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SHEATHES FOR SURGICAL INSTRUMENTS, AND RELATED DEVICES AND METHODS

Abstract

A method of assembling a protective sheath to a surgical instrument comprises advancing the protective sheath over a distal working end of a surgical instrument shaft to a relatively proximally disposed sheath connector portion of the surgical instrument; moving a retention mechanism of the sheath into alignment with the sheath connector portion; and moving a moveable locking feature from a first configuration permitting the retention mechanism to be moved relative to the sheath connector portion to a second configuration in which complementary engagement features on the retention mechanism and the sheath connector portion are lockably engaged to retain the sheath in position on the instrument.

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Background/Summary

[0001] This application is a continuation of U.S. application Ser. No. 17/471,307, filed Sep. 10, 2021, which is a divisional application of application U.S. application Ser. No. 16/068,375, filed Jul. 6, 2018 (Now U.S. Pat. No. 11,129,687), which is a U.S. national phase of International Patent Application No. PCT/US2016/067705, filed Dec. 20, 2016, which designated the United States and claimed right of priority to U.S. provisional application No. 62/276,471, filed Jan. 8, 2016 (now expired), each of which are incorporated herein by reference in their entirety.

TECHNICAL FIELD

[0002] Aspects of the present disclosure relate to protective sheaths for use with surgical instruments, and related devices and methods.

INTRODUCTION

[0003] Remotely controlled surgical instruments, which can include teleoperated surgical instruments (e.g., surgical instruments operated at least in part with computer assistance, such as instruments operated with robotic technology) as well as manually operated (e.g., laparoscopic, thorascopic) surgical instruments, are often used in minimally invasive medical procedures. During such procedures, a surgical instrument, which may extend through a cannula inserted into a patient's body, can be remotely manipulated to perform a procedure at a surgical site. For example, in a teleoperated surgical system (e.g., robotic surgical system), cannulas and surgical instruments can be mounted at manipulator arms of a patient side cart and may be remotely manipulated via teleoperation at a surgeon console.

[0004] The instruments employed during such procedures may be complex mechanical devices having many separate components (e.g., cables and mechanical members, such as joint and link structures. Accordingly, to reduce cost, it is desirable for the instruments to be reusable. However, reuse of a surgical instrument generally requires stringent cleaning and sterilization procedures that are made more difficult by the large number of small components and tight intervening spaces within such instruments.

[0005] To facilitate cleaning procedures for minimally invasive surgical instruments and/or reduce the cost per use of such instruments, sheaths have been used to cover the instrument shaft during use. It is desirable, however, to facilitate the installation and removal of sheaths on an instrument by surgical personnel. Further, it is desirable to provide sheaths that are relatively inexpensive to make, while providing robust attachment to the instruments to prevent accidental removal and/or repositioning relative to the instrument during use.

SUMMARY

[0006] Exemplary embodiments of the present disclosure may solve one or more problems and/or may demonstrate one or more desirable features, which will become apparent from the description that follows.

[0007] In accordance with various exemplary embodiments, a sheath for a surgical instrument may include a sleeve having a distal end and proximal end, and a retention mechanism at a proximal end portion of the sleeve. The retention mechanism may comprise a sleeve attachment portion configured to be attached to the sleeve at the proximal end portion, and a locking collar extending from the sleeve attachment portion, wherein the locking collar is configured to receive a connector portion of a surgical instrument. The locking collar further may include a locking feature movable between a first configuration, in which the sheath is moveable relative to the surgical instrument, and a second configuration, in which the locking feature is configured to engage with the connector portion to retain the sheath in position on the surgical instrument.

[0008] In accordance with further exemplary embodiments, a surgical instrument sheath assembly may include a surgical instrument comprising a shaft and a sheath connector portion, the shaft having a distal end configured to be introduced to a remote surgical site; a sheath sleeve configured to at least partially cover a shaft of a surgical instrument; and a sheath sleeve retention mechanism disposed at a proximal end portion of the sheath sleeve. At least one of the sheath sleeve retention mechanism and the sheath connector portion can include a movable locking feature, the movable locking feature having a first configuration allowing the sheath to be moved relative to the instrument and a second configuration engageably locking the sheath to the connector portion to retain the sheath sleeve in position to at least partially cover the instrument shaft.

[0009] In yet other exemplary embodiments, a method of assembling a protective sheath to a surgical instrument may include advancing the protective sheath over a distal working end of a surgical instrument shaft to a relatively proximally disposed sheath connector portion of the surgical instrument; moving a retention mechanism of the sheath into alignment with the sheath connector portion; and moving a moveable locking feature from a first configuration permitting the retention mechanism to be moved relative to the sheath connector portion to a second configuration in which complementary engagement features on the retention mechanism and the sheath connector portion are lockably engaged to retain the sheath in position on the instrument.

[0010] In further exemplary embodiments, a method of removing a protective sheath from a shaft of a surgical instrument may include applying a laterally inwardly directed force to a proximal end portion of retention mechanism to deform the proximal end portion from a first configuration to a second configuration, wherein in the first configuration, the retention mechanism is engaged with a connector portion of the instrument to retain a position of the sheath on the instrument, and in the second configuration retention mechanism is disengaged from the connector portion and the sheath is movable relative to the instrument. The method may further include moving the retention mechanism distally away from the connector portion to remove the sheath while the retention mechanism is in the second configuration.

[0011] Additional objects, features, and/or advantages will be set forth in part in the description which follows, and in part will be obvious from the description, or may be learned by practice of the present disclosure and/or claims. At least some of these objects and advantages may be realized and attained by the elements and combinations particularly pointed out in the appended claims.

[0012] Both the foregoing general description and the following detailed description are exemplary and explanatory only and are not restrictive of the claims; rather the claims should be entitled to their full breadth of scope, including equivalents.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] The present disclosure can be understood from the following detailed description, either alone or together with the accompanying drawings. The drawings are included to provide a further understanding of the present disclosure, and are incorporated in and constitute a part of this specification. The drawings illustrate one or more exemplary embodiments of the present teachings

and together with the description serve to explain certain principles and operation.
[0014] FIG. **1** is a perspective view of a patient side cart of a teleoperated surgical system, according to an exemplary embodiment.
[0015] FIG. **2** is a perspective, diagrammatic view of a surgical instrument for use with the teleoperated surgical system of FIG. **1**, according to an exemplary embodiment.
[0016] FIG. **3** is a perspective, diagrammatic view of a surgical instrument sheath according to an exemplary embodiment.
[0017] FIG. **4**A is a perspective view of a sheath retainer body and a sheath connector portion of a surgical instrument in an unassembled configuration, according to an exemplary embodiment.
[0018] FIG. **4**B is a perspective view of the sheath retainer body and sheath connector portion of FIG. **4**A in an assembled configuration.
[0019] FIG. **5** is a perspective view of a sheath retainer body and a sheath connector portion of a surgical instrument according to another exemplary embodiment.
[0020] FIG. **6** is a perspective view of a sheath retainer body and a sheath connector portion of a surgical instrument according to yet another exemplary embodiment.
[0021] FIG. **7**A is a top and side perspective view of a sheath retainer body according to another exemplary embodiment.
[0022] FIG. **7**B is a bottom and side perspective view of a sheath retainer body according to the embodiment of FIG. **7**A.
[0023] FIG. **7**C is a detailed, partial perspective view of a surgical instrument according to another exemplary embodiment.
[0024] FIG. **7**D is a perspective view of the sheath retainer body of FIGS. **7**A and **7**B in an assembled configuration on the surgical instrument of FIG. **7**C.
[0025] FIG. **8**A is a perspective view a sheath and sheath retainer body in an unassembled configuration according to another exemplary embodiment.
[0026] FIG. **8**B is a perspective view of the sheath and retainer body according to the embodiment of FIG. **8**A in a partially assembled configuration.
[0027] FIG. **8**C is a perspective view of the sheath and retainer body of FIGS. **8**A and **8**B in a fully assembled configuration.
[0028] FIG. **9**A is a perspective view of a sheath on an instrument shaft according to yet another exemplary embodiment.
[0029] FIG. **9**B is a cross-sectional view of the sheath of FIG. **9**A and a sheath connection device of a surgical instrument according to an exemplary embodiment.
[0030] FIG. **9**C is a cross-sectional view of the sheath and sheath connection device according to the embodiment of FIGS. **9**A and **9**B.
[0031] FIG. **9**D is a cross-sectional view of the sheath and sheath connection device according to the embodiment of FIGS. **9**A through **9**C.
[0032] FIG. **10**A is a perspective view of a sheath and an instrument according to another exemplary embodiment.
[0033] FIG. **10**B is a perspective view of the sheath and instrument of FIG. **10**A in an assembled configuration.
DETAILED DESCRIPTION
[0034] This description and the accompanying drawings that illustrate exemplary embodiments should not be taken as limiting. Various mechanical, compositional, structural, electrical, and operational changes may be made without departing from the scope of this description and the claims, including equivalents. In some instances, well-known structures and techniques have not been shown or described in detail so as not to obscure the disclosure. Like numbers in two or more figures represent the same or similar elements. Furthermore, elements and their associated features that are described in detail with reference to one embodiment may, whenever practical, be included in other embodiments in which they are not specifically shown or described. For example, if an

element is described in detail with reference to one embodiment and is not described with reference to a second embodiment, the element may nevertheless be claimed as included in the second embodiment.

[0035] For the purposes of this specification and appended claims, unless otherwise indicated, all numbers expressing quantities, percentages, or proportions, and other numerical values used in the specification and claims, are to be understood as being modified in all instances by the term “about,” to the extent they are not already so modified. Accordingly, unless indicated to the contrary, the numerical parameters set forth in the following specification and attached claims are approximations that may vary depending upon the desired properties sought to be obtained. At the very least, and not as an attempt to limit the application of the doctrine of equivalents to the scope of the claims, each numerical parameter should at least be construed in light of the number of reported significant digits and by applying ordinary rounding techniques.

[0036] It is noted that, as used in this specification and the appended claims, the singular forms “a,” “an,” and “the,” and any singular use of any word, include plural referents unless expressly and unequivocally limited to one referent. As used herein, the term “include” and its grammatical variants are intended to be non-limiting, such that recitation of items in a list is not to the exclusion of other like items that can be substituted or added to the listed items.

[0037] Further, this description's terminology is not intended to limit the disclosure or claims. For example, spatially relative term-such as “top”, “bottom”, “lower”, “above”, “below”, “upper”, “proximal”, “distal”, and the like-may be used to describe one element's or feature's relationship to another element or feature as illustrated in the orientation of the figures. These spatially relative terms are intended to encompass different positions (i.e., locations) and orientations (i.e., rotational placements) of a device in use or operation in addition to the position and orientation shown in the figures. For example, if a device in the figures is inverted, elements described as “below” or “beneath” other elements or features would then be “above” or “over” the other elements or features. Thus, the exemplary term “below” can encompass both positions and orientations of above and below. A device may be otherwise oriented (rotated 90 degrees or at other orientations) and the spatially relative descriptors used herein interpreted accordingly. The relative proximal and distal directions of surgical instruments are labeled in the figures.

[0038] The present disclosure contemplates various surgical device sheaths, components of such sheaths, and methods of manufacturing such sheaths and associated components, systems, and methods of use. In accordance with an exemplary embodiment of the present disclosure, an instrument for minimally invasive surgical procedures employs a removable (e.g., replaceable) sheath to cover a shaft, wrist mechanism, and/or other joints and portions of the surgical instrument. The sheath may include a retention mechanism configured to engage with a corresponding (e.g., complementary) sheath connector portion (also “sheath connection portion”) of a surgical instrument. Through the engagement, the retention mechanism may be configured to lock the sheath to the instrument to retain the sheath in position over at least a portion of a main shaft of the surgical instrument and/or at least a portion of a wrist mechanism of the surgical instrument during use of the instrument to perform a surgical procedure. The retention mechanism may be configured to facilitate manual placement and removal by an operator, such as a physician, nurse, and other operating room or hospital personnel. For example, in some exemplary embodiments, the retention mechanism may be configured to enable the sheath to be removed and installed with one hand.

[0039] In various exemplary embodiments, retention mechanisms may be configured to lockably engage with a connector portion of the instrument to prevent axial movement of the sheath relative to the instrument such that the sheath is prevented from being removed from the instrument in the absence of a force on the retention mechanism sufficient to unlock the sheath from engagement with the connector portion. Further, in various exemplary embodiments, retention mechanisms of the present disclosure may include anti-rotational features configured to prevent rotation of the sheath with respect to the surgical instrument when the sheath is in an assembled configuration (lockably engaged) on the surgical instrument. Such features may allow assembly of the sheath on the surgical instrument in any rotational orientation, or in a limited number of rotational orientations, the latter of which thus also allows the features to serve as rotational alignment mechanisms. In some embodiments, the corresponding sheath connector structure of the surgical instrument may not include any moving parts on the surgical instrument. Such an arrangement may enhance the reliability and robustness of the surgical instrument, and facilitate a user in assembly of the sheath and instrument. For example, for a surgical instrument that is designed to be reusable, exemplary embodiments provide sheath retention and connection designs that minimize the risk of parts of the instrument that relate to connection of the sheath failing and thus negatively impacting the ability to reuse the instrument.

[0040] The present disclosure also contemplates exemplary embodiments that use materials for the sheath, including the retention mechanism, that are relatively inexpensive and permit manufacturing via extrusion and/or molding, in addition to relatively inexpensive techniques to join the sheath sleeve body to the retention mechanism.

[0041] Although various exemplary embodiments described herein are discussed with regard to surgical instruments used with a patient side cart of a teleoperated surgical system, the present disclosure is not limited to use with surgical instruments for a teleoperated surgical system. For example, various exemplary embodiments of sheaths for assembly with surgical instruments described herein can be used in conjunction with hand-held, manual surgical instruments.

[0042] Referring now to FIG. **1**, an exemplary embodiment of a patient side cart **100** of a teleoperated surgical system is shown. A teleoperated surgical system may further include a surgeon console (not shown) for receiving input from a user to control instruments mounted at patient side cart **100**. A teleoperated surgical system also can optionally include an auxiliary control/vision cart (not shown), as described in, for example, U.S. Pub. No. US 2013/0325033 A1, entitled “Multi-Port Surgical Robotic System Architecture” and published on Dec. 5, 2013, U.S. Pub. No. US 2013/0325031 A1, entitled “Redundant Axis and Degree of Freedom for Hardware-Constrained Remote Center Robotic Manipulator” and published on Dec. 5, 2013, and U.S. Pat. No. 8,852,208, entitled “Surgical System Instrument Mounting” and published on Oct. 7, 2014, each of which is hereby incorporated by reference in its entirety. Further, the exemplary embodiments described herein may be used, for example, with a da Vinci® Surgical System, such as the da Vinci Si® Surgical System or the da Vinci Xi® Surgical System, both with or without Single-Site® single orifice surgery technology, all commercialized by Intuitive Surgical, Inc. However, those having ordinary skill in the art would appreciate that other surgical systems are contemplated as being used in conjunction with the sheaths and surgical instruments of the present disclosure, including for example, controllers and processors in other components of a surgical system, such as for example the patient side cart and/or surgeon console, rather than as part of a separate auxiliary/control cart; control and processing architecture can also be distributed between various components of the surgical system as those having ordinary skill in the art would appreciate.

[0043] According to an exemplary embodiment, patient side cart **100** includes a base **102**, a main column **104**, and a main boom **106** connected to the main column **104**. The patient side cart **100** also includes a plurality of teleoperated manipulator arms **110**, **111**, **112**, **113** (sometimes referred to as patient side manipulators), which are each connected to the main boom **106**, as depicted in the exemplary embodiment of FIG. **1**. Manipulator arms **110**, **111**, **112**, **113** may each include an instrument mount portion **120** to which an instrument **130** may be mounted, which is illustrated as being attached to manipulator arm **110**. Portions of the manipulator arms **110**, **111**, **112**, **113** may be manipulated during a surgical procedure according to commands provided by a user at the surgeon console. In an exemplary embodiment, signal(s) or input(s) transmitted from a surgeon console are transmitted to the control/vision cart, which interprets the input(s) and generate command(s) or output(s) to be transmitted to the patient side cart **100** to cause manipulation of an instrument **130** (only one such instrument being mounted in FIG. **1**) and/or portions of manipulator arm **110** to which the instrument **130** is coupled at the patient side cart **100**.

[0044] Instrument mount portion **120** may comprise an actuation interface assembly **122** and a cannula mount **124**. A shaft **132** of instrument **130** extends through cannula mount **124** and mounted cannula, and on to a remote site during a surgical procedure. A force transmission mechanism **134** at a proximal end of instrument **130** is mechanically coupled with the actuation interface assembly **122**, according to an exemplary embodiment. Persons skilled in the art are familiar with surgical instrument force transmission mechanisms, which receive a mechanical input force from a source (e.g., an electric motor on a manipulator arm supporting the instrument) and convert and/or redirect the received force to an output force to drive a component (e.g., a wrist, an end effector, etc.) at a relatively distal end portion of the instrument. Cannula mount **124** may be configured to hold a cannula **136** through which shaft **132** of instrument **130** may extend to a surgery site during a surgical procedure. Actuation interface assembly **122** may contain a variety of drive and other mechanisms that are controlled to respond to input commands at the surgeon console and transmit forces to the force transmission mechanism **134** to actuate instrument **130**, as those skilled in the art are familiar with.

[0045] Although the exemplary embodiment of FIG. **1** shows an instrument **130** attached to only manipulator arm **110** for ease of illustration, an instrument may be attached to any and each of manipulator arms **110**, **111**, **112**, **113**. An instrument **130** may be a surgical instrument with an end effector such as forceps or graspers, a needle driver, a scalpel, scissors, a stapler, a cauterizing tool, etc., or may be an endoscopic imaging instrument or other sensing instrument used during a surgical procedure to provide information, (e.g., visualization, electrophysiological activity, pressure, fluid flow, and/or other sensed data) of a remote surgical site. In the exemplary embodiment of FIG. **1**, a surgical instrument with an end effector or a sensing instrument may be attached to and used with any of manipulator arms **110**, **111**, **112**, **113**. However, the embodiments described herein are not limited to the exemplary embodiment of the patient side cart of FIG. **1** and various other teleoperated surgical system configurations, including patient side cart configurations, may be used with the exemplary embodiments described herein.

[0046] FIG. **2** shows an exemplary embodiment of a surgical instrument **230** in more detail. The surgical instrument **230** includes a shaft **233**, a force transmission housing **234** disposed at a proximal end of the shaft **233**, and an end effector **240** disposed at a distal end of the shaft **233**. The exemplary embodiment of FIG. **2** further illustrates an embodiment of a surgical instrument having a wrist mechanism **231** and an end effector **240**, which are the components of the instrument **230** that generally move extensively during a medical procedure. In the illustrated embodiment, the wrist mechanism **231** includes a joint **232** that connects an extended member **235** to the shaft **233**, and extended member **235** connects to a multi-member wrist **236** on which effector **240** is mounted. Joint **232** can have two angular degrees of freedom for movement of member **235**, which, as a result of the extended length of member **235**, provides a significant range of spatial motion for the wrist **236** and the end effector **240**. Wrist **236** includes multiple vertebrae that may be independently controlled to provide one or more degrees of freedom for moving and orienting end effector **240** during a medical procedure. The specifics of wrist mechanism **231** are provided here merely as an illustration of one type of wrist mechanism. Many other types of wrist mechanisms are known and could be used with removable sheaths as described herein. For example, U.S. Pat. No. 6,817,974, entitled “Surgical tool having Positively Positionable Tendon-Actuated Multi-Disk Wrist Joint,” to Cooper et al. describes some known wrist mechanisms containing multiple disks and tendon controlled joints. In addition, those of ordinary skill in the art would appreciate that a surgical instrument can lack any wrist mechanism, with an end effector being couple directly to the shaft.

[0047] FIG. **2** also illustrates that shaft **233** may optionally include cleaning holes **222**, which facilitate cleaning of the interior of the instrument **230** between medical procedures. In some cases, such cleaning holes have the drawback of creating flow paths for biological material or gas flow from a region of elevated pressure that may be maintained in a patient during a medical procedure. However, in accordance with exemplary embodiments of the disclosure, a replaceable sheath can be installed on instrument **230** and seal cleaning holes **222** to help prevent penetration of biological material or gas into the holes and to maintain a pressure differential during a medical procedure. Further, the sheath can be removed between medical procedures to permit access to cleaning holes **222** and other portions of the instrument when the instrument **230** is cleaned. Cleaning passages (not shown) also can be in wrist mechanism **231**, for example as holes, in extended member **234** and/or via interstitial openings created by space between adjacent wrist structures and/or where an end effector is coupled to the shaft. The sheath can also seal wrist mechanism **231** but in case of contamination, can be removed to permit cleaning of an instrument protected by the sheath. On a camera instrument, which may be relatively large or have lower mechanical load requirements, the cleaning holes can be made large to enable easy cleaning, while the sheath reduces the amount of access that biomaterial has to the camera system during use. In some situations, instruments such as camera systems that are not generally in direct contact with biomaterial may not require a full seal.

[0048] Referring now to FIG. **3**, an exemplary embodiment of a protective sheath configured to cover at least a portion of the shaft of a surgical instrument, such as instrument **130** (FIG. **1**) or instrument **230** (FIG. **2**), is illustrated. As a non-limiting example, the sheath **300** of FIG. **3** may be similar in function, materials, and/or construction to the sheaths described at least in U.S. Pat. No. 9,089,351 to Park et al., issued Jul. 28, 2015, entitled “Sheath for Surgical Instrument,” the disclosure of which is hereby incorporated by reference in its entirety. The sheath **300** has a proximal end **302**, which in various exemplary embodiments may be disposed proximate a transmission housing when the protective sheath **300** is assembled on a surgical instrument, and a distal end **304**, which may be disposed proximate the end effector and/or wrist mechanism of a surgical instrument when the protective sheath **300** is assembled on the instrument **130**. Thus, in an exemplary embodiment, the sheath may extend to cover substantially the entire length of an instrument shaft from a proximal end transmission housing of the surgical instrument to an end effector or a sensing element, such as an imaging capture device, allowing enough exposure of the end effector or instrument such that it is able to perform its intended function.

[0049] Although the sheaths of various disclosed exemplary embodiment are configured to lockably engage with a sheath connector portion of a surgical instrument that is disposed where the instrument shaft meets the transmission housing, those having ordinary skill in the art will appreciate that connector portions can be provided at other locations along the surgical instrument, including at locations along the shaft distal to the transmission housing with appropriate modification.

[0050] The protective sheath **300** includes a retention mechanism **306** located at or near the proximal end **302**. The retention mechanism **306** is configured to interact with (e.g., engage) one or more corresponding (e.g., complementary) features (not shown in FIG. **3**) disposed on a portion of a surgical instrument to lockably engage and retain the sheath **300** in an assembled configuration on the instrument. While the retention mechanism **306** is illustrated in FIG. **3** as attached to a sleeve **308** of the sheath **300**, the retention mechanism **306** may be or include one or more features formed in the sleeve **308** of the sheath **300**, for example, as described in greater detail below in connection with the exemplary embodiment of FIGS. **10**A and **10**B.

[0051] The sheath sleeve in accordance with various exemplary embodiments herein may be made of various relatively flexible and biocompatible materials that are selected to impart various properties as desired, including, dielectric materials, porous materials that allow gases to permeate the sheath sleeve wall while preventing passage of biomaterials and liquid, relatively durable to protect against damage due to other surgical instruments and structures rubbing against the sheath, etc. While the sheath sleeve can be made of a single material, the present disclosure also contemplates sheath sleeves made of different materials, such as differing layers of materials and/or materials having differing properties along different length portions of the sleeve. In exemplary embodiments, the various sheath tube/body structures and materials used to make such structures disclosed U.S. Pat. No. 9,089,351 B2, issued Jul. 28, 2015 (entitled “SHEATH FOR SURGICAL INSTRUMENT”), incorporated by reference herein, can be used to make the sheath sleeves of the present disclosure.

[0052] In some exemplary embodiments, such as those shown and described in connection with FIGS. **4**A through **9**D, a sheath retention mechanism includes one or more resilient portions configured to provide a lockable engagement with a complementary feature of the surgical instrument. The resilient portions may comprise resilient deflection portions configured to deflect as they move past the complementary feature of the instrument as the sheath is fitted over the instrument, and to engage the complementary feature of the surgical instrument once the sheath **300** is assembled with the instrument.

[0053] Application of sufficient force to one or more force application surfaces of the retention mechanism causes the resilient portions to deflect so as to disengage the retention mechanism from the complementary feature of the instrument, thereby enabling removal of the sheath from the instrument.

[0054] FIG. **4**A shows an exemplary embodiment of a sheath **400** including a retention mechanism **402** configured to interact with a sheath connector portion **413** of a surgical instrument **1030**, which may have a configuration similar to surgical instrument **230** in FIG. **2**, with the connector portion being provided at the juncture between the instrument shaft and a transmission housing (e.g., housing **234** in FIG. **2**) in an exemplary embodiment. In the embodiment of FIG. **4**A, the retention mechanism **402** comprises a generally tubular-shaped retainer body **403** affixed to a proximal end portion of a sheath sleeve **405**. The retainer body **403** has a sheath sleeve attachment portion **406** disposed at a distal end portion of the body **403**. The sheath sleeve attachment portion **406** is configured to be affixed to the sleeve **405** of the sheath **400**, as will be described in further detail below. Extending proximally from the sheath sleeve attachment portion **406** is a locking collar **404** that defines a proximal end **408** of the retainer body **403**. The locking collar **404** comprises one or more resilient members **410**. The resilient members **410** may be integrally formed (e.g., molded) with the retainer body **403**, as shown in FIG. **4**A, or may comprise components of the retention mechanism **402** formed separately from the retainer body **403**.

[0055] The resilient members **410** are configured to lockably engage one or more complementary retention features **412** of the sheath connector portion **413** of the instrument **1030** when the sheath **400** is in an assembled configuration on the instrument. In the depicted exemplary embodiment, the complementary retention feature **412** of the sheath connector portion **413** includes a circumferentially disposed protrusion with a ramped portion **414**, which may have a generally frustoconical surface profile with an acute angle relative to a longitudinal axis of the instrument shaft **1032**. More specifically, the ramped portion **414** extends upwardly and outwardly in a direction from distal to proximal along an axial direction of the surgical instrument. In this way, as the surfaces of the resilient members **410** come into contact with the beginning of the ramped portion **414** they are gradually spread apart by the ramped portion **414** as a continued force is exerted on the retainer body **403** sliding it over the connector portion **413**. Eventually, the resilient members **410** move proximally past the complementary retention feature **412** and spring back to their initial, undeformed configuration. A retaining surface **416** of the retention feature **412**, is disposed substantially orthogonal to the longitudinal axis of the shaft **1032** and provides a shoulder that prevents axial downward movement of the sheath in an assembled configuration of the sheath on the instrument by interaction with the resilient members **410**. In other words, in their undeformed configuration, the resilient members come into contact with the shoulder provided by the surface **416** to prevent the axial movement in a distal direction of the retention mechanism **402**, and thus the sheath.

[0056] Those having ordinary skill in the art would appreciate that the retention feature **412** may be a continuous feature around the circumference of the connector portion **413**, or may be plural features disposed in select locations around the circumference, which may assist in orienting the sheath in a desired rotational positioning relative to the instrument.

[0057] The sheath **400** may be placed in the assembled configuration on the instrument **1030** by advancing the locking collar **404** of the retainer body **403** over the sheath connector portion **413** of the instrument **1030**. As the locking collar **404** is moved axially into engagement with the sheath connector portion **413** of the surgical instrument (i.e., moving the locking collar **404** in a proximal direction), the ramped portion **414** of the retention feature **412** come into contact with resilient members **410**. Continued movement of the locking collar **404** proximally cause the resilient members **410** to be deflected laterally (e.g., radially) outwardly by the ramped portion **414**. The deflection of the resilient members **410** radially outwardly allows the complementary retention feature **412** to pass between and move axially past the resilient members **410**.

[0058] As shown in FIG. 4B, once the resilient members **410** have cleared the ramped portion **414** of the complementary retention feature **412**, the resilient members **410** return to their initial, undeflected configuration and are positioned proximal to the retaining surface **416** of the complementary retention feature **412**. Relatively rapid movement of the resilient members **410** as they return to their undeflected configuration and contact a portion of the sheath connector portion **413** of the instrument **1030** may create an audible or tactile indication that the sheath **400** has fully engaged the sheath connector portion **413** of the instrument **1030**. For example, such an indication may include one or more of an audible noise (e.g., a “click”), a low-frequency vibratory wave traveling through the retention feature **412** that results in a tactile sensation in an operator, or the like. Due to the shoulder of the retaining surface **416**, a mechanical interference between the retaining surface **416** (FIG. 4A) of the complementary retention feature **412** and the one or more resilient members **410** retains (locks) the sheath **400** in position over the shaft **1032** of the instrument **1030**, preventing axial movement and disassembly of the retaining mechanism **402** relative to the surgical instrument absent a sufficient force acting on the instrument or sheath retention mechanism **402**.

[0059] Following use of the instrument **1030** and sheath **400**, (e.g., in a surgical procedure), it may be necessary or desirable to remove the sheath **400** to clean (e.g., sterilize) the instrument **1030**, for example reprocessing it for reuse. Referring still to FIG. 4B, to remove the sheath **400** from the instrument **1030**, a force **418** directed radially inwardly (e.g., a squeezing force) may be applied to the proximal end **408** of the retainer body **403**, for example, at locations on the proximal end **408** substantially ninety degrees apart from the resilient members **410**. For example, the retainer body **403** may be grasped (e.g., pinched) by an operator at force application surfaces **420**, **422**. Radially inwardly directed force applied to the force application surfaces **420**, **422** may cause portions of the proximal end **408** of the retainer body **403** located at and around the force application surfaces **420**, **422** to deflect inward toward the sheath connector portion **413** of the instrument **130**, while the resilient members **410** deflect away from sheath connector portion **413**. In other words, the lateral (e.g., radial) distance the resilient members **410** may increase as the compressive force **418** is applied to the force application surfaces **420**, **422**. The outward deflection of the resilient members **410** laterally (e.g., radially) beyond retention feature **412** allows the resilient members **410** to clear the complementary retention feature **412**, enabling the locking collar **404** to be disengaged (unlocked) from the connector portion **413** and the sheath **400** removed from the instrument **1030** by moving the retention mechanism **402** and sheath sleeve distally relative to the instrument **1030**.

[0060] In some exemplary embodiments, the resilient members **410** and/or other portions of the retainer body **403** elastically deform under the force **418**. Additionally or alternatively, the resilient members **410** and/or the other portions of the retainer body **403** may plastically deform under the force **418**. In some embodiments, the sheath **400** may be disposed of after a single use.

[0061] The retainer body **403** of the sheath **400** may be made from a resilient material to facilitate deflection of the resilient members **410** and the force application surfaces **420**, **422**. As non-limiting examples, the retainer body **403** is made from a thermoplastic such as nylon, polyether block amide (PEBAX), high-density polyethylene (HDPE), or other polymers. In some embodiments, the retainer body **403** is made of a composite material, such as a fiber-reinforced polymer, and/or may include non-polymer materials. The retainer body **403** may be made using forming processes such as injection molding, casting, negative manufacturing processes such as machining, and/or additive manufacturing processes such as fused deposition modeling, powder bed sintering, etc. In some embodiments, the retainer body **403** and the sheath sleeve **405** are made of the same or similar materials so as to facilitate attachment of the retainer body **403** to the sheath sleeve **405**. In one exemplary embodiment, the retainer body **403** and the sheath sleeve **405** both comprise polyether block amide. However, the retainer body **403** and other portions or components of the sheath **400** may include any materials that exhibit suitable characteristics. For example, in some embodiments, a material may be chosen at least in part based on stiffness, elastic modulus, or other mechanical characteristics that may be desired. As a non-limiting example, some suitable materials may exhibit an elastic modulus ranging from about 500 MPa to about 5000 MPa. Other suitable materials may include elastic moduli of less than about 500 MPa or greater than about 5000 MPa, for example, while wall thicknesses are adjusted to compensate. In some embodiments, a material also may be chosen based on manufacturing characteristics, such as moldability, machinability, etc. Materials also may be chosen based at least in part on the cost of raw materials, the costs associated with manufacturing processes suitable in working with such materials, etc. In some embodiments, a relatively low-cost material may be desirable, e.g., for a sheath limited to a single use (i.e., disposable). Other material selection criteria may include, without limitation, the ability of the material to withstand various sterilization processes without significant degradation (e.g., gamma sterilization, ethylene oxide sterilization, autoclave, e-beam sterilization, etc.); and the biocompatibility of the material, such as, for example, being latex free.

[0062] The retainer body **403** and the sheath sleeve **405** may be attached to one another by any suitable method. As a non-limiting example, the retainer body **403** and the sheath sleeve **405** may be fused to one another by a welding process such as ultrasonic welding, laser welding, spin fusing, etc. In some exemplary embodiments, an adhesive may be used to affix the retainer body **403** to the sheath sleeve **405**. In one exemplary embodiment, the retainer body **403** is affixed to the sheath sleeve **405** using one or more spot welds. In some embodiments, the sheath sleeve **405** may be attached to the retainer body **403** with a mechanical attachment device, as described in greater detail below in connection with FIGS. **8**A through **8**C.

[0063] The retainer body **403** may have a geometry configured to facilitate deformation of the resilient members **410** for installation and removal of the sheath **400**. For example, in the embodiment of FIGS. **4**A and **4**B, the retainer body **403** may have a cross-sectional shape that gradually transitions from a circular interior transverse cross-section along the sheath sleeve attachment portion **406** to an elongated (e.g., oval or elliptical) interior transverse cross-section at the proximal end **408** and locking collar **404**. In an initial, undeformed state, the force application surfaces **420**, **422** may be oriented at opposite ends of a major axis A.sub.ma of the oval, while portions of the resilient members **410** are positioned at opposite ends of a minor axis A.sub.mi of the oval. When force is applied to the force application surfaces **420**, **422**, the major axis A.sub.ma shortens while the minor axis A.sub.mi lengthens, and the elongated cross-sectional shape of the proximal end **408** and locking collar, at least around the resilient members **410**, deforms. In some embodiments, under deformation due to a force applied to the force application surfaces **420**, **422**, the major and minor axis A.sub.ma, A.sub.mi may become substantially equal and the cross-sectional shape of the retainer body **403** at the proximal end **408**, including at least the resilient members **410** and proximate the force application surfaces **420**, **422**, becomes substantially circular. Elongation of the minor axis A.sub.mi by a sufficient amount results in the resilient members **410** deflecting radially outwardly by an amount sufficient to permit disengaging (unlocking) from the complementary retention feature **412** of the instrument **1030**.

[0064] The retainer body **403** may be configured such that the compressive force **418** required to be applied to the force application surfaces **420**, **422** to deform the resilient members **410** sufficiently to remove the sheath **400** is below a certain threshold. For example, the retainer body **403** may be configured such that the force **418** required to be applied to the force application surfaces **420**, **422** to remove the sheath **400** is low enough that an operator (e.g., physician, nurse, etc.) can remove the sheath **400** by applying force **418** manually, for example, with one hand. As a non-limiting example, the compressive force **418** required to be applied to the force application surfaces **420**, **422** may range from about 2 pound-force (lb.sub.f) to about 10 pound-force (lb.sub.f), for example about 4 pound-force (lb.sub.f). However, the applied force required may be higher, for example, if tools designed to apply the force are used instead of the force being applied by a user's hand.

[0065] The magnitude of the compressive force **418** required to be applied to the force application surfaces **420**, **422** may depend at least partially on the properties of the materials from which the retainer body **403** is constructed. For example, a material with a relatively higher modulus of elasticity may require a correspondingly higher force compared to a material with a relatively lower modulus of elasticity. Additionally, the geometry of the retainer body **403** may affect the magnitude of the force **418** required to remove the sheath **400** from the instrument **1030**. For example, relatively thicker walls of retainer body **403** and relatively thicker resilient members **410** may require a relatively greater force to remove the sheath **400** than relatively thinner components.

[0066] The force application surfaces **420**, **422** may include features configured to facilitate manipulation by the operator. For example, the force application surfaces **420**, **422** may include features such as ridges **424**, knurling, or other textures or features, to improve grip and/or to enable tactile recognition of force application surfaces **420**, **422**.

[0067] Additionally, the retainer body **403** may include reliefs configured to alter the magnitude of the compressive force **418** that results in deflecting the resilient members **410** to remove the sheath **400**. The reliefs may increase flexibility (e.g., elastic deformability) of the locking collar **404** so as to concentrate stress in the resilient members **410**, resulting in greater deflection of the resilient members **410** for a given applied force. Furthermore, the reliefs may relieve areas of the locking collar **404** that may otherwise experience relatively high stress, which may cause plastic deformation, fractures, etc. in the locking collar **404**. While the reliefs **426** shown in FIGS. **4**A and **4**B are configured as an “I” shape cut-out portion, configurations different from that shown are contemplated. Aside from providing a cut-out portion of the wall of the locking collar, reliefs may be provided by other weakening of the retainer body wall, such as by using a different and/or thinner material at certain locations around the circumference of the body **403**. Additionally, some embodiments may not include any reliefs. Such embodiments may include one or more radially inwardly extending protrusions or shoulders located at the proximal end **408** of the retainer body **403** configured to interact with the complementary retention feature **412** in substantially the same manner as the resilient members **410** described above. For example, the retainer body **403** may include an undercut on an internal surface, a portion of which forms a distal-facing surface that interacts with a proximally-facing surface of the complementary retention feature **412**.

[0068] Various exemplary embodiments also contemplate preventing rotation of a sheath relative to the instrument once the sheath is in an assembled configuration on the instrument. For example, rotation of the sheath with respect to the instrument shaft during use or transportation may cause the sheath **400** to rip, tear, or otherwise degrade. However, for ease and speed of installation, it may be undesirable to require the operator to align the sheath in a particular rotational alignment with respect to the instrument.

[0069] Accordingly, FIG. **5** shows another embodiment of a retention mechanism **500** according to an exemplary embodiment of the present disclosure. Functionality of the retention mechanism **500** may be similar in many respects to the functionality of the retention mechanism **402** described in connection with FIGS. **4**A and **4**B. For clarity, shaft **1032** (FIG. **4**A) of instrument **1030** (FIG. **4**A) is omitted from the illustration in FIG. **5**. The sheath retention mechanism **500** has an internal surface **502** of a distal portion of the locking collar **504** that includes a plurality of longitudinally oriented and circumferentially spaced internal splines **505**. A sheath connector portion **513** of an instrument (not shown) may have an outer surface **508** with a plurality of longitudinally oriented and circumferentially spaced recesses **510** configured to interface with the internal splines **505**. When the sheath retention mechanism **500** is engaged with the sheath connector portion **513** of the instrument, the internal splines **505** are received in the recesses **510** to align and prevent rotation of the sheath retention mechanism **500** relative to the sheath connector portion **513**, and thus prevent rotation of the sheath relative to the instrument in the assembled, locked configuration of the retention mechanism **500** on the connector portion **513**.

[0070] In some embodiments, the internal splines **505** and the recesses **510** may include features and/or geometry configured to facilitate self-aligning of the sheath retention mechanism **500** with the sheath connector portion **506**. For example, the internal splines **505** and/or the edges of the connector portion between recesses **510** can have a rounded leading ends **512**. As the sheath retention mechanism **500** is slid into engagement with the sheath connector portion **513**, the rounded leading ends **512** facilitate self-aligning of the internal splines **505** and the recesses **510**. Thus, the sheath retention mechanism **500** is configured to self-align with the sheath connector portion **513** with minimal or no external rotational forces by a user. The number of rotational orientations at which the sheath retention mechanism **500** can be installed on the sheath connector portion **513** of the instrument **1030** may be determined at least in part by the number and/or configuration of the internal splines **505** and the recesses **510**. For example, the pitch of the internal splines **505** and the recesses **510** may determine the number of rotational orientations in which the sheath retention mechanism **500** can be installed on the sheath connector portion, a greater pitch resulting in more possible installed rotational orientations, and a lesser pitch resulting in fewer possible installed rotational orientations.

[0071] Additionally, in some embodiments, the sheath retention mechanism **500** and the sheath connector portion **513** may include features configured to require alignment of the sheath retention mechanism **500** with the sheath connector portion **513** in one or more predetermined rotational orientations. For example, one or more of the internal splines and a corresponding one or more of the recesses may have a different size, shape, and/or configuration than the remaining internal splines and recesses, such that the one or more internal splines and the corresponding one or more recesses having the different size, shape, and/or configuration must be rotationally aligned with one another before the sheath retention mechanism **500** can be fully installed on the sheath connector portion **513**.

[0072] For example, as shown in FIG. **6**, a sheath retention mechanism **5000** includes a plurality of internal splines **5050**, and a sheath connector portion **5130** includes a plurality of recesses **5100**. At least one recess **5102** of the plurality of recesses **5100** has a different dimension (e.g., a different circumferential width W around the sheath connector portion **5130**) than other recesses of the plurality of recesses **5100**, and a corresponding at least one spline (not shown) of the plurality of internal splines **5050** has a circumferential width corresponding to the circumferential width w of the at least one recess **5102**. Thus, the at least one recess **5102** must be aligned with the corresponding at least one spline (not shown) before the sheath retention mechanism **5000** can be fully installed on the sheath connector portion **5130**. While the embodiment of FIG. **6** shows the at least one recess **5102** having a greater width w than other recesses of the plurality of recesses **5100**, additional or other dimensions or features of the at least one recess **5102** may be altered with respect to the other recesses of the plurality of recesses **5100**. For example, one or more of a length, a depth (e.g., radial dimension) or a shape of the at least one recess **5102** and the corresponding at least one spline may be altered with respect to the other recesses of the plurality of recesses **5100** and splines of the plurality of internal splines **5050**.

[0073] Some embodiments may include multiple splines and corresponding recesses having different dimensions than the other splines and recesses, which may be spaced around the circumference of the sheath retention mechanism **5000** and the sheath connector portion **5130** to provide multiple possible installation orientations. For example, two splines and corresponding recesses having a different dimension than the other splines and recesses may be spaced 180 degrees apart around the circumference of the sheath retention mechanism **5000** and the sheath connector portion **5130** to provide two possible installation orientations, 180 degrees apart. Three splines and corresponding recesses having a different dimension than the other splines and recesses may be spaced 120 degrees apart to provide three installation orientations 120 degrees apart, four splines and corresponding recesses having a different dimension than the other splines and recesses may be spaced 90 degrees apart to provide four installation orientations 90 degrees apart, etc. Constraining the rotational orientation of the sheath retention mechanism **5000** with respect to the sheath connector portion **5130** may enable design and/or material properties of the sheath to be tailored for a particular movement or range of movements of an instrument shaft and/or end effector of a surgical instrument to which the sheath is attached. Those having ordinary skill in the art would appreciate that various other configurations, arrangements, and numbers of splines and recesses may be used to achieve a desired engagement and/or rotational alignment.

[0074] FIGS. **7**A and **7**B show yet another exemplary embodiment of a sheath retention mechanism according to the present disclosure. The sheath retention mechanism **600** may be configured similarly to the exemplary embodiment of FIGS. **4-5**, with differences being described below. In this embodiment, the sheath retention mechanism **600** includes a sheath sleeve attachment portion **606** with a substantially elongated (e.g., oval or elliptical) interior transverse cross-sectional shape, as shown in FIG. **7**A, so as to be configured to receive a similarly shaped sheath sleeve of elongated cross-section (e.g., oval or elliptical) (not shown)) configured to cover an instrument shaft having an elongated (e.g., oval or elliptical) outer transverse cross-sectional shape, such as instrument shaft **632** partially depicted in FIG. **7**C. The cross-sectional shape of the sheath retention mechanism **600** may gradually transition from the oval shape of sheath sleeve attachment portion **603** to a substantially circular interior transverse cross-sectional shape at the locking collar **604** including the proximal end, as shown in FIG. **7**A. As in the embodiments of FIGS. **4** and **5**, oppositely disposed resilient members **610** and oppositely disposed force application surfaces **620**, **622** are provided at the proximal end of the locking collar **604**, with the resilient members **610** being offset ninety degrees from the respective force application surfaces **620**, **622**.

[0075] With reference now to FIG. **7**C, the sheath retention mechanism **600** and associated sheath sleeve (not shown) may be installed on an instrument with a sheath connector portion **613** and instrument shaft **632**. The sheath connector portion **613** may have a shape corresponding to the shape of the cross-section and opening of the sheath sleeve attachment portion **606** of the sheath retention mechanism **600**, such as, for example, oval or elliptical. The sheath connector portion **613** may include a complementary retention feature such as plurality of protrusions **614**. For example, as shown in FIG. **7**C, the sheath connector portion **613** may include two protrusions **614** located at opposite ends of a major axis of the oval shape of the connector portion **613**. The sheath may be installed on the instrument by guiding the sheath retention mechanism **600** and sleeve over the distal end of the instrument (not shown) and advancing the sheath retention mechanism **600** and sheath sleeve along the instrument shaft **632** and over the sheath connector portion **613**. As the locking collar **604** of the sheath retention mechanism **600** contacts the elliptical (or oval-shaped) sheath connector portion **612**, the gradual transition between the circular cross section of the opening of the locking collar **604** and the oval cross section of sheath sleeve attachment portion **606** orients the retention mechanism **600** into alignment with the elliptical (or oval-shaped) sheath connector portion **612** and shaft **632** of the surgical instrument in one of two orientations (e.g., such that the major axes of the sheath attachment portion **606** is aligned with the major axis of the sheath connector portion **613** and shaft **632** in a first orientation, or in a second orientation rotated 180 degrees from the first orientation).

[0076] In a manner similar to the exemplary embodiments of FIGS. **3-5** discussed above, with the continued advancement of the sheath proximally relative to the instrument, the resilient members **610** of the sheath retention mechanism **600** deflect laterally (e.g., radially) outward as they come into contact the distally positioned ramped surface of the protrusions **614** of the sheath connector portion **612**, allowing them to provide sufficient clearance to move proximally past the protrusions **614**. Due to their resiliency, once they are past the protrusions **614**, the resilient members **610** return to their initial position (i.e., return to an undeformed configuration), as shown in FIG. **7**D. In the assembled configuration of the retention mechanism **600** over the sheath connector portion **613** shown in FIG. **7**D, the interference between the protrusion **614** and the resilient members **610** prevent the retention mechanism **600** and sheath from moving axially relative to the instrument and thus locks the sheath in position on the instrument shaft **632**. The protrusions **614** can have a surface similar to that described above with respect to the retention features of the exemplary embodiments of FIGS. **3-5** to provide an interference of the resilient members **610** and the protrusions **614**, thereby preventing the retention mechanism **600** and sheath sleeve attached thereto from being removed axially relative to the instrument.
[0077] To remove the sheath retention mechanism **600** and sheath from the instrument, a laterally (e.g., radially) inwardly directed force **618** is applied to the force application surfaces **620**, **622**, causing the locking collar **604**, at least at the proximal end portion including the resilient members **610** of the sheath retention mechanism **600**, to deform from its circular cross-sectional shape into an elongated (e.g., oval or elliptical) cross-sectional shape, thereby increasing the distance between the resilient members **610**. Under sufficient applied force **618**, the distance between the resilient members **610** increases so as to disengage (unlock) from the protrusions **614**, and provide sufficient clearance to move the retention mechanism **600** distally past the protrusions **614**. The sheath retention mechanism **600** can then be disengaged from the sheath connector portion **613** and the sheath removed from the instrument.
[0078] In yet another exemplary embodiment, a sheath retention mechanism may be configured to provide a mechanical attachment to the sheath sleeve, as opposed to a thermal fusing or adhesive bond. In some instances, the sleeve of a sheath may be difficult or impossible to fuse or bond to the retention mechanism of the sheath, due to material properties of the sheath sleeve, the retention mechanism, or both. For example, in some embodiments, the sheath sleeve may be made of a material, such as polytetrafluoroethylene (PTFE), which may not readily weld or otherwise bond to other materials from which the retention mechanism is likely to be made. Accordingly, the sheath sleeve of the sheath and the retention mechanism may be attached together using mechanical attachment components, as described below.
[0079] With reference now to the exemplary embodiment of FIG. **8**A, a sheath **700** includes a sheath sleeve **702** and a retention mechanism that has an outer retention mechanism part **703** and an inner retention mechanism part **707**. The outer retention mechanism part **703** can be configured similar to the retention mechanism embodiments of FIGS. **3-6**, with the exception of including an engagement feature for attachment to the inner retention mechanism part **707**, as described below. For example, the outer retention mechanism part **703** is configured to receive a proximal portion of a sheath sleeve **702**, and has a sheath sleeve attachment portion **706** and a locking collar **704** that extends from the sheath sleeve attachment portion **706**. The inner retention mechanism part **707** is configured to be inserted within the proximal end portion **708** of the sheath sleeve **702**, as shown in FIGS. **8**B and **8**C. The outer retention mechanism part **703** and the inner retention mechanism part **707** include interlocking features configured to mechanically couple the inner retention mechanism part **707** to the outer retention mechanism part **703**, capturing the proximal end portion **708** of the sheath sleeve **702** therebetween. For example, the inner retention mechanism part **707** may include deflectable retaining tabs **709** configured to engage with the distal end **712** of the sheath sleeve attachment portion **706** of the outer retention mechanism part **703**.
[0080] Referring now to FIG. **8**C, the outer retention mechanism part **703** can be positioned over

the proximal end portion **708** of the sheath sleeve **702** and over the inner retention mechanism part **707** positioned within the proximal end portion **708** of the sleeve **702** (FIG. **8**B). As can be seen in FIG. **8**A, the proximal end portion **708** includes longitudinally oriented cutout portions **711** in a side wall of the sleeve, positioned and configured to receive the deflection tabs **710** of the inner retention mechanism part **707**. In the exemplary embodiment of FIGS. **8**A-**8**C, there are two deflectable retaining tabs **709** disposed opposite each other around the inner retention mechanism part **707** and two cutout portions **711** disposed opposite each other around the proximal end portion **708** of the sleeve **702**. However, those of ordinary skill in the art would appreciate that the present disclosure is not limited to the use of two deflectable retaining tabs and any number including one or more than two could be used.

[0081] The retaining tabs **709** on the inner retention mechanism part **707** deflect inwardly as the sleeve attachment portion **706** of the outer retention mechanism part **703** is brought over the proximal end portion **708** of the sleeve **702** and into engagement with radially outwardly extending protrusions **7091** on the end of the tabs **709**. When the outer retention mechanism part **703** reaches its final position, shown in FIG. **8**C, the distal end **712** of the sleeve attachment portion **706** comes to rest just above the end of the cutout portions **711**, allowing radially outwardly extending protrusions **7091** to be released from contact with the inner surface of the sleeve attachment portion **706**, thereby returning the deflectable retaining tabs **709** to their initial configuration with protrusions **7091** extending through the cutout portions **711** and providing a surface to prevent distal axial movement of the outer retention mechanism part **703** (see FIG. **8**C). Mechanical interaction (e.g., a clamping force) acting on the sheath sleeve **702** by the inner retention mechanism part **707** and the outer retention mechanism part **703** thus secures the sleeve **702** to the retention mechanism.

[0082] Another exemplary embodiment of a sheath and instrument sheath connector portion is shown in FIGS. **9**A through **9**D. As shown in FIG. **9**A, the sheath **900** has a proximal end portion **902** with a retention mechanism **903** secured thereto. The retention mechanism includes a sheath sleeve attachment portion **906** and a locking collar **904** having longitudinally extending reliefs **907**, such as cut-outs or regions of weakened or thinner material extending generally axially so as to separate the locking collar **904** into deflectable segments **910**. At the free end of the locking collar, the deflectable segments **910** terminate in an annular, outwardly extending protrusions (which can be in the shape of barbs) **912** with a ramped leading end, the surface of which tapers inwardly in a proximal to distal direction of the sheath.

[0083] Referring now to FIG. **9**B, the sheath **900** may be placed in an assembled configuration with a sheath connector portion **914** of an instrument. The sheath connector portion **914** includes an inner collar **916** and an outer collar **918** biased to a distal position (e.g., the position shown in FIG. **9**B) by a biasing element (e.g., a coil spring) **921**. Spherical biased retainer members **920** (e.g., ball bearings) are trapped within through holes **917** that extend through a lateral sidewall of the inner collar **916** as a result of an inner surface of the outer collar **918** closing the outer surface openings of the through holes when the outer collar **918** is in the locking position depicted in FIG. **9**C. With reference to FIG. **9**B, as the sheath retention mechanism **903** is inserted into the inner collar **916**, the segments **908** of the locking collar **904** deflect radially inward as the leading ends of the protrusions **912** bear against the retainer members **920**. As shown in FIG. **9**C, once the protrusions **912** move proximally past the retainer members **920**, the segments **908** return to the initial, undeflected position. As shown in FIG. **9**C, in the assembled (locked) configuration of the sheath on the instrument shaft **932**, the distal facing surface of the protrusions **912** forms a shoulder that engage with the retainer members **920** to prevent the sheath **900** from being moved distally and removed from the sheath connector device **914**.

[0084] Now referring to FIG. **9**D, the sheath **900** may be unlocked and removed from the sheath connector device **914**, and thus the instrument shaft **932**, by moving the outer collar **918** axially and proximally with respect to the inner collar **916** and against a biasing force of the biasing element

921 until an annular relief **924** on an inner surface of the outer collar **918** aligns with the retaining members **920**. The retaining members **920** may thus be allowed to move radially outward to be at least partially received into the reliefs **924** of the outer collar **918**, allowing the locking collar **904** and protrusions **912** to move distally past the retaining members **920** and the sheath **900** to be removed from the sheath connector device **914** and the instrument.

[0085] Referring now to FIG. **10**A, another exemplary embodiment of a sheath **1000** and a corresponding sheath connector portion **1113** of an instrument **1130** is shown, with the sheath being a tubular sleeve having features configured to be engaged with the sheath connector portion **1113** of the instrument. The sheath **1000** includes a proximal end portion **1002** with female features **1004**, such as holes, recesses, or other negative relief features on the lateral wall and at least through an outer surface, a plurality of which may be circumferentially spaced around a perimeter of the proximal end portion **1002**. The sheath connector portion **1113** of the instrument may be positioned at a junction where the instrument shaft **1132** connects to the instrument transmission housing **1106**. The sheath connector portion **1113** can comprise an inner collar **1115** configured to be received within the proximal end portion **1002** of the sheath **1000**. The inner collar **1115** includes one or more male features **1114**, such as, for example barbs or other similar protrusions, extending radially outwardly from an outer surface of the inner collar **1115**. The male features **1114** are positioned and configured to fit within female features **1004** of the sheath **1000**. The sheath connector portion **1113** further comprises an outer collar **1112** biased in a distal position by a biasing device **1116**, such as, for example, a compression spring, or other biasing element. The collar **1112** is positioned to at least partially cover the male features **1114** when the biasing device **1116** is in an extended position forcing the collar **1112** in the distal position shown in FIG. **10**B.

[0086] To install the sheath **1000**, the collar **1112** is retracted in a proximal direction relative to the instrument, e.g., toward the instrument transmission housing **1106**. In this position of the collar **1112**, the sheath **1000** can be slid over the male features **1114** and can be rotated, if needed, until the holes **1004** are aligned with and receive one or more of the male features **1114**, respectively. Releasing the collar **1112** then moves the collar **1112** over the male features **1114** to lock the connector portion **1113** and sheath **1000** together and to protect against disengagement of the male features **1114** with the sheath. In this way, the sheath **1000** is assembled to the instrument and prevented from being moved laterally and axially relative to the instrument shaft **1032**.

[0087] In various exemplary embodiments described and shown herein, the sheath connector portion of the instruments are positioned at a juncture where the instrument shaft extends from a transmission housing, thereby allowing the sheath sleeve to extend substantially the entire length of the instrument shaft. However, the present disclosure contemplates positioning a sheath connector portion at other locations along the instrument shaft, in which configurations, the sheath would not extend to cover the entire length of the instrument shaft.

[0088] Further, in various exemplary embodiments that rely on an engagement of complementary retention features provided on the sheath and/or on the instrument, those of ordinary skill in the art would appreciate that modifications to the number and arrangement of those features may be altered as desired, for example, based on factors including, but not limited to, ease of installation of a sheath on an instrument, ease of manufacturing, desired retention forces tending to prevent rotation and/or axial movement of the sheath relative to an instrument in the assembled configuration, etc. By way of example, various exemplary embodiments include complementary and engageable male and female features. Persons having ordinary skill in the art would appreciate that the locations of the male and female features could be reversed on the various components with appropriate modification without departing from the scope of the present disclosure.

[0089] Further modifications and alternative embodiments will be apparent to those of ordinary skill in the art in view of the disclosure herein. For example, the devices, systems, and methods may include additional components or steps that were omitted from the diagrams and description for clarity of operation. Accordingly, this description is to be construed as illustrative only and is for the purpose of teaching those skilled in the art the general manner of carrying out the present disclosure. It is to be understood that the various embodiments shown and described herein are to be taken as exemplary. Elements and materials, and arrangements of those elements and materials, may be substituted for those illustrated and described herein, parts and processes may be reversed, and certain features of the present teachings may be utilized independently, all as would be apparent to one skilled in the art after having the benefit of the description herein. Changes may be made in the elements described herein without departing from the scope of the present disclosure and following claims.

[0090] It is to be understood that the particular examples and embodiments set forth herein are non-limiting, and modifications to structure, dimensions, materials, and methodologies may be made without departing from the scope of the present disclosure.

[0091] Other embodiments in accordance with the present disclosure will be apparent to those skilled in the art from consideration of the specification and practice of the invention disclosed herein. It is intended that the specification and examples be considered as exemplary only, with being entitled to their full breadth of scope, including equivalents by the following claims.

Claims

1. A method of assembling a protective sheath to a surgical instrument, the method comprising: advancing the protective sheath over a distal working end of a surgical instrument shaft to a relatively proximally disposed sheath connector portion of the surgical instrument; moving a retention mechanism of the sheath into alignment with the sheath connector portion; and moving a moveable locking feature from a first configuration permitting the retention mechanism to be moved relative to the sheath connector portion to a second configuration in which complementary engagement features on the retention mechanism and the sheath connector portion are lockably engaged to retain the sheath in position on the instrument.

2. A method of removing a protective sheath from a shaft of a surgical instrument, the method comprising: applying a laterally inwardly directed force to a proximal end portion of retention mechanism to deform the proximal end portion from a first configuration to a second configuration, wherein: in the first configuration, the retention mechanism is engaged with a connector portion of the instrument to retain a position of the sheath on the instrument, and in the second configuration, the retention mechanism is disengaged from the connector portion and the sheath is movable relative to the instrument; while in the second configuration of the retention mechanism, moving the retention mechanism distally away from the connector portion to remove the sheath.