effector at a distal end of the shaft. A first actuator of the plurality of actuators is configured to actuate the end effector in response to translation of the first actuator relative to the handle along an axis parallel to the longitudinal axis. A second actuator of the plurality of actuators is configured to deflect the end effector relative to the shaft in response to pivoting the second actuator about an axis transverse to the longitudinal axis. A third actuator of the plurality of actuators is configured to rotate the end effector relative to the shaft in response to rotation of the third actuator relative to the handle about the longitudinal axis.

Inventors: **Bhowmick; Nabarun (Kolkata, IN), Sharma; Deepak Kumar (Muzaffarnafar, IN), Raut; Shrikant Vasant (Mumbai, IN), Morey; Subodh (Ponda, IN), Aradhye; Charudatta Chandrakant (Solapur, IN), Scutti; James J. (Norwell, MA)**

Applicant: **Boston Scientific Medical Device Limited** (Galway, IE)

Family ID: **1000008767462**

Assignee: **Boston Scientific Medical Device Limited (Galway, IE)**

Appl. No.: **18/606445**

Filed: **March 15, 2024**

Prior Publication Data

Document Identifier	**Publication Date**
US 20240260953 A1	Aug. 08, 2024

Related U.S. Application Data

continuation parent-doc US 17179099 20210218 US 11957323 child-doc US 18606445

Publication Classification

Int. Cl.: **A61B17/00** (20060101); A61M25/01 (20060101)

U.S. Cl.:

CPC **A61B17/00234** (20130101); A61B2017/00323 (20130101); A61B2017/00367 (20130101); A61M25/0136 (20130101)

Field of Classification Search

CPC: A61B (17/00234); A61B (2017/00323); A61B (2017/00327); A61B (2017/00331); A61B (2017/00367); A61B (2017/00371); A61B (2017/00376); A61B (2017/0038); A61B (2017/00384); A61B (2017/00389); A61M (25/0136); A61M (25/0138); A61M (25/0141); A61M (25/0144); A61M (25/0147)

USPC: 606/130

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Primary Examiner: Roane; Aaron F

Attorney, Agent or Firm: Bookoff McAndrews, PLLC

Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS (1) This application is a continuation of U.S. application Ser. No. 17/179,099, filed on Feb. 18, 2021, which claims the benefit of priority from U.S. Provisional Application No. 62/978,093, filed Feb. 18, 2020, each of which is incorporated by reference herein in its entirety.

TECHNICAL FIELD
(1) Various aspects of the disclosure relate generally to medical systems, devices, and related methods. More specifically, at least certain examples of the disclosure relate to systems, devices, and related methods for positioning and/or controlling one or more medical devices within a subject during a procedure via a handle assembly, among other aspects.
BACKGROUND
(2) Technological developments have given users of medical systems, devices, and methods, the ability to conduct increasingly complex procedures on subjects. One challenge in the field of minimally invasive surgeries such as endoscopy, laparoscopy, and thoracoscopy, among other surgical procedures, is associated with providing control of medical devices during a procedure.

Placement of such medical devices within a subject (e.g., a patient) may be difficult. Additionally, actuating various medical systems that control a placement of such medical devices may be counterintuitive or complex to understand. The limitations on medical devices that facilitate access of other devices into a patient for placement may prolong the procedure, limit its effectiveness, and/or cause injury to the patient due to device failure or breakage. There is a need for devices and methods that address one or more of these difficulties or other related problems

SUMMARY

(3) Aspects of the disclosure relate to, among other things, systems, devices, and methods for accessing a target treatment site with a medical apparatus having intuitive handle assemblies that facilitate positioning of the apparatus, among other aspects. Each of the aspects disclosed herein may include one or more of the features described in connection with any of the other disclosed aspects.

(4) According to an example, a medical device includes a handle including a plurality of actuators, wherein the handle defines a central longitudinal axis extending through a distal end of the handle. The medical device includes a shaft extending from the handle and an end effector at a distal end of the shaft. A first actuator of the plurality of actuators is configured to actuate the end effector in response to translation of the first actuator relative to the handle along an axis parallel to the central longitudinal axis. A second actuator of the plurality of actuators is configured to deflect the end effector relative to the shaft in response to pivoting the second actuator about an axis transverse to the central longitudinal axis. A third actuator of the plurality of actuators is configured to rotate the end effector relative to the shaft in response to rotation of the third actuator relative to the handle about the central longitudinal axis.

(5) Any of the medical devices described herein may have any of the following features. The first actuator of the plurality of actuators includes a trigger positioned along a bottom wall of the handle. The trigger is configured to translate along the bottom wall of the handle along the axis parallel to the central longitudinal axis of the handle. Further including an actuation wire coupled to and extending between the trigger and the end effector. At least a portion of the trigger is movably received within an inner slot of the handle and is coupled to the actuation wire. Actuating the trigger moves the trigger along the inner slot and the actuation wire along the shaft to actuate the end effector. The second actuator of the plurality of actuators includes a rocker with a protrusion positioned along a top wall of the handle. Further including a pair of drive wires coupled to and extending between the rocker and the distal end of the shaft. Actuating the rocker moves at least one of the pair of drive wires along the shaft to deflect the distal end of the shaft. The third actuator of the plurality of actuators includes a roller positioned along a sidewall of the handle. The handle includes one or more walls defining an exterior of the handle, wherein each of the first actuator, the second actuator, and the third actuator are positioned along different walls of the one or more walls of the handle. Further including an actuation wire coupled to and extending between the roller and the end effector, wherein actuating the roller rotates the actuation wire and the end effector relative to the shaft. The handle includes one or more walls defining an exterior of the handle, wherein the first actuator is positioned along a top wall of the handle, and the second actuator and the third actuator are positioned along a first sidewall of the handle. The second actuator extends at least partially over the top wall of the handle.

(6) According to another example, a medical device includes a handle including an actuation wire and a drive wire, a shaft extending from the handle, and an end effector at a distal end of the shaft. The handle is configured to actuate the end effector in response to the actuation wire translating relative to and independent of the drive wire. The handle is configured to deflect the end effector relative to the shaft in response to the drive wire translating relative to and independent of the actuation wire. The handle is configured to rotate the end effector relative to the shaft in response to the actuation wire rotating relative to and independent of the drive wire.

(7) Any of the medical devices described herein may have any of the following features. The

handle includes a first actuator configured to actuate the end effector along a first plane, a second actuator configured to deflect the end effector along a second plane that is transverse to the first plane, and a third actuator configured to rotate the end effector and adjust the first plane relative to the second plane. The handle is configured to deflect the end effector in a downward direction relative to the shaft in response to a distal translation of the drive wire relative to the actuation wire. The handle is configured to deflect the end effector in an upward direction relative to the shaft in response to a proximal translation of the drive wire relative to the actuation wire. The handle includes an actuator that is configured to translate the actuation wire relative to the drive wire. The actuator transitions the end effector to an open configuration when translating the actuation wire in a first longitudinal direction, and transitions the end effector to a closed configuration when translating actuation wire in a second longitudinal direction that is opposite of the first longitudinal direction. The handle includes an actuator that is configured to translate the drive wire relative to the actuation wire. The actuator deflects the end effector upward relative to the shaft when translating the actuation wire in a first longitudinal direction, and deflects the end effector downward when translating actuation wire in a second longitudinal direction that is opposite of the first longitudinal direction.
(8) According to another example, a medical device includes a shaft including a distal end and a proximal end, an end effector at the distal end of the shaft, and a handle at the proximal end of the shaft. The handle includes a first actuator that is movable in a first direction relative to the handle, wherein the first actuator is configured to actuate the end effector in response to moving the first actuator in the first direction. The handle includes a second actuator that is movable in a second direction relative to the handle, wherein the second actuator is configured to deflect the end effector relative to the shaft in response to moving the second actuator in the second direction. The handle includes a third actuator that is movable in a third direction relative to the handle, wherein the third actuator is configured to rotate the end effector relative to the shaft in response to moving the third actuator in the third direction. The first direction is parallel to a longitudinal axis of the handle, and the third direction is about the longitudinal axis of the handle.
(9) It may be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only and are not restrictive of the invention, as claimed.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate exemplary aspects of the disclosure and together with the description, serve to explain the principles of the disclosure.
(2) FIG. **1** is a perspective view of an exemplary medical device having a handle assembly and an end effector, according to aspects of this disclosure;
(3) FIG. **2** is a cross-sectional side view of the handle assembly of the medical device of FIG. **1**, including an actuator, according to aspects of this disclosure;
(4) FIG. **3**A is a partial perspective view of the end effector of the medical device of FIG. **1** in a first articulated position, according to aspects of this disclosure;
(5) FIG. **3**B is a partial perspective view of the end effector of the medical device of FIG. **1** in a second articulated position, according to aspects of this disclosure;
(6) FIG. **4**A is a cross-sectional side view of the handle assembly of the medical device of FIG. **1**, including an actuator in a first actuated state, according to aspects of this disclosure;
(7) FIG. **4**B is a partial side view of the end effector of the medical device of FIG. **1** in the first actuated state, according to aspects of this disclosure;
(8) FIG. **5**A is a cross-sectional side view of the handle assembly of the medical device of FIG. **1**,

with an actuator in a second actuated state, according to aspects of this disclosure;
(9) FIG. 5B is a partial side view of the end effector of the medical device of FIG. **1** in the second actuated position, according to aspects of this disclosure;
(10) FIG. **6** is a partial perspective view of another exemplary medical device including a handle assembly, according to aspects of this disclosure;
(11) FIG. **7** is a partial perspective view of another exemplary medical device including a handle assembly, according to aspects of this disclosure;
(12) FIG. **8** is a perspective view of another exemplary medical device including a handle assembly and a coiled shaft, according to aspects of this disclosure;
(13) FIG. **9** is a cross-sectional perspective view of the coiled shaft of FIG. **8**, according to aspects of this disclosure; and
(14) FIG. **10** is a partial perspective view of the handle assembly of FIG. **8** including an actuator with a guidewire disposed therein.

DETAILED DESCRIPTION

(15) Examples of the disclosure include systems, devices, and methods for controlling multiple components of a medical device at a target site within the body, where the components generally require manipulation to access a target site, among other aspects. Reference will now be made in detail to aspects of the disclosure, examples of which are illustrated in the accompanying drawings. Wherever possible, the same or similar reference numbers will be used through the drawings to refer to the same or like parts. The term “distal” refers to a portion farthest away from a user when introducing a device into a patient. By contrast, the term “proximal” refers to a portion closest to the user when placing the device into the subject (e.g., patient). As used herein, the terms “comprises,” “comprising,” or any other variation thereof, are intended to cover a non-exclusive inclusion, such that a process, method, article, or apparatus that comprises a list of elements does not necessarily include only those elements, but may include other elements not expressly listed or inherent to such process, method, article, or apparatus. The term “exemplary” is used in the sense of “example,” rather than “ideal.” As used herein, the terms “about,” “substantially,” and “approximately,” indicate a range of values within +/−10% of a stated value.
(16) Examples of the disclosure may be used to facilitate control and positioning of an end effector (tools/devices) of a medical device at a target treatment site by providing one or more mechanisms and/or assemblies for positioning said tools/devices at the target treatment site. Some examples combine a handle assembly on a medical device for selective control and/or manipulation of components of the medical device, such as, for example, an end effector. The medical device may include a plurality of actuators along the handle assembly that are independently movable relative to one another for controlling a position and/or orientation of the end effector. The handle assembly is configured such that actuation of the plurality of actuators of the handle assembly may provide a respective rotation, actuation, and/or deflection of the end effector relative to the handle assembly.
(17) Examples of the disclosure may relate to devices and methods for performing various medical procedures and/or treating portions of the large intestine (colon), small intestine, cecum, esophagus, any other portion of the gastrointestinal tract, and/or any other suitable subject anatomy (collectively referred to herein as a “target treatment site”). The device and related methods may be used laparoscopically or endoscopically, or in any other open or minimally invasive procedure, including thorascopic and ENT procedures. Reference will now be made in detail to examples of the present disclosure described above and illustrated in the accompanying drawings. Wherever possible, the same reference numbers will be used throughout the drawings to refer to the same or like parts.
(18) FIG. **1** shows a schematic depiction of an exemplary medical device **100** in accordance with an example of this disclosure. The medical device **100** may include a handle assembly **102** having a top wall **101**, a pair of sidewalls **103**, and a bottom wall **105**. In the example, the top wall **101**, the sidewalls **103**, and the bottom wall **105** of the handle assembly **102** extend between a distal end

104 and a proximal end **106** that define a longitudinal length of the handle assembly **102**. At least a portion of the longitudinal length of the handle assembly **102** (e.g., a distal portion proximate to the distal end **104**), as defined by the top wall **101**, the sidewalls **103**, and the bottom wall **105**, may define a central longitudinal axis **10** (FIG. **2**) of the handle assembly **102**. In other embodiments, the handle assembly **102** may be defined by additional, fewer, and/or different walls than those shown and described herein, including, for example, a pair of curved sidewalls **103** that are coupled to one another. As described in further detail below, the handle assembly **102** may include one or more bends and/or angles formed along one or more of the top wall **101**, the sidewalls **103**, and the bottom wall **105** such that at least a portion of the longitudinal length of the handle assembly **102** (e.g., a proximal portion proximate to the proximal end **106**) may be transverse to the central longitudinal axis **10**.

(19) In this instance, with at least a portion of the longitudinal length of the handle assembly **102** being transverse to the central longitudinal axis **10** of the handle assembly **102**, the top wall **101**, the sidewalls **103**, and the bottom wall **105** of the handle assembly **102** may be sized, shaped, and configured such that a hand of a user of the medical device **100** may form an ulnar deviation relative to a forearm of the user when manually grasping the handle assembly **102**. In other words, the handle assembly **102** includes a configuration with the top wall **101**, the sidewalls **103**, and the bottom wall **105** that positions a hand of a user of the medical device **100** at an angle relative to a forearm of the user when the handle assembly **102** is grasped by the hand of the user.

(20) The medical device **100** may further include a shaft **108** extending distally from the distal end **104** of the handle assembly **102**, and an articulation joint **140** extending distally from a distal end of the shaft **108**. The shaft **108** of the medical device **100** may be flexibly deformable such that an orientation and/or a configuration of the shaft **108** may be adjustable. The shaft **108** may define a longitudinal axis extending between a proximal end of the shaft **108**, located adjacent to the handle assembly **102**, and a distal end of the shaft **108** located adjacent to the articulation joint **140** of the medical device **100**. In the example, the shaft **108** may be rotatably fixed relative to the handle assembly **102** and secured to, and/or coupled with, the articulation joint **140**. Accordingly, and as described in further detail herein, the shaft **108** of the medical device **100** is configured to move (e.g., rotate) the articulation joint **140** in response to rotation of the handle assembly **102**.

(21) Still referring to FIG. **1**, the medical device **100** may include one or more actuators **110**, **120**, **130** disposed along one or more exterior surfaces and/or walls of the handle assembly **102**. In the example, the medical device **100** includes a first (actuation) actuator **110** positioned along the bottom wall **105** of the handle assembly **102**, a second (articulation) actuator **120** positioned along the top wall **101** of the handle assembly **102**, and a third (rotation) actuator **130** positioned along one or more of the sidewalls **103** of the handle assembly **102**. The first (actuation) actuator **110** of the medical device **100** is configured to translate relative to the handle assembly **102**, such as, for example, in one or more directions (e.g., distally, proximally, etc.) parallel to the central longitudinal axis **10** of the handle assembly **102**. In the example, the first (actuation) actuator **110** is sized and shaped in the form of a trigger.

(22) The second (articulation) actuator **120** of the medical device **100** may be configured to pivot relative to the handle assembly **102**, such as, for example in one or more directions (e.g., distally, proximally, etc.) parallel to the central longitudinal axis **10** of the handle assembly **102**. In other words, the second (articulation) actuator **120** pivots about an axis (not shown) that is transverse (e.g., perpendicular) to the central longitudinal axis **10** of the handle assembly **102**. In the example, the second (articulation) actuator **120** may be a button/actuator that is sized and shaped in the form of a rocker, switch, a rotary slider, a knob and/or the like. For example, as shown in FIG. **1**, the second (articulation) actuator **120** may comprise a rocker having a base wheel and one or more projections for secure placement of a user's thumb or fingers for actuation thereof. The second (articulation) actuator **120** may extend outwardly from the top wall **101** of the handle assembly **102** to facilitate access to the second (articulation) actuator **120** by a user of the medical device **100**. For

example, the rocker of the second (articulation) actuator **120** may be at least partially rotatable and/or pivotable about an axis that is relatively transverse to the central longitudinal axis **10** (FIG. **2**) of the handle assembly **102**. In the example, the projections of the second (articulation) actuator **120** may be movable in one or more directions that is at least relatively parallel to the central longitudinal axis **10**.

(23) Still referring to FIG. **1**, the third (rotation) actuator **130** may be configured to rotate (e.g., clockwise, counter-clockwise, etc.) relative to the handle assembly **102**, such as, for example, about an axis (not shown) that is collinear or parallel to the central longitudinal axis **10** of the handle assembly **102**. In the example, the third (rotation) actuator **130** is a button/actuator that is sized and shaped in the form of a roller, a drum, and/or the like. In some examples, the third (rotation) actuator **130** may extend laterally outward from at least one (or both) of the sidewalls **103** of the handle assembly **102** to facilitate access to the third (rotation) actuator **130** by a user of the medical device **100**. In other examples, the third (rotation) actuator **130** may be fully disposed within the handle assembly **102** and one or more of the sidewalls **103** of the handle assembly **102** may include a recess and/or opening that is sized, shaped, and aligned with a location of the third (rotation) actuator **130**. In this instance, the opening on the handle assembly **102** may be operable to facilitate access to the third (rotation) actuator **130** to a user of the medical device **100**.

(24) It should be appreciated that additional and/or fewer actuators **110**, **120**, **130** may be included on various other walls **101**, **103**, **105** (and/or surfaces) of the handle assembly **102** without departing from the scope of this disclosure. It should further be understood that, in other examples, the actuators **110**, **120**, **130** may have various other configurations than those shown and described herein (see FIGS. **6-7**). Additionally, the handle assembly **102** may include one or more actuators **110**, **120**, **130** that are any combination of an actuation, articulation, and/or rotation actuator. As described in further detail herein, the actuators **110**, **120**, **130** are configured and operable to actuate one or more components of the medical device **100**, such as, for example, an articulation joint **140** and/or an end effector **146**.

(25) In embodiments, a position of the actuators **110**, **120**, **130** on the handle assembly **102** may be provided in an ergonomic manner such that the actuators **110**, **120**, **130** may be operable by a single hand of a user of the medical device **100**. For example, the actuators **110**, **120**, **130** may be positioned such that a first finger (e.g., an index finger) may operate the first (actuation) actuator **110**, a second finger (e.g., a thumb) may operate the second (articulation) actuator **120**, and a third finger and/or at least one of the first or second fingers may operate the third (rotation) actuator **130**. In this instance, the medical device **100** may be operable to provide control of the handle assembly **102** with a single hand, thereby facilitating control of a second device (e.g., an endoscope, medical instrument, etc.) with another hand during a medical procedure.

(26) Still referring to FIG. **1**, the articulation joint **140** of the medical device **100** may include a plurality of articulation links **142** and a clevis **144**. The plurality of articulation links **142** may be sequentially aligned with one another and at least partially define a longitudinal length of the articulation joint **140**. In the example, the plurality of articulation links **142** are movably coupled to one another such that each of the plurality of articulation links **142** are configured to move (e.g., bend, pivot, deflect) relative to one another. In an unactuated state, a longitudinal length of the articulation joint **140**, defined by the plurality of articulation links **142**, may be substantially parallel to a longitudinal axis of the shaft **108**. As described above, a distal end of the shaft **108** may be positioned adjacent to and/or secured at a proximal end of the articulation joint **140**, such as, for example, a first (i.e., proximalmost) articulation link **142** of the plurality of articulation links **142**.

(27) The clevis **144** may extend distally from and/or be coupled to a distal end of the articulation joint **140**, such as, for example, a last (i.e., distalmost) articulation link **142** of the plurality of articulation links **142**. The end effector **146** of the medical device **100** extends distally from a distal end of the clevis **144**. It should be appreciated that the end effector **146** of the medical device **100**

may include various suitable components, including, but not limited to, one or more clamps, shears, forceps, suturing devices, lighting devices, imaging systems, grasper assemblies, and various other suitable tools and/or devices. Accordingly, the end effector **146** shown and described herein is merely provided for exemplary purposes and may include various other configurations without departing from the scope of this disclosure. With the end effector **146** and the clevis **144** of the medical device **100** positioned relatively distal of the articulation joint **140**, it should be understood that movement of the plurality of articulation links **142** may provide movement of the end effector **140** and the clevis **144** relative to at least a distal end of the shaft **108**.

(28) Referring now to FIG. **2**, the handle assembly **102** of the medical device **100** further includes a slot **112** formed within a cavity of the handle assembly **102**. Further, the first (actuation) actuator **110** may include a slider **111** that is sized, shaped, and configured to be slidably received within the slot **112** of the handle assembly **102**. The slider **111** may be configured and operable to translate relative to the handle assembly **102** along the slot **112** in response to translation of at least the portion of the first (actuation) actuator **110**. As described in greater detail herein, the slider **111** of the first (actuation) actuator **110** may include a cavity disposed therein that is sized and shaped to receive one or more components of the medical device **100** therein, such as, for example, at least a portion of an actuation wire **116**. The handle assembly **102** of the medical device **100** further includes a rotation joint **132** disposed along at least a portion of the third (rotation) actuator **130**. Accordingly, the rotation joint **132** is configured and operable to rotate relative to the handle assembly **102** in response to rotation of the third (rotation) actuator **130** within the handle assembly **102**. As described in further detail herein, the rotation joint **132** is rotatably fixed relative to the third (rotation) actuator **130** and longitudinally translatable relative to the third (rotation) actuator **130**.

(29) Still referring to FIG. **2**, the third (rotation) actuator **130** may include a cavity that is sized and shaped in accordance with a configuration of the rotation joint **132** such that the rotation joint **132** may be received within the cavity of the third (rotation) actuator **130**. By way of illustrative example, the rotation joint **132** may include a rectangular (and/or cuboidal) shape and a cavity of the third (rotation) actuator **130** may be likewise rectangularly (and/or cuboidal) shaped, such that the corresponding configurations of the rotation joint **132** and the cavity of the third (rotation) actuator **130** may key and/or rotatably fix the rotation joint **132** to the third (rotation) actuator **130**, while permitting axial translation therebetween.

(30) In this instance, the rotation joint **132** may be configured to translate through, along, and/or relative to the cavity of the third (rotation) actuator **130** and be inhibited from rotating independent of the third (rotation) actuator **130**. For example, due to the interaction between the edges, points, and/or contacts planes of the rotation joint **132** with one or more surfaces of the cavity of the third (rotation) actuator **130**, rotation of third (rotation) actuator **130** may result in likewise rotation of the rotation joint **132**. Additionally, due to the corresponding configurations of the rotation joint **132** and the cavity of the third (rotation) actuator **130**, axial advancement of the rotation joint **132** (e.g., as caused by actuation of first (actuation) actuator **110**) will not result in likewise advancement of third (rotation) actuator **130**. As described in detail herein, the rotation joint **132** may be monolithically formed with, and/or fixedly coupled to (e.g., immovable relative to), one or more components of the medical device **100**, such as, for example, an actuation wire **116**.

(31) The medical device **100** may further include an actuation wire **116** and one or more drive wires **122** (e.g., top drive wire **122**T, bottom drive wire **122**B) disposed within the handle assembly **102**. In the example, the actuation wire **116** is secured and/or coupled to the slider **111** at a proximal end of the actuation wire **116**. For example, the actuation wire **116** includes a hub **114** at a proximal end of the actuation wire **116** that is sized and shaped in accordance with the cavity formed in the slider **111** of the first (actuation) actuator **110**, such that the hub **114** is received within the cavity of the slider **111**. It should be appreciated that the hub **114** may comprise an enlargement and/or protrusion positioned at a proximal end of the actuation wire **116**. In some examples, the hub **114** of

the actuation wire **116** may be monolithically formed with, and/or fixedly coupled to (e.g., immovable relative to), the actuation wire **116**. Additionally, the hub **114** may be sized and shaped to be movable (e.g., rotatable) relative to the cavity of the slider **111** in which the hub **114** is disposed.

(32) In other words, the slider **111** of the first (actuation) actuator **110** may include a cavity that is sized and shaped in accordance with a configuration of the hub **114** such that the hub **114** may be received within, and movable relative to, the cavity of the slider **111** of the first (actuation) actuator **110**. By way of illustrative example, the hub **114** may include a cylindrical shape and a cavity of the slider **111** may be cylindrically shaped such that movement (e.g., rotation) of the hub **114** relative to the cavity of the slider **111** is permitted.

(33) The actuation wire **116** has a longitudinal length that extends through the handle assembly **102** and the shaft **108**. In the example, the actuation wire **116** extends through at least a portion of the first (actuation) actuator **110** and the third (rotation) actuator **130**. For example, the hub **114** of the actuation wire **116** is received in the slider **111** of the first (actuation) actuator **110** and through the rotation joint **132**, which is disposed within the third (rotation) actuator **130**. In this instance, the hub **114** is configured and operable to move (e.g., translate) the actuation wire **116** relative to the handle assembly **102** in response to, for example, translation of the first (actuation) actuator **110** and the slider **111** within the slot **112**. Further, the rotation joint **132** is secured to and/or coupled with the actuation wire **116** such that the rotation joint **132** is configured and operable to move (e.g., rotate) the actuation wire **116** relative to the handle assembly **102** in response to, for example, rotation of the third (rotation) actuator **130** and the rotation joint **132**.

(34) Still referring to FIG. **2**, with the hub **114** of the actuation wire **116** secured to and/or coupled with the slider **111**, as described above, it should be understood that rotation of the rotation joint **132** may provide a simultaneous rotation of the hub **114** within the cavity of slider **111** of the first (actuation) actuator **110**. Further, with at least a portion of the actuation wire **116** extending through and/or fixedly coupled to the rotation joint **132**, as described above, it should be understood that translation of the slider **111**, and the hub **114** disposed therein, may provide a simultaneous translation of the rotation joint **132** relative to the third (rotation) actuator **130**. It should be appreciated that a longitudinal length of the rotation joint **132** is such that at least a portion of the rotation joint **132** may remain disposed within the third (rotation) actuator **130** during translation of the rotation joint **132** relative to the third (rotation) actuator **130**. In this instance, rotation of the third (rotation) actuator **130** may provide rotation of the rotation joint **132** and the actuation wire **116** despite an extent of translation of the slider **111** relative to the slot **112**.

(35) Although not shown, it should be understood that the actuation wire **116** may extend through the shaft **108** of the medical device **100** and a second, distal end of the actuation wire **116** may be secured and/or coupled to the end effector **146** of the medical device **100**. As described further herein, the actuation wire **116** is configured to actuate the end effector **146** of the medical device **100** in response to an actuation of the first (actuation) actuator **110**. Additionally, the actuation wire **116** is further configured to rotate the end effector **146** relative to the shaft **108** and/or the articulation joint **140** in response to rotation of the third (rotation) actuator **130** relative to the handle assembly **102**.

(36) Still referring to FIG. **2**, the handle assembly **102** includes a pair of drive wires **122** (e.g., top drive wire **122**T, bottom drive wire **122**B) secured and/or coupled to the second (articulation) actuator **120** within the handle assembly **102**. In the example, a first, proximal end of each of the drive wires **122**T, **122**B is secured to the second (articulation) actuator **120** at respective connection points **124**. The drive wires **122**T, **122**B have a longitudinal length that extend through the handle assembly **102**. Although not shown, it should be understood that the drive wires **122**T, **122**B may extend through the shaft **108** of the medical device **100** and a second, distal end of each of the drive wires **122**T, **122**B may be secured and/or coupled to the articulation joint **140** of the medical device **100**. For instance, a distal end of the drive wires **122**T, **122**B may be secured to a distalmost

articulation link **142** of the plurality of articulation links **142**, such as, for example, on opposing sides/portions of the distalmost articulation link **142**. As described further herein, the pair of drive wires **122**T, **122**B are configured to articulate the articulation joint **140** of the medical device **100**, such as the plurality of articulation links **142**, in response to actuation of the second (articulation) actuator **120**.

(37) Referring now to FIGS. **4**B and **5**B, in some embodiments, the end effector **146** of the medical device **100** includes a plurality of first links **143**, a plurality of second links **145**, a first jaw **147**, and a second jaw **148**. At least one of the plurality of first links **143** (i.e., a proximalmost first link **143**) is movably coupled to the clevis **144** and at least one of the plurality of second links **145** (i.e., a proximalmost second link **145**) is movably coupled to the clevis **144**. At least one of the plurality of first links **143** (i.e., a distalmost first link **143**) is movably coupled to a proximal end of the second jaw **148** and at least one of the plurality of second links **145** (i.e., a distalmost second link **145**) is movably coupled to a proximal end of the first jaw **147**. In other examples, the first links **143** and the second links **145** may be arranged such that at least one of the plurality of first links **143** (e.g., a distalmost first link **143**) is movably coupled to a proximal end of the first jaw **147**, and at least one of the plurality of second links **145** (e.g., a distalmost second link **145**) is movably coupled to a proximal end of the second jaw **148**.

(38) As best seen in FIG. **5**B, each of the plurality of first links **143** and each of the plurality of second links **145** may include a pivot joint **149** at opposing, terminal ends of the links **143**, **145**, respectively. Accordingly, each of the plurality of first links **143** may be movably (e.g., rotatably) coupled to one another at opposing ends of the first links **143** via respective pivot joints **149**. Each of the plurality of second links **145** may be movably (e.g., rotatably) coupled to one another at opposing ends of the second links **145** via respective pivot joints **149**. Further, the distalmost first link **143** is movably coupled to the second jaw **148** via the pivot point **149**, and the distalmost second link **145** is movably coupled to the first jaw **147** via the pivot point **149**.

(39) In the example, the end effector **146** includes a pair of first links **143** and a pair of second links **145**. Accordingly, the proximalmost first link **143** is movably coupled to the distalmost first link **143** by engaging the respective pivot joints **149** of each first link **143** to one another. The proximalmost second link **145** is movably coupled to the distalmost second link **145** by engaging the respective pivot joints **149** of each second link **145** to one another. It should be understood that the end effector **146** may include additional and/or fewer links **143**, **145** than those shown and described herein without departing from the scope of this disclosure. The proximalmost first link **143** and the proximalmost second link **145** are secured to and/or coupled with a distal end of the actuation wire **116** at the respective pivot joints **149** of each link **143**, **145**.

(40) It should be appreciated that the actuation wire **116** is coupled to the proximalmost links **143**, **145** within and/or through the clevis **144**. As described in greater detail below, movement of the actuation wire **116** (e.g., translation) relative to the handle assembly **102** and/or the shaft **108** may provide movement of the plurality of links **143**, **145** (including the proximalmost links **143**, **145**, the distalmost links **143**, **145**, and the like). With the plurality of links **143**, **145** coupled to the jaws **147**, **148** of the end effector **146**, movement of the actuation wire **116** may further provide movement of the pair of jaws **147**, **148** relative to the clevis **144** and/or to one another.

(41) According to an exemplary method of using the medical device **100**, the medical device **100** may be used to treat a target treatment site within a subject by positioning the end effector **146** adjacently thereto. The medical device **100** may be used for various suitable procedures, including, but not limited to, endoluminal surgical procedures such as endoscopic mucosal resection (EMR), endoscopic submucosal dissection (ESD), pre-oral endoscopic myotomy (POEM), and the like. It should be understood that the steps of the exemplary method described herein, and the sequence in which they are presented, are merely illustrative such that additional and/or fewer steps may be included without departing from the scope of this disclosure. It should further be appreciated that the exemplary method of utilizing the medical device **100** described and shown herein may be

employed for various other procedures and used with various medical systems, devices, instruments, and/or assemblies, such as, for example, an endoscope (e.g., duodenoscope).
(42) Referring back to FIGS. **1-2**, the medical device **100** may be actuated by moving (e.g., rotating) the third (rotation) actuator **130** to rotate the end effector **146** relative to the articulation joint **140**, the shaft **108**, and/or the handle assembly **102**. For example, the third (rotation) actuator **130** may be rotated in a clockwise and/or counter-clockwise direction relative to the central longitudinal axis **10** of the handle assembly **102**. In this instance, with the actuation wire **116** disposed within the handle assembly **102** and secured to and/or coupled with the third (rotation) actuator **130** via the rotation joint **132**, the actuation wire **116** is rotated when the third (rotation) actuator **130** rotates. Accordingly, rotation of the third (rotation) actuator **130** in a direction may provide a simultaneous rotation of the end effector **146** relative to and independent of the articulation joint **140**, the shaft **108**, and/or the handle assembly **102** as the end effector **146** is coupled to a distal end of the actuation wire **116**. In other instances, the shaft **108** and/or the articulation joint **140** may be rotated with the end effector **146** of the medical device **100** in response to a rotation of the handle assembly **102** by a user of the medical device **100**.
(43) Further, the medical device **100** may be actuated by moving (e.g., pivoting) the second (articulation) actuator **120** to articulate the articulation joint **140**. For example, the second (articulation) actuator **120** may be pivoted in a first (distal) direction A and/or a second (proximal) direction B relative to the handle assembly **102** of the medical device **100**. In this instance, with the pair of drive wires **122** disposed within the handle assembly **102** and secured to the second (articulation) actuator **120** at the connection points **124**, the drive wires **122** are actuated when the second (articulation) actuator **120** moves, thereby articulating the articulation joint **140**. For example, movement of the second (articulation) actuator **120** in the first (distal) direction A may provide a proximal retraction (e.g., pulling) of at least one of the drive wires **122**, and a simultaneous relaxation and/or distal extension of the other drive wire **122**.
(44) As described above, with each of the pair of drive wires **122**T, **122**B secured to opposing sides/portions of the distalmost articulation link **142** of the plurality of articulation links **142** (e.g., adjacent to the clevis **144**), the articulation joint **140** is operable to articulate (e.g., bend, pivot, deflect, etc.) in a direction of the drive wire **122**T, **122**B that is retracted (i.e., pulled) proximally. In this instance, upon the second (articulation) actuator **120** being pivoted in the first (distal) direction A, the drive wire **122**B positioned along a lower/bottom portion of the second (articulation) actuator **120** is tensioned and thereby pulled proximally relative to the opposing drive wire **122**T positioned along an upper/top portion of the second (articulation) actuator **120**. Accordingly, the top drive wire **122**T is relaxed and/or extended distally relative to the bottom drive wire **122**B.
(45) As seen in FIG. **3**A, the plurality of articulation links **142** of the articulation joint **140** is articulated in the direction A′ relative to the central longitudinal axis **10** of the handle assembly **102** and/or the shaft **108**. As a result of pivoting the second (articulation) actuator **120** in the first (distal) direction A, the end effector **146** is moved in accordance with an articulation of the articulation joint **140** in a downward direction relative to the central longitudinal axis **10** of the handle assembly **102** and/or the shaft **108**. Additionally and/or alternatively, the medical device **100** may be actuated by moving (e.g., pivoting) the second (articulation) actuator **120** in the second (proximal) direction B relative to the handle assembly **102** to articulate the articulation joint **140**. In this instance, the drive wires **122**T, **122**B are actuated such that at least one of the drive wires **122**T, **122**B is retracted (i.e., pulled) proximally while the other drive wire **122**T, **122**B is relaxed and/or extended distally. As described above, the articulation joint **140** is operable to articulate (e.g., bend, pivot, deflect, etc.) in a direction of the drive wire **122**T, **122**B that is retracted (pulled) proximally. In this instance, the drive wire **122**T, **122**B positioned relative to the handle assembly **102** along an upper/top portion of the second (articulation) actuator **120** (e.g., the top drive wire **122**T) is tensioned and thereby pulled proximally relative to the opposing drive wire **122**T, **122**B positioned along a lower/bottom portion of the second (articulation) actuator **120** (e.g., the bottom drive wire

122B).
(46) Accordingly, the bottom drive wire **122**B is relaxed and/or extended distally relative to the top drive wire **122**T. As seen in FIG. **3**B, the plurality of articulation links **142** of the articulation joint **140** is articulated in the direction B′ relative to the central longitudinal axis **10** of the handle assembly **102** and/or the shaft **108**. As a result of pivoting the second (articulation) actuator **120** in the second (proximal) direction B, the end effector **146** is moved in accordance with an articulation of the articulation joint **140** in an upward direction relative to the central longitudinal axis **10** of the handle assembly **102** and/or the shaft **108**. In other examples, the second (articulation) actuator **120** and/or the pair of drive wires **122**T, **122**B may be configured such that actuation of the second (articulation) actuator **120** may provide lateral (e.g., left/right) articulation (e.g., deflection) of the end effector **146** relative to the articulation joint **140** and/or the shaft **108** of the medical device **100**.
(47) Referring now to FIGS. **4**A-**4**B, the medical device **100** may be further actuated by actuating the first (actuation) actuator **110** to actuate the end effector **146**. For example, the first (actuation) actuator **110** may be moved (e.g., translated) in a first (proximal) direction C relative to the handle assembly **102**. In this instance, the slider **111** of the first (actuation) actuator **110** received within the slot **112** may be moved to a proximal, terminal end of the slot **112**. With the hub **114** of the actuation wire **116** secured to and/or coupled with the first (actuation) actuator **110** within the slider **111**, the actuation wire **116** may simultaneously translate with the first (actuation) actuator **110** in the first (proximal) direction C relative to the handle assembly **102**.
(48) In this instance, the actuation wire **116** moves proximally and pulls the plurality of first links **143** and the plurality of second links **145** in the first (proximal) direction C. In response, the plurality of links **143**, **145** may move (e.g., pivot) about the respective pivot points **149** and relative to one another to move the pair of jaws **147**, **148** relative to one another to a closed configuration. In other words, a proximal retraction of the actuation wire **116** moves the plurality of links **143**, **145** toward one another thereby closing the pair of jaws **147**, **148** relative to each other.
(49) Additionally and/or alternatively, referring now to FIGS. **5**A-**5**B, the medical device **100** may be actuated by moving the first (actuation) actuator **110** in a second (distal) direction D relative to the handle assembly **102**. In this instance, the slider **111** of the first (actuation) actuator **110** received within the slot **112** may be moved to a distal, terminal end of the slot **112**. With the hub **114** of the actuation wire **116** secured to and/or coupled with the first (actuation) actuator **110** at the slider **111**, the actuation wire **116** may simultaneously translate with the first (actuation) actuator **110** in the second (distal) direction D relative to the handle assembly **102**.
(50) In this instance, the actuation wire **116** may move distally and push the plurality of first links **143** and the plurality of second links **145** in the second (distal) direction D. In response, the plurality of links **143**, **145** may move (e.g., pivot) about the respective pivot points **149** and relative to one another to move the pair of jaws **147**, **148** outwardly relative to one another to an open configuration. In other words, a distal extension of the actuation wire **116** moves the plurality of links **143**, **145** away from one another thereby permitting the pair of jaws **147**, **148** to move outwardly (open) relative to each other.
(51) Referring now to FIG. **6**, another exemplary medical device **200** is schematically depicted in accordance with an example of this disclosure. Except as otherwise described below, the medical device **200** may be substantially similar to the medical device **100** described above, respectively, such that the same components are identified via the same reference numerals and/or similar components are identified via similar reference numerals plus the value of 100. Accordingly, it should be understood that the medical device **200** may be configured and operable like the medical device **100** except for the differences explicitly noted herein. For example, the medical device **200** may include the handle assembly **102**, the shaft **108** (see FIG. **1**), the articulation joint **140**, and/or the end effector **146** (see FIG. **1**).
(52) As described above, the medical devices shown and described herein may include additional

and/or fewer actuators positioned along various walls **101**, **103**, **105** (and/or surfaces) of the handle assembly **102**. Further, the actuators of this disclosure may have various sizes, shapes, and/or configurations. For example, the medical device **200** includes one or more actuators **210**, **220**, **230** disposed along one or more walls **101**, **103**, **105** of the handle assembly **102**, and that are configured to actuate one or more components of the medical device **200**, such as, for example, an articulation joint **140** and/or an end effector **146**. As described in detail above, the one or more actuators **210**, **220**, **230** may be disposed on the handle assembly **102** in an ergonomic manner to facilitate control of the medical device **200** with a single hand of a user.

(53) In the example, the medical device **200** includes a first (actuation) actuator **210** positioned along the top wall **101** of the handle assembly **102**, a second (articulation) actuator **220** positioned along at least a portion of the top wall **101** and at least one of the sidewalls **103** of the handle assembly **102**, and a third (rotation) actuator **230** positioned along at least one of the sidewalls **103** of the handle assembly **102**. In this instance, the second (articulation) actuator **220** and the third (rotation) actuator **230** may be positioned along the same sidewall **103** of the handle assembly **102**, however, it should be understood that in other examples the second (articulation) actuator **220** and the third (rotation) actuator **230** may be positioned along opposing sidewalls **103** of the handle assembly (see FIG. **7**).

(54) Still referring to FIG. **6**, the first (actuation) actuator **210** of the medical device **200** is configured to translate relative to the handle assembly **102**, such as, for example, in one or more directions (e.g., distally, proximally, etc.) parallel to the central longitudinal axis **10** of the handle assembly **102**. In the example, the first (actuation) actuator **210** is a button/actuator that is sized and shaped in the form of a slidable switch that extends outwardly from the top wall **101** of the handle assembly **102**. The second (articulation) actuator **220** of the medical device **200** is configured to translate, pivot, and/or rotate relative to the handle assembly **102**, such as, for example in one or more directions (e.g., distally, proximally, etc.) parallel to the central longitudinal axis **10** of the handle assembly **102**.

(55) For example, the second (articulation) actuator **220** may include a rocker **222** disposed along the sidewall **103** of the handle assembly **102** and a lever **224** disposed along the top wall **101** of the handle assembly **102**. In the example, the rocker **222** and the lever **224** of the second (articulation) actuator **220** are integrally formed such that the rocker **222** and the lever **224** form a unitary structure. Accordingly, the rocker **222** of the second (articulation) actuator **220** is configured to rotate along the sidewall **103** about an axis (not shown) that is transverse (e.g., perpendicular) to the central longitudinal axis **10** of the handle assembly **102**. Further, the lever **224** of the second (articulation) actuator **220** is configured to translate and/or pivot along the top wall **101** of the handle assembly **102**. In the example, rocker **222** of the second (articulation) actuator **220** extends laterally outward from an exterior surface of the sidewall **103** of the handle assembly **102** and the lever **224** extends laterally outward from an exterior surface of the top wall **101** of the handle assembly **102**.

(56) Still referring to FIG. **6**, the third (rotation) actuator **230** is configured to rotate (e.g., clockwise, counter-clockwise, etc.) along the sidewall **103** of the handle assembly **102** and about an axis (not shown) that is parallel to the central longitudinal axis **10** of the handle assembly **102**. In the example, the third (rotation) actuator **230** is a button/actuator that is sized and shaped in the form of a roller. Further, the third (rotation) actuator **230** extends at least partially outward along the top wall **101** and the bottom wall **105** of the handle assembly **102** such that the third (rotation) actuator **230** is at least partially accessible along the top wall **101**, the sidewall **103**, and the bottom wall **105** of the handle assembly **102**.

(57) It should be understood that the actuators **210**, **220**, **230** of the medical device **200** are configured and operable identical to the actuators **110**, **120**, **130** of the medical device **100** shown and described above, respectively. Accordingly, the actuators **210**, **220**, **230** of the medical device **200** may actuate the articulation joint **140** and/or the end effector **146** of the medical device **200** in

a substantially similar manner as the actuators **110**, **120**, **130** of the medical device **100** described in greater detail above. It should be appreciated that the medical device **200** may include additional and/or fewer actuators **210**, **220**, **230** on various other walls **101**, **103**, **105** (and/or surfaces) of the handle assembly **102** without departing from the scope of this disclosure. It should further be understood that, in other examples, the actuators **210**, **220**, **230** of the medical device **200** may have various other suitable configurations than those shown and described herein.

(58) Referring now to FIG. **7**, another exemplary medical device **300** is schematically depicted in accordance with an example of this disclosure. Except as otherwise described below, the medical device **300** may be substantially similar to the medical device **100**, **200** described above, respectively, such that the same components are identified via the same reference numerals and/or similar components are identified via similar reference numerals plus the value of 100. Accordingly, it should be understood that the medical device **300** may be configured and operable like the medical device **100**, **200** except for the differences explicitly noted herein. For example, the medical device **300** may include the handle assembly **102**, the shaft **108** (see FIG. **1**), the articulation joint **140** (see FIG. **1**), the end effector **146** (see FIG. **1**), and/or the second (articulation) actuator **220**.

(59) In the example, the medical device **300** includes a first (actuation) actuator **310** positioned along the top wall **101** of the handle assembly **102** and a third (rotation) actuator **330** positioned along at least one of the sidewalls **103** of the handle assembly **102**. In this instance, the second (articulation) actuator **220** and the third (rotation) actuator **330** may be positioned along opposing sidewalls **103** of the handle assembly **102**. The first (actuation) actuator **310** of the medical device **300** is configured to translate relative to the handle assembly **102**, such as, for example, in one or more directions (e.g., distally, proximally, etc.) parallel to the central longitudinal axis **10** of the handle assembly **102**. In the example, the first (actuation) actuator **310** is a button that is sized and shaped in the form of a slidable switch that is disposed within a recess **107** formed along the top wall **101** of the handle assembly **102**.

(60) Still referring to FIG. **7**, the third (rotation) actuator **330** is configured to rotate (e.g., clockwise, counter-clockwise, etc.) along the sidewall **103** of the handle assembly **102** and about an axis (not shown) that is transverse (e.g., perpendicular) to the central longitudinal axis **10** of the handle assembly **102**. In the example, the third (rotation) actuator **330** is a button/actuator that is sized and shaped in the form of a roller. Further, the third (rotation) actuator **330** extends at least partially outward along at least the top wall **101** of the handle assembly **102** such that the third (rotation) actuator **330** is at least partially accessible along the top wall **101** and the sidewall **103** of the handle assembly **102**.

(61) It should be understood that the first (actuation) actuator **310** and the third (rotation) actuator **330** of the medical device **300** are configured and operable identical to the first (actuation) actuators **110**, **210** and the third (rotation) actuators **130**, **230** of the medical devices **100**, **200** shown and described above, respectively. Accordingly, the actuators **310**, **330** of the medical device **300** may actuate the articulation joint **140** and/or the end effector **146** of the medical device **300** in a substantially similar manner as the first (actuation) actuators **110**, **210** and the third (rotation) actuators **130**, **230** of the medical devices **100**, **200** described in greater detail above. It should be appreciated that the medical device **300** may include additional and/or fewer actuators **310**, **220**, **330** on various other walls **101**, **103**, **105** (and/or surfaces) of the handle assembly **102** without departing from the scope of this disclosure. It should further be understood that, in other examples, the actuators **310**, **220**, **330** of the medical device **300** may have various other suitable configurations than those shown and described herein.

(62) Referring now to FIG. **8**, another exemplary medical device **400** is schematically depicted in accordance with an example of this disclosure. Except as otherwise described below, the medical device **400** may be substantially similar to the medical device **100**, **200**, **300** described above, respectively, such that the same components are identified via the same reference numerals and/or

similar components are identified via similar reference numerals plus the value of 100. Accordingly, it should be understood that the medical device **400** may be configured and operable like the medical device **100**, **200**, **300** except for the differences explicitly noted herein. For example, the medical device **400** may include the handle assembly **102** and the articulation joint **140**.

(63) The handle assembly **102** of the medical device **400** includes the first (actuation) actuator **110**, the second (articulation) actuator **120**, and a third (guidewire) actuator **430**. The third (guidewire) actuator **430** is positioned along at least one of the sidewalls **103** of the handle assembly **102**. The third (guidewire) actuator **430** includes one or more rollers **432** configured to rotate about an axis that is transverse to the central longitudinal axis **10** of the handle assembly **102** (see FIG. **1**). As described further herein, the third (guidewire) actuator **430** is configured and operable to actuate one or more components of the medical device **400**, such as, for example, a guidewire **436**. In the example, the handle assembly **102** further includes an irrigation port **109** disposed along the top wall **101** that is in fluid communication with one or more lumens of the handle assembly **102** and/or one or more other components of the medical device **400** (e.g., a working channel of a shaft **408**).

(64) Still referring to FIG. **8**, the medical device **400** may include a coiled shaft **408** extending distally from the distal end **104** of the handle assembly **102**, with the articulation joint **140** positioned at a distal end of the coiled shaft **408**. Further, the medical device **400** may include an end effector **446** positioned at a distal end of the articulation joint **140**. The end effector **446** of the medical device **400** may extends distally from the distalmost articulation link **142** of the articulation joint **140**. Further, the end effector **446** may include an extension line **447**, a tubular member **448**, and a distal opening **449**. In the example, the extension line **447** and the tubular member **448** may include a nonlinear (e.g., curved) configuration such that the distal opening **449** of the end effector **446** is positioned at least partially transverse to a proximal end of the end effector **446**.

(65) The tubular member **448** of the end effector **446** may include one or more inner lumens that are aligned with and/or in communication with one or more working channels of the coiled shaft **408** (see FIG. **9**). Further, the distal opening **449** at a distal end of the tubular member **448** may be further aligned with and/or in communication with the one or more working channels of the coiled shaft **408** via the one or more inner lumens of the tubular member **448**. The tubular member **448** is configured and operable to position one or more medical devices and/or instruments received through the handle assembly **102** and/or coiled shaft **408** proximate to a target treatment site. The extension line **447** of the end effector **446** is secured to, and between, a proximal end of the tubular member **448** and a distal end of the tubular member **448**, adjacent to the distal opening **449**.

(66) Still referring to FIG. **8**, the extension line **447** is configured to tension a distal end of the tubular member **448** toward the proximal end of the tubular member **448** to form the nonlinear configuration of the tubular member **448**. In other words, the extension line **447** is operable to apply a force on a distal end of the tubular member **448** to thereby form a bend and/or angle along a longitudinal length of the tubular member **448** between the opposing terminal ends of the tubular member **448**. In this instance, the distal opening **449** at a distal end of the tubular member **448** is positioned and/or aligned relatively transverse to the central longitudinal axis **10** of the handle assembly **102** (see FIG. **1**), rather than collinear with and/or parallel to the central longitudinal axis **10**. It should be appreciated that with the tubular member **448** of the end effector **446** including the nonlinear and/or curved configuration, the medical device **400** may facilitate positioning one or more medical instruments and/or devices (e.g., devices/guidewire **436** received through the coiled shaft **408**) at a target treatment site.

(67) Referring now to FIG. **9**, the coiled shaft **408** may include one or more lumens extending therethrough, such as, for example, one or more working channels that are sized and shaped to receive one or more medical instruments and/or devices therethrough. By way of example only, the

coiled shaft **408** of the medical device **400** may include a working channel **409** configured to receive a guidewire (e.g., guidewire **436**), a working channel **410** configured to receive an imaging device (e.g., camera), a pair of working channels **412** configured to receive the pair of drive wires **122**B, **122**T, and/or a working channel **413** configured to receive a cautery wire. It should be understood that the number and arrangement of working channels **409**, **410**, **412**, **413** shown and described herein are merely illustrative such that the coiled shaft **408** may include additional, fewer, and/or various other lumens/working channels configurations.

(68) The coiled shaft **408** of the medical device **400** may further include an exterior surface having a protective plastic sheath **414** disposed thereon. In the example, the one or more working channels **409**, **410**, **412**, **413** of the coiled shaft **408** are insulated by the protective plastic sheath **414** included along the exterior of the coiled shaft **408**. In some examples, the coiled shaft **408** may be a coil disposed over the working channels **409**, **410**, **412**, **413**. For example, the coiled shaft **408** may be a coil having a pair of layers (e.g., a dual-layer coil), with a first layer extending about the working channels **409**, **410**, **412**, **413** in a first direction (e.g., clockwise) and a second layer extending about the working channels **409**, **410**, **412**, **413** in a second direction (e.g., counter-clockwise).

(69) Referring now to FIG. **10**, a partial schematic of the handle assembly **102** of the medical device **400** is depicted. In the example, the third (guidewire) actuator **430** may include a pair of rollers **432** disposed within the handle assembly **102**, with at least one of the pair of rollers **432** being accessible to a user of the medical device **400** (e.g. extending through a surface of the handle assembly **102**). The pair of rollers **432** of the third (guidewire) actuator **430** are configured to rotate about an axis that is at least partially transverse (e.g., perpendicular) to the central longitudinal axis **10** of the handle assembly **102** (see FIG. **1**). The handle assembly **102** of the medical device **400** may further include an opening **434** along the third (guidewire) actuator **430** that is sized, shaped and configured to receive a guidewire **436** therethrough.

(70) The opening **434** of the handle assembly **102** is positioned in alignment with a region between the pair of rollers **432** of the third (guidewire) actuator **430**. In this instance, the guidewire **436** inserted through the opening **434** is received between the pair of rollers **432**. Accordingly, it should be appreciated that actuation (e.g., rotation) of the third (guidewire) actuator **430** in a first direction (e.g., clockwise, counter-clockwise, etc.) may provide for a relative movement of the guidewire **436** in the handle assembly **102** and/or the coiled shaft **408** in a first direction, and actuation of the third (guidewire) actuator **430** in a second direction may provide for another relative movement of the guidewire **436** in the handle assembly **102** and/or the coiled shaft **408**.

(71) Still referring to FIG. **10**, in the example, the pair of rollers **432** of the third (guidewire) actuator **430** may each include one or more ridges and/or cavities (formed between an adjacent pair of ridges) extending along a longitudinal length of the roller **432**. The one or more ridges and/or cavities of the pair of rollers **432** may be configured and operable to engage the guidewire **436** to facilitate movement of the guidewire **436** relative to the handle assembly **102**. Although not shown, it should be understood that a proximal end of the guidewire **436** may be positioned proximate to the opening **434** of the handle assembly **102** and a distal end of the guidewire **436** may extend through the working lumen **409** of the coiled shaft **408** and distally from the distal opening **449** of the end effector **436**.

(72) Each of the aforementioned devices, assemblies, and methods may be used to facilitate access to a target treatment site and provide enhanced control of ancillary tools/devices for use at the target treatment site. By providing a medical device with a handle assembly capable of controlling and moving a plurality of tools/devices (end effector) coupled to the medical device, a user may interact with a target treatment site using the various tools/devices of the medical instrument during a procedure via an intuitive interface of the handle assembly. In this instance, a user may reduce overall procedure time, increase efficiency of procedures, and/or avoid unnecessary harm to a subject's body caused by limited control of the ancillary tools/devices. Additionally, a user may

control and move the plurality of tools/devices (end effector) of the medical device with a single hand, and about a plurality of degrees of freedom, pursuant to the intuitive interface of the handle assembly.

(73) It will be apparent to those skilled in the art that various modifications and variations may be made in the disclosed devices and methods without departing from the scope of the disclosure. Other aspects of the disclosure will be apparent to those skilled in the art from consideration of the specification and practice of the features disclosed herein. It is intended that the specification and examples be considered as exemplary only.

Claims

1. A medical device, comprising: a handle assembly including a plurality of actuators, wherein at least a distal portion of the handle assembly defines a longitudinal axis of the medical device, wherein a first actuator of the plurality of actuators is configured to translate proximally and distally relative to the handle assembly along a second axis parallel to the longitudinal axis, wherein the first actuator is positioned along a top wall of the handle assembly; wherein a second actuator of the plurality of actuators is configured to pivot about a third axis perpendicular to the longitudinal axis, wherein a first portion of the second actuator is positioned along the top wall and a second portion of the second actuator is positioned along a sidewall of the handle assembly; and wherein a third actuator of the plurality of actuators is configured to rotate relative to the handle assembly and about the longitudinal axis or a fourth axis parallel to the longitudinal axis, wherein the third actuator is positioned along the sidewall of the handle assembly.

2. The medical device of claim 1, wherein the first actuator includes a slider slideably received within a slot of the handle assembly, wherein the first actuator includes a cavity configured to receive a proximal end of an actuation wire, and wherein the cavity is disposed on the slider.

3. The medical device of claim 2, wherein each of a first drive wire and a second drive wire are fixed to the second actuator.

4. The medical device of claim 2, wherein the actuation wire is configured to actuate an end effector.

5. The medical device of claim 1, wherein the first actuator is a slidable switch, the second actuator is a rocker, and the third actuator is a roller.

6. The medical device of claim 1, wherein the first actuator is adjacent to the first portion of the third actuator, and wherein the second actuator is distal to the first actuator and the third actuator.

7. The medical device of claim 1, wherein the third actuator extends at least partially outward along the top wall and a bottom wall of the handle assembly.

8. The medical device of claim 1, wherein the first portion of the second actuator includes a lever and the second portion of the second actuator includes a rocker.

9. A medical device comprising: a shaft defining a longitudinal axis, wherein a distal portion of the shaft includes an articulation portion; and a handle fixed to a proximal end of the shaft, the handle having: a first actuator that is movable in a first direction relative to the handle; a second actuator that is movable in a second direction relative to the handle; and a third actuator that is movable in a third direction relative to the handle; wherein the first direction is parallel to the longitudinal axis of the shaft, and the third direction is about the longitudinal axis of the shaft or parallel to the longitudinal axis of the shaft, wherein a first drive wire configured to articulate the articulation portion in the first direction extends along the third actuator on a first side of the third actuator, wherein a second drive wire configured to articulate the articulation portion in the second direction extends through the shaft and around the third actuator on a second side of the third actuator, and wherein the second side of the third actuator is opposite the first side of the third actuator; and wherein a proximal end of the first drive wire is secured to the second actuator at a first connection point on a first side of the second actuator, wherein a proximal end of the second drive wire is

secured to the second actuator at a second connection point on a second side of the second actuator, wherein, in an unactuated state of the handle, the first drive wire extends between the second actuator and the third actuator without crossing the second drive wire that extends between the second actuator and the third actuator.
10. The medical device of claim 9, wherein the first actuator includes a slider slideably disposed between the second actuator and the third actuator.
11. The medical device of claim 10, wherein the slider includes a channel, and wherein the first drive wire extends through the channel.
12. The medical device of claim 10, wherein a proximal end of an actuation wire is fixed within a cavity of the slider, wherein the actuation wire is configured to actuate an end effector fixed to a distal end of the shaft.
13. The medical device of claim 12, wherein the actuation wire extends through the third actuator.
14. The medical device of claim 9, wherein the first actuator is a trigger, the second actuator is a rocker, and the third actuator is a roller.
15. The medical device of claim 9, wherein the third actuator includes a rotation joint, wherein the rotation joint is rotatably fixed relative to the third actuator and longitudinally translatable relative to the third actuator.
16. The medical device of claim 9, wherein the third actuator extends at least partially outward relative to a top wall of the handle.
17. A medical device comprising: a handle having: a first actuator that is movable in a first direction relative to the handle, wherein the first actuator comprises a slider, wherein the first actuator is positioned along a top wall of the handle; a second actuator that is movable in a second direction relative to the handle, wherein the second actuator includes a rocker and a lever, wherein the rocker and the lever are integrally formed, wherein the rocker is positioned along a first sidewall of the handle, and wherein the lever extends over the top wall of the handle; and a third actuator that is movable in a third direction relative to the handle, wherein the third actuator is positioned along a second sidewall of the handle, opposite the first sidewall of the handle; wherein the slider of the first actuator is disposed between the second actuator and the third actuator.
18. The medical device of claim 17, wherein the slider is slideably disposed within a slot of the handle.
19. The medical device of claim 17, wherein the third actuator is a roller and is configured to rotate an end effector of the medical device.
20. The medical device of claim 17, wherein an axis of rotation of the second actuator is parallel to an axis of rotation of the third actuator.