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Inventor(s)	Wulc; Allan et al.

Suturing device and clamp for use with same

Abstract

A suturing device comprising an elongated member including a cavity formed in a surface thereof, a needle passage, and a vacuum port. When the elongated member is inserted into a body including tissue and a vacuum is applied to the cavity, the tissue is captured by the cavity. A needle pusher is operable to move a needle having a sutured attached thereto through the tissue until a first end of the needle is captured by a needle capturing assembly. A clamp coupled to the elongated member is used to extract the needle from the needle capturing assembly and reposition the needle with suture attached to be re-engaged by the needle pusher. The cavity may include a plurality of cavity portions for capturing multiple contiguous portions of the tissue such that a single pass of the needle and the suture results in the suturing of the multiple portions of the tissue.

Inventors: **Wulc; Allan (Bryn Mawr, PA), Bernstein; Joel (Belle Mead, NJ), Hudson; Douglas (Hopkinton, MA), Bernstein; Bruce (Wynnewood, PA)**

Applicant: **TSYMM INNOVATIONS LLC** (Wynnewood, PA)

Family ID: **1000008751572**

Assignee: **TSYMM INNOVATIONS LLC (Wynnewood, PA)**

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Primary Examiner: Erezo; Darwin P

Assistant Examiner: Khandker; Raihan R

Attorney, Agent or Firm: Volpe Koenig

Background/Summary

CROSS REFERENCE TO RELATED APPLICATION (1) This application is a continuation of U.S. application Ser. No. 17/703,771, filed Mar. 24, 2022, entitled SUTURING DEVICE AND CLAMP FOR USE WITH SAME, which claims the benefit of U.S. Provisional Application No. 63/166,864, filed Mar. 26, 2021, entitled SUTURING DEVICE AND CLAMP FOR USE WITH SAME, the contents of each of these aforementioned applications are hereby incorporated by reference as if fully set forth herein.

FIELD OF THE DISCLOSURE
(1) The disclosed embodiments relate generally to medical devices used in surgical procedures and, more particularly, to suturing devices and clamps for facilitating multiple passes of a needle and suture through tissue.
BACKGROUND
(2) Surgery has evolved such that many operations are being performed through incisions of ever-decreasing size. The greatest limitations in performing surgery through small incisions is the difficulty of engaging tissue and passing sutures at a location remote from the incision point. While some surgeons develop the manual dexterity and experience to effectively suture tissue remote from the incision point, very few techniques have been developed to deal with this problem effectively.
(3) Often surgeons are forced to make additional, and potentially longer, incisions, simply because of the difficulty of passing the suture. For example, in performing an endoscopic facelift, the surgeon is often forced to place an incision inside the mouth for wide access to the suturing location. The surgeon may also need to create a large internal space within the patient body (oftentimes referred to as "undermining") to clear enough space to allow for the instrumentation required to pass the suture and subsequently retrieve the needle. With manual remote access techniques, often a significant amount of skin must be (lifted) undermined from the underlying fascia, fat and musculature to allow room to maneuver an endoscope, a needle holder, and the grasping forceps. The creation of this large internal space has the potential to damage internal nerves, blood vessels, and organs. It is also disruptive to the tissue, which can prolong and/or compromise healing. Furthermore, oftentimes four hands are necessary (the surgeon's and an assistant's) to hold the instrumentation, to grasp the needle, and to pass and retrieve the suture.
(4) The limitations of currently available techniques as discussed above produce certain potential

surgical risks including needle breakage within the face, needle loss within the face, injury to the facial nerve, its branches, sensory nerves, and blood vessels, dimpling in the skin, improper needle location, inability to pass the suture to obtain the desired lifting effect, as well as the need to open the area completely to retrieve a lost needle or for repair of nerves or vessels.

(5) Passing a suture within the body demands the opening of a space created by subcutaneous undermining thereby allowing enough tissue to be opened to create a space in which to pass the suture and retrieve the needle. In procedures using minimally invasive approaches through a small incision remote from the incision point, wide undermining must be carried out in order to deliver the needle using forceps and to remove it from tissue under endoscopic visualization. This procedure is extremely difficult, if not impossible, without endoscopic visualization or a larger open-access incision to allow for direct visualization. Certain conventional suturing devices do not allow the surgeon to make multiple passes of a suture, and require that multiple sutures be used. Those conventional suturing devices that do allow for multiple passes of the suture, however, are mechanically complex. Hence, there exists a need for a device that facilitates easy passage of a suture in a remote location from the incision point with minimal undermining under either endoscopic or non-visualized means and that allows for multiple passes of the suture to secure tissues within the body.

SUMMARY

(6) A suturing device according to the present disclosure is a device used in surgical procedures for sewing tissue. The suturing device can be controlled externally of the patient, for example under direct visualization by the surgeon, by endoscopic means, or without any visualization by the surgeon, and typically uses a needle attached to a length of suture. A clamp according to the present disclosure is a mechanical device having parts brought together for holding or compressing an object, such as a needle. As described herein, according to the present disclosure, a clamp in combination with a suturing device may be used to facilitate multiple passes of a needle and suture through tissue.

(7) In an embodiment of the present disclosure, a suturing device is provided. The suturing device includes an elongated member dimensioned for insertion into a body including tissue. The elongated member including a first end and a second end opposite the first end, a cavity formed in a surface of the elongated member, a needle passage, and a vacuum port. The cavity includes a first end and a second end opposite the first end and wherein when the elongated member is inserted into the body and a vacuum is applied to the cavity by a vacuum source through the vacuum port, the tissue is captured by the cavity. The suturing device further includes a needle capturing assembly disposed between the second end of the cavity and the second end of the elongated member, a needle pusher including a first end for engaging a needle, wherein when the needle is engaged by the needle pusher and the tissue is captured by the cavity, the needle pusher is moveable in a first direction to move the needle through the needle passage in the first direction such that entirety of the needle passes through the tissue and a first end of the needle is captured by the needle capturing assembly and the needle pusher is further moveable in a second direction such that the needle is disengaged from the needle pusher while the first end of the needle remains captured by the needle capturing assembly, and a clamp coupled to the elongated member and moveable in the second direction such that when the clamp clamps the second end of the needle and is moved in the second direction, the first end of the needle is extracted from the needle capturing assembly and the needle is repositioned to be engaged by the first end of the needle pusher.

(8) In another embodiment of the present disclosure, an apparatus for use with a suturing device is provided, wherein the suturing device includes an elongated member dimensioned for insertion into a body including tissue. The elongated member includes a first end and a second end opposite the first end, a cavity formed in a surface thereof, a needle passage, and a vacuum port. The cavity includes a first end and a second end opposite the first end. When the elongated member is inserted

into the body and a vacuum is applied to the cavity by a vacuum source through the vacuum port, the tissue is captured by the cavity. The suturing device further includes a needle capturing assembly disposed between the second end of the cavity and the second end of the elongated member and a needle pusher including a first end for engaging a needle. When the needle is engaged by the needle pusher and the tissue is captured by the cavity, the needle pusher is moveable in a first direction to move the needle through the needle passage in the first direction such that entirety of the needle passes through the tissue and a first end of the needle is captured by the needle capturing assembly and the needle pusher is further moveable in a second direction such that the needle is disengaged from the needle pusher while the first end of the needle remains captured by the needle capturing assembly. The apparatus includes a base dimensioned to fit within the cavity. The apparatus further includes a clamp coupled to the base so as to be moveable in the second direction with respect to the base. The clamp is operable to clamp a second end of the needle opposite the first end of the needle such that when the clamp clamps the second end of the needle when the first end of the needle is captured by the needle capturing assembly and the clamp is moved in the second direction, the first end of the needle is extracted from the needle capturing assembly and the needle is repositioned to be engaged by the first end of the needle pusher.

(9) In yet another embodiment of the present disclosure, a suturing device and an apparatus for use with the suturing device are provided. The suturing device includes a needle capturing assembly and a needle pusher. The apparatus includes a clamp that is configured to move with respect to the suturing device. The clamp is operable to clamp a second end of the needle opposite a first end of the needle when the first end of the needle is captured by the needle capturing assembly and the second end of the needle has been disengaged from the needle pusher. The clamp is operable to extract the first end of the needle from the needle capturing assembly and reposition the needle to be re-engaged by the needle pusher.

(10) In yet another embodiment of the present disclosure, a suturing device is provided. The suturing device includes an elongated member dimensioned for insertion into a body including tissue, the elongated member including a first end and a second end opposite the first end, a cavity formed in a surface thereof, a needle passage, and a vacuum port, wherein the cavity includes a first end and a second end opposite the first end and wherein when the elongated member is inserted into the body and a vacuum is applied to the cavity by a vacuum source through the vacuum port, the tissue is captured by the cavity. The suturing device further includes a needle capturing assembly disposed between the second end of the cavity and the second end of the elongated member and a needle pusher including a first end for engaging a needle. When the needle is engaged by the needle pusher and the tissue is captured by the cavity, the needle pusher is moveable in a first direction to move the needle through the needle passage in the first direction such that entirety of the needle passes through the tissue and a first end of the needle is captured by the needle capturing assembly. The needle pusher is further moveable in a second direction such that the needle is disengaged from the needle pusher while the first end of the needle remains captured by the needle capturing assembly. Application of the vacuum to the cavity is controlled by the movement of the needle pusher.

(11) In yet another embodiment of the present disclosure, light from a light source may be used to illuminate tissue when the suturing device is inserted within the body to assist with placement of the suturing device within the body without having visual contact with the device. In addition, during operation of the suturing device, a user may be provided with audible and/or tactile feedback from the device to enable the user to ascertain a position of the needle pusher and needle without having visual contact with either the needle pusher or the needle.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) Various embodiments of the present disclosure are illustrated by way of example, and not limited by the appended figures, in which like references indicate similar elements, and in which:

(2) FIG. **1**A illustrates a perspective view of a suturing device, in accordance with an exemplary embodiment of the present disclosure;

(3) FIG. **1**B illustrates a cross-sectional side view of the suturing device, in accordance with an exemplary embodiment of the present disclosure;

(4) FIG. **1**C illustrates a cross-sectional top view of the suturing device, in accordance with an exemplary embodiment of the present disclosure;

(5) FIG. **1**D illustrates an enlarged view of a portion of a needle pusher of the suturing device, in accordance with an exemplary embodiment of the present disclosure;

(6) FIG. **1**E illustrates a perspective view of a needle pusher assembly and a blocking member of the suturing device, in accordance with an exemplary embodiment of the present disclosure;

(7) FIG. **1**F illustrates an enlarged cross-sectional side view of a ball-spring detent mechanism of the suturing device, in accordance with an exemplary embodiment of the present disclosure;

(8) FIGS. **1**G-**1**I illustrate enlarged views of operation of the ball-spring detent mechanism of the suturing device, in accordance with an exemplary embodiment of the present disclosure;

(9) FIG. **1**J illustrates a representative view of a face of a patient, with a slit incision shown therein, through which the suturing device is inserted, in accordance with an exemplary embodiment of the present disclosure;

(10) FIG. **1**K illustrates a cross-sectional side view of the suturing device when the operating handle is in an advancing position, in accordance with an exemplary embodiment of the present disclosure;

(11) FIG. **1**L illustrates a perspective view and an enlarged view of a distal end of the suturing device when an operating handle is in a fully advanced position, in accordance with an exemplary embodiment of the present disclosure;

(12) FIG. **1**M illustrates an enlarged view of the distal end of the suturing device when the operating handle is in a fully retracted position, in accordance with an exemplary embodiment of the present disclosure;

(13) FIG. **1**N illustrates a representative view of the face of the patient, with the slit incision shown therein, through which the suturing device is removed, in accordance with an exemplary embodiment of the present disclosure;

(14) FIG. **1**O illustrates a cross-sectional side view of the suturing device with a light channel, in accordance with an exemplary embodiment of the present disclosure;

(15) FIG. **2**A illustrates a perspective side view of an apparatus for use with the suturing device, in accordance with an exemplary embodiment of the present disclosure

(16) FIG. **2**B illustrates an exploded view of the apparatus, in accordance with an exemplary embodiment of the present disclosure;

(17) FIG. **2**C illustrates a perspective front view of the apparatus, in accordance with an exemplary embodiment of the present disclosure;

(18) FIG. **2**D illustrates an enlarged rear perspective view of the apparatus, in accordance with an exemplary embodiment of the present disclosure;

(19) FIG. **3**A illustrates a perspective view of the suturing device and the apparatus, in accordance with an exemplary embodiment of the present disclosure;

(20) FIG. **3**B illustrates a cross-sectional side view of the suturing device coupled with the apparatus, in accordance with an exemplary embodiment of the present disclosure;

(21) FIG. **3**C illustrates a perspective view and an enlarged perspective view of the distal end of the suturing device coupled with the apparatus when the apparatus is engaged with a needle, in accordance with an exemplary embodiment of the present disclosure;

(22) FIG. **3**D illustrates an enlarged perspective view of suturing device coupled with the apparatus when the needle is released from a needle capturing member, in accordance with an exemplary embodiment of the present disclosure;
(23) FIG. **3**E illustrates a perspective view and an enlarged perspective view of the distal end of the suturing device coupled with the apparatus when the operating handle is in a partially advanced position, in accordance with an exemplary embodiment of the present disclosure;
(24) FIG. **4**A illustrates a perspective view of an apparatus for use with a suturing device, in accordance with an exemplary embodiment of the present disclosure;
(25) FIG. **4**B illustrates an exploded view of the apparatus, in accordance with an exemplary embodiment of the present disclosure;
(26) FIG. **4**C illustrates an enlarged rear perspective view of the apparatus, in accordance with an exemplary embodiment of the present disclosure;
(27) FIG. **5**A illustrates a perspective view of the suturing device and the apparatus, in accordance with an exemplary embodiment of the present disclosure;
(28) FIG. **5**B illustrates an enlarged perspective view of the suturing device and the apparatus, in accordance with an exemplary embodiment of the present disclosure
(29) FIG. **5**C illustrates a cross-sectional side view of the suturing device and the apparatus, in accordance with an exemplary embodiment of the present disclosure;
(30) FIG. **5**D illustrates a perspective view of the suturing device and the clamp when the apparatus is in a moving position, in accordance with an exemplary embodiment of the present disclosure;
(31) FIG. **5**E illustrates an enlarged side sectional view of the apparatus positioned at a distal end of the suturing device, in accordance with an exemplary embodiment of the present disclosure;
(32) FIGS. **5**F and **5**G illustrate an enlarged perspective view and a side sectional view, respectively, of the apparatus positioned at the distal end of the suturing device when an operating handle is at a partially advanced position, in accordance with an exemplary embodiment of the present disclosure;
(33) FIGS. **5**H and **5**I illustrate an enlarged perspective view and a side sectional view, respectively, of the apparatus positioned at the distal end of the suturing device when an operating handle is at a partially advanced position, in accordance with an exemplary embodiment of the present disclosure;
(34) FIG. **6**A illustrates an exploded view of an apparatus for use with a suturing device, in accordance with an exemplary embodiment of the present disclosure;
(35) FIG. **6**B illustrates a perspective view of the apparatus, in accordance with an exemplary embodiment of the present disclosure;
(36) FIG. **7**A illustrates a perspective view of the suturing device and the apparatus, in accordance with an exemplary embodiment of the present disclosure;
(37) FIG. **7**B illustrates an enlarged top view of the apparatus and the suturing device, in accordance with an exemplary embodiment of the present disclosure;
(38) FIG. **7**C illustrates an enlarged view of the apparatus at a distal end of the suturing device when the apparatus is moved towards the distal end, in accordance with an exemplary embodiment of the present disclosure;
(39) FIG. **7**D illustrates an enlarged view of the apparatus at the distal end of the suturing device when the apparatus is moved away from the distal end, in accordance with an exemplary embodiment of the present disclosure;
(40) FIG. **7**E illustrates an enlarged view of the apparatus and the suturing device when an operating handle is at a partially advanced position, in accordance with an exemplary embodiment of the present disclosure;
(41) FIG. **8**A illustrates a perspective view of an apparatus for use with a suturing device, in accordance with an exemplary embodiment of the present disclosure;
(42) FIG. **8**B illustrates a perspective view of a sliding member of the apparatus, in accordance

with an exemplary embodiment of the present disclosure;
(43) FIG. **8**C illustrates a perspective view of a lever of the apparatus, in accordance with an exemplary embodiment of the present disclosure;
(44) FIGS. **8**D and **8**E illustrate front and rear perspective views of the apparatus, in accordance with an exemplary embodiment of the present disclosure;
(45) FIG. **8**F illustrates a front view of the apparatus, in accordance with an exemplary embodiment of the present disclosure;
(46) FIG. **8**G illustrates a bottom view of the apparatus, in accordance with an exemplary embodiment of the present disclosure;
(47) FIGS. **9**A and **9**B illustrate a perspective view and an enlarged view, respectively of the suturing device and the apparatus, in accordance with an exemplary embodiment of the present disclosure;
(48) FIGS. **9**C and **9**D illustrate a perspective view and an enlarged view, respectively of the apparatus at a distal end of the suturing device when the apparatus is moved towards the distal end, in accordance with an exemplary embodiment of the present disclosure;
(49) FIGS. **9**E and **9**F illustrate a perspective view and an enlarged view, respectively of the apparatus at the distal end of the suturing device, in accordance with an exemplary embodiment of the present disclosure;
(50) FIGS. **9**G and **9**H illustrate a perspective view and an enlarged view, respectively of the apparatus at the distal end of the suturing device when the apparatus is moved away from the distal end, in accordance with an exemplary embodiment of the present disclosure;
(51) FIGS. **91** and **9**J illustrate a perspective view and an enlarged view of the apparatus and the suturing device when an operating handle is at a fully advanced position, in accordance with an exemplary embodiment of the present disclosure; and
(52) FIGS. **10**A-**10**C illustrate a perspective side view, a perspective top view, and a cross-sectional side view, respectively, of a suturing device, in accordance with an exemplary embodiment of the present disclosure;
(53) FIG. **10**D illustrates an enlarged view of a distal end of the suturing device when an operating handle of the suturing device is in a partially advanced position, in accordance with an exemplary embodiment of the present disclosure;
(54) FIG. **10**E illustrates an enlarged view of the distal end of the suturing device of when the operating handle is in a fully advanced position, in accordance with an exemplary embodiment of the present disclosure;
(55) FIG. **10**F illustrates an enlarged cross sectional side view of the distal end of the suturing device when the operating handle is moved to the fully advanced position;
(56) FIG. **10**G illustrates an enlarged cross sectional side view of the distal end of the suturing device, in accordance with an exemplary embodiment of the present disclosure;
(57) FIG. **10**H illustrates an enlarged top view of the distal end of the suturing device when the operating handle is moved to the fully advanced position, in accordance with an exemplary embodiment of the present disclosure;
(58) FIG. **10**I illustrates an enlarged view of the distal end of the suturing device when the operating handle is moved from the fully advanced position to an intermediate position, in accordance with an embodiment of the disclosure;
(59) FIGS. **11**A-**11**C illustrate a perspective view, an enlarged view, and a cross-sectional side view, respectively, of a suturing device, in accordance with an exemplary embodiment of the present disclosure;
(60) FIG. **11**D illustrates an enlarged cross-sectional side view of a distal end of the suturing device, in accordance with an exemplary embodiment of the present disclosure;
(61) FIGS. **12**A-**12**D illustrate a perspective side view, another perspective side view, an enlarged view, and a cross-sectional side view, respectively, of a suturing device, in accordance with an

exemplary embodiment of the present disclosure;
(62) FIG. **12**E illustrates an enlarged cross-sectional view of a distal end of the suturing device when an operating handle of the suturing device is moved to a fully advanced position, in accordance with an exemplary embodiment of the present disclosure;
(63) FIG. **12**F illustrates an enlarged cross-sectional view of the distal end of the suturing device, in accordance with another exemplary embodiment of the present disclosure;
(64) FIG. **12**G illustrates a cross-sectional top view of the suturing device, in accordance with an exemplary embodiment of the present disclosure; and
(65) FIG. **12**H illustrates a perspective view of a needle pusher assembly of the suturing device, in accordance with an exemplary embodiment of the present disclosure.
(66) Further areas of applicability of the present disclosure will become apparent from the detailed description provided hereinafter. It should be understood that the detailed description of exemplary embodiments is intended for illustration purposes only and is, therefore, not intended to necessarily limit the scope of the present disclosure.

DETAILED DESCRIPTION

(67) The present disclosure is best understood with reference to the detailed figures and description set forth herein. Various embodiments are discussed below with reference to the figures. However, those skilled in the art will readily appreciate that the detailed descriptions given herein with respect to the figures are simply for explanatory purposes as the methods and systems may extend beyond the described embodiments. In one example, the teachings presented and the needs of a particular application may yield multiple alternate and suitable approaches to implement the functionality of any detail described herein. Therefore, any approach may extend beyond the particular implementation choices in the following embodiments that are described and shown.
(68) References to “an embodiment”, “another embodiment”, “yet another embodiment”, “one example”, “another example”, “yet another example”, “for example”, and so on, indicate that the embodiment(s) or example(s) so described may include a particular feature, structure, characteristic, property, element, or limitation, but that not every embodiment or example necessarily includes that particular feature, structure, characteristic, property, element or limitation. Furthermore, repeated use of the phrase “in an embodiment” does not necessarily refer to the same embodiment.
(69) FIGS. **1**A, **1**B, and **1**C illustrate a perspective view, a cross-sectional side view, and cross-sectional top view of a suturing device **100**, in accordance with an exemplary embodiment of the disclosure. As shown in FIGS. **1**A, **1**B, and **1**C, the suturing device **100** includes an elongated member **102**. Preferably, the elongated member **102** is dimensioned for insertion into a body including tissue (e.g., tissue **103**) to suit a particular application. For example, in situations where the suturing device **100** is to be used to perform endoscopic plastic surgery, such as described in U.S. Pat. No. 7,060,079, the elongated member **102** is dimensioned for insertion into an incision in the patient and for engaging subcutaneous tissue, fat, fascia, or muscle. The elongated member **102** further includes a proximal end **102***a* and a distal end **102***b* (“proximal” and “distal” being from the perspective of a user of the suturing device **100**) and a cavity **104** is formed in a surface of the elongated member **102**. The elongated member **102** is provided with a working channel **106***a* and a suction channel **106***b*, as shown in FIG. **1**B. A first end of the suction channel **106***b* has a vacuum port **108** that may be coupled to a vacuum source (not shown). A second end of the suction channel **106***b* is coupled to the cavity **104** such that the cavity **104**, the suction channel **106***b*, and the vacuum source are in fluidic communication. Thus, when the elongated member **102** is inserted into a body including the tissue **103** to be sutured and a vacuum (i.e., negative pressure) is applied to the cavity **104** by the vacuum source coupled to the vacuum port **108**, the tissue **103** is suctioned into and captured by the cavity **104**. Preferably, the cavity **104** is dimensioned to suit a particular application and to accommodate the type and amount of tissue that is to be captured. For example, the cavity **104** can be formed as a cuboid, as shown in FIG. **1**A, to include a first wall **104***a* (i.e., a

front wall from the perspective of the user of the suturing device **100**) at a first end of the cavity **104** and a second wall **104***b* (i.e., a rear wall from the perspective of the user of the suturing device **100**) at a second end of the cavity **104** parallel and opposite to the first wall **104***a*. The cavity **104** may have other shapes, such as an ovoid, cylindrical, cuboid, pyramidal, parabolic, conical, or free-form shape.

(70) As further shown in FIGS. **1**A, **1**B, and **1**C, a needle capturing assembly **110** is disposed between the second wall **104***b* of the cavity **104** and the distal end **102***b* of the elongated member **102** for capturing and allowing for the subsequent release of a needle **112** during operation of the suturing device **100** as described below. The needle capturing assembly **110** may be made of any material, such as but not limited to rubber, elastomer, or the like, that allows the needle capturing assembly **110** to capture the needle **112** during operation of the suturing device **100** and allows the needle **112** to be subsequently released as described below. The needle capturing assembly **110** may be permanently disposed within the elongated member **102** such that it is not intended for replacement. Alternatively, the needle capturing assembly **110** may be removably disposed within the elongated member **102** such that it may be replaced with a new needle capturing assembly, for example, should the original needle capturing assembly become unusable or be in need of repair. For example, the elongated member **102** may include an opening **113** for receiving the needle capturing assembly **110**. The opening **113** is preferably dimensioned such that the needle capturing assembly **110** may be secured within the opening **113**, but may also be removed and replaced with the new needle capturing assembly as needed. It should be appreciated that the needle capturing assembly **110** may take forms other than the form shown in FIGS. **1**A, **1**B, and **2**C. For example, the needle capturing assembly **110** may take the form of the punch needle notch and key assembly described in U.S. Pat. No. 8,172,857, the contents of which are hereby incorporated by reference. Other assemblies know to those skilled in the art for capturing and allowing for the subsequent release of a needle during operation of the suturing device may also be used.

(71) As shown in FIG. **1**E, the suturing device **100** further includes a needle pusher assembly **114**. The needle pusher assembly **114** includes a needle pusher **116** and an operating handle **118**, both of which are also shown in FIGS. **1**A and **1**B. The needle pusher **116** is dimensioned such that it may be moved in directions X and X′ (see FIG. **1**A) within the working channel **106***a* of the elongated member **102** as described below. As further shown in FIG. **1**A, the needle **112** having a suture **120** attached to a first end thereof may be engaged by a first end of the needle pusher **116**. The suture **120** may be attached to the first end of the needle **112**, for example, by use of shrink tubing, swaging, or other means known to those skilled in the art. The first end of the needle pusher **116** is configured to engage the needle **112** having the suture **120** attached thereto. In one embodiment, the needle pusher **116** may comprise a solid rod and the needle **112** may be engaged by the first end of the needle pusher **116**, for example, by slip fitting the first end of the needle **112** into a hole or slot formed in the first end of the needle pusher **116**, such as shown in FIG. **1**E. In another embodiment, the needle pusher **116** may comprise a cylindrical tube and the needle **112** may be engaged by the first end of the needle pusher **116** by slip fitting the first end of the needle **112** into the first end of the needle pusher **116**. Other configurations known to those skilled in the art may be used to cause the needle pusher **116** to engage the needle **112**. Preferably, when the needle **112** is engaged by the needle pusher **116**, the suture **120** may exit the suturing device **100**, for example, through a slit or other opening formed in the elongated member **102** as shown in FIG. **1**A. The needle pusher **116** is explained in detail in conjunction with FIG. **1**D.

(72) During operation of the suturing device **100**, a user may push and/or pull the operating handle **118**, using a fixed handle **122** as leverage, to control movement of the needle pusher **116** within the working channel **106***a*. For example, advancement or retraction of the operating handle **118** translates to a corresponding advancement or retraction of the needle pusher **116** (and the needle **112** and the suture **120** when the needle **112** is engaged by the needle pusher **116**) within the working channel **106***a*. A user operating the suturing device **100** may move the operating handle

118 from a retracted position towards the fixed handle **122** of the suturing device **100**, until the operating handle **118** reaches its fully advanced position. In the fully advanced position, the operating handle **118** is preferably in contact with the fixed handle **122**. The longitudinal advancement of the operating handle **118** towards the fixed handle **122** forces the needle pusher **116**, and, consequently, the needle **112** and the suture **120**, to advance longitudinally from a current position towards the distal end **102***b* of the elongated member **102**. As the needle pusher **116**, the needle **112**, and the suture **120** are advanced, at least the needle **112** and the suture **120** (and, preferably, also the needle pusher **116**) pass over the cavity **104** and, in doing so, may penetrate the tissue **103** that has been suctioned into the cavity **104** by a vacuum applied to the suction channel **106***b*. Preferably, during operation of the suturing device **100**, the operating handle **118** is sufficiently advanced towards the fixed handle **122** such that the entirety of the needle **112** passes through the captured tissue **103** and a second end of the needle **112**, i.e., the end opposite to the first end at which the suture **120** is attached, is captured by the needle capturing assembly **110**, thereby suturing the captured tissue **103** (as shown in FIGS. **1**K and **1**L).

(73) It should be appreciated that during operation of the suturing device **100**, application of a vacuum to the cavity **104** should be coordinated with the passing of the needle **112** and the suture **120** through the tissue **103** such that the tissue **103** is suctioned into and released from the cavity **104** at the appropriate times. Control of the vacuum can be accomplished by manually turning the vacuum source on and off. Alternatively, a blocking member **124** attached to the needle pusher assembly **114**, in combination with a first aperture **126** and a vacuum control channel **106***c* formed in the elongated member **102**, may be provided to control application of the vacuum to the cavity **104** through normal operation of the suturing device **100** without having to manually turn the vacuum source on and off.

(74) As shown in FIGS. **1**A, and **1**E the blocking member **124** may comprise an elongated member coupled to the operating handle **118** and arranged parallel and adjacent to the needle pusher **116**. The blocking member **124** is dimensioned to fit within the vacuum control channel **106***c* (shown in FIG. **1**C), which is in fluidic communication with the suction channel **106***b*. As shown in FIG. **1**C, the length of the vacuum control channel **106***c* is preferably shorter than the length of the working channel **106***a*. During operation of the suturing device **100**, advancement or retraction of the operating handle **118** translates to a corresponding movement of the blocking member **124** through the vacuum control channel **106***c*, and such movement of the blocking member **124** within the vacuum control channel **106***c*, in turn, opens or blocks the first aperture **126**. Because the first aperture **126** is in fluidic communication with the vacuum control channel **106***c*, which is further in fluidic communication with the suction channel **106***b*, opening of the first aperture **126** releases any vacuum pressure created within the cavity **104**. Similarly, blocking the first aperture **126** maintains any vacuum pressure created within the cavity **104**. Thus, retracting the operating handle **118** results in retraction of the blocking member **124** such that the blocking member **124** does not block the first aperture **126** and air from the environment enters the suction channel **106***b* via the vacuum control channel **106***c* through the first aperture **126**, thereby negating any vacuum created at the cavity **104** and releasing any captured tissue from the cavity **104**. Similarly, advancing the operating handle **118** results in advancement of the blocking member **124** such that the blocking member **124** blocks the first aperture **126**, thereby maintaining a vacuum at the cavity **104** such that the tissue **103** may be captured. It should be appreciated that provision of the blocking member **124**, the first aperture **126**, and the vacuum control channel **106***c* avoids the need to manually turn the vacuum source on/off. It also enables synchronization of the application of the vacuum to the cavity **104** with the passage of the needle **112** and the suture **120** through the tissue **103** during normal operation of the suturing device **100**. As an alternative to the blocking member **124**, the user of the suturing device **100** may manually cover/uncover the first aperture **126**, for example, with his/her finger, to control the application of the vacuum to the cavity **104**. However, in that situation, the user must be aware of the timing of covering/uncovering the first aperture **126** such

that application of the vacuum to the cavity **104** is properly synchronized with the movement of the needle **112** and the suture **120**.

(75) FIG. **1**D illustrates an enlarged view of a portion of the needle pusher **116**, in accordance to an exemplary embodiment of the invention. As shown in FIG. **1**D, the needle pusher **116** comprises a cylindrical tube or rod. A first end of the needle pusher **116** includes an opening **128** that is configured to engage the first end of the needle **112**, as described earlier. The opening **128** is preferably dimensioned to engage the needle **112** by slip fitting. The needle pusher **116** further includes a slit **129** (or other opening) that allows the suture **120** to exit the suturing device **100** and prevent the suture **120** from being in the path of the needle pusher **116** during operation of the suturing device **100**. In one embodiment, as shown in FIG. **1**D, the slit **129** extends from the end of the needle pusher **116** at which the needle **112** is engaged towards the opposite end of the needle pusher **116**. Preferably, the slit **129** slopes towards the outer surface of the needle pusher **116** as shown to help guide and protect the suture **120** as it exits the needle pusher **116** during operation of the suturing device **100**.

(76) FIG. **1**E illustrates a perspective view of the needle pusher assembly **114** and the blocking member **124** attached to the needle pusher assembly **114**, in accordance to an exemplary embodiment of the invention. The needle pusher assembly **114** includes the needle pusher **116** and the operating handle **118**. Attached to the operating handle **118** is the blocking member **124**. The length of the blocking member **124** is preferably shorter than the length of the needle pusher **116**. The needle pusher **116** and the blocking member **124** are configured to slide within the working channel **106***a* and the vacuum control channel **106***c*, respectively. The needle pusher **116** may include one or more detents. Each of the one or more detents may engage with a ball-spring pair of a ball-spring detent mechanism of the suturing device **100** for providing the user of the suturing device **100** with audible and/or tactile feedback on a position of the needle pusher **116** relative to the elongated member **102**. For example, the number of detents used may vary depending on number of positions that the user requires feedback. In a non-limiting example, each detent may be an indentation, a notch, or a slot formed on a peripheral surface of the needle pusher **116**. Preferably, the size of the notch or the indentation or the slot is less than or equal to size or diameter of a ball included in the ball-spring detent mechanism. As an example, the needle pusher **116** in FIG. **1**E is shown to include first through third detents **132***a*-**132***c* and the ball-spring detent mechanism **130** is shown in FIG. **1**F. Functionality and working of the ball-spring detent mechanism **130** is explained in detail in conjunction with the FIGS. **1**F-**1**I.

(77) FIG. **1**F illustrates an enlarged cross-sectional view of the suturing device **100**, in accordance with an exemplary embodiment of the present disclosure. As shown in FIG. **1**F, the suturing device **100** includes the ball-spring detent mechanism **130** seated below the needle pusher **116** in a bore **134** (e.g., a cylindrical bore) formed under the working channel **106***a* through the elongated member **102** of the suturing device **100**. The bore **134** is preferably in alignment with a second aperture **136** formed on the elongated member **102** (see, e.g., FIG. **1**A). The second aperture **136** may allow the user to visually identify the position of the needle pusher **116** with respect to the elongated member **102**. The second aperture **136** also provides a passage through which the ball-spring detent mechanism **130** may be positioned in the bore **134** during assembly of the suturing device **100**. The ball-spring detent mechanism **130** includes a spring **138***a* and a ball **138***b* loaded over the spring **138***a*. The spring **138***a* is dimensioned to be installed in the bore **134**. The spring **138***a* is preferably loaded such that it pushes the ball **138***b* against the needle pusher **116** as the needle pusher **116** traverses through the working channel **106***a* (via the advancement and/or retraction of the operating handle **118** by the user). During the traversal of the needle pusher **116** through the working channel **106***a*, if any of the first through third detents **132***a*-**132***c* aligns with the second aperture **136**, the ball **138***b* being pushed by the loaded spring **138***a* engages with a corresponding one of the detents (e.g., the second detent **132***b* as shown in FIG. **1**F). When the ball **138***b* engages with one of the first through third detents **132***a*-**132***c*, the ball-spring detent

mechanism **130** preferably generates an audible feedback (e.g., a "click" sound) and/or tactile feedback (e.g., a stopping force) for the user of the suturing device **100**. The pressure of the ball **138***b* against one of the first through third detents **132***a*-**132***c* holds the needle pusher **116** in position until a requisite level of force is applied by the user to the operating handle **118** for advancement or retraction of the needle pusher **116**. When the requisite level of force is applied by the user, the ball **138***b* is pushed back into the bore **134** towards the spring **138***a*, enabling the advancement or the retraction of the needle pusher **116** across the working channel **106***a*. In a non-limiting example, the ball-spring detent mechanism **130** may use an object of any shape in place of the ball **138***b* shown and any type of spring in place of the spring **138***a* shown, in order to provide the foregoing functions.

(78) It should be appreciated that the audible and/or tactile feedback generated by the engagement and disengagement of the ball **138***b* and the first through third detents **132***a*-**132***c* enables the user of the suturing device **100** to ascertain a relative position of the needle pusher **116** and needle **112** within the working channel **106***a* without having visual contact with either the needle pusher **116** or the needle **112**. The audible and/or tactile feedback may also inform the user of the status of the vacuum applied to the cavity **104** when the blocking member **124** is provided as discussed above given that the position of the needle pusher **116** within the working channel **106***a* corresponds to the position of the blocking member **124** relative to the first aperture **126**.

(79) For example, in order to prepare the suturing device **100** for use, the needle pusher **116** (with the needle **112** and the suture **120** engaged) is inserted into the proximal end **102***a* of the elongated member **102** and pushed towards the fixed handle **122** until the first detent **132***a* aligns with the second aperture **136**, causing the ball **138***b* to engage with the first detent **132***a*. As shown in FIG. **1**G, when the ball **138***b* is engaged with the first detent **132***a*, the ball-spring detent mechanism **130** generates a first audible click sound and holds the needle pusher **116** in position. The first audible click and/or the tactile feedback caused by the engagement of the ball **138***b* with the first detent **132***a* indicate that the needle pusher **116** is in the fully retracted position and that the suturing device **100** is ready for use. Moreover, because the blocking member **124** does not block the first aperture **126** when the needle pusher **116** is in the fully retracted position, the first audible click and/or the tactile feedback caused by the engagement of the ball **138***b* with the first detent **132***a* also indicate that no vacuum is being applied to the cavity **104**.

(80) Upon application of a requisite force to the operating handle **118** pushing it towards the fixed handle **122**, the ball **138***b* is disengaged from the first detent **132***a* and pushed back into the bore **134** towards the spring **138***a*. If the user continues to push on the operating handle **118**, the needle pusher **116** continues to advance through the working channel **106***a* until the second detent **132***b* aligns with the second aperture **136** and engages with the ball **138***b* generating a second audible click sound and holding the needle pusher **116** in an intermediate position (as shown in FIG. **1**H). The second audible click and/or the tactile feedback caused by the engagement of the ball **138***b* with the second detent **132***b* indicate that the needle pusher **116** is in an intermediate position and that needle **112** is in a preparatory position to be passed through the tissue **103**. Moreover, because the blocking member **124** blocks the first aperture **126** when the needle pusher **116** is in the intermediate position, the second audible click and/or the tactile feedback caused by the engagement of the ball **138***b* with the second detent **132***b* also indicate that the vacuum is being applied to the cavity **104** (via the suction channel **106***b*).

(81) When the operating handle **118** is further advanced by the user to the fully advanced position, the third detent **132***c* eventually becomes aligned with the second aperture **136** and engaged with the ball **138***b*, generating a third audible click sound and holding the needle pusher **116** in position (as shown in FIG. **1**I). The third audible click and/or the tactile feedback caused by the engagement of the ball **138***b* with the third detent **132***c* indicate that the needle pusher **116** is in the fully advanced position, i.e., that the needle pusher **116** has advanced past the second wall **104***b* of the cavity **104** towards the distal end **102***b* such that the entirety of the needle **112** has passed through

the tissue **103**, the suture **120** has passed through the tissue **103**, and the needle **112** has been captured by the needle capturing assembly **110**.

(82) A preferred operation of the suturing device **100** is explained in conjunction with FIGS. **1**A through **1**M. By way of example only, the operation of the suturing device **100** will be described in connection with a mid-face lift procedure. As explained above, the operating handle **118** is initially in the fully retracted position as shown in FIG. **1**A, i.e., the ball **138***b* is engaged with the first detent **132***a* of the needle pusher **116**. While in the fully retracted position, a vacuum source (not shown) coupled to the vacuum port **108** is turned on. As explained above, however, no vacuum is applied to the cavity **104** because the first aperture **126** is not blocked by the blocking member **124**. A user then inserts the elongated member **102** into a patient's body. For example, when forming a mid-face lift procedure, the elongated member **102** is inserted into a slit incision **139** that has been cut through the skin of the face of the patient, generally above the temporal hairline of the patient, e.g., as shown in FIG. **1**J. Once the cavity **104** is positioned at a desired location within the body, the user pushes on the operating handle **118**, using the fixed handle **122** as leverage, to move the operating handle **118** towards the fixed handle **122**. Eventually, the operating handle **118** is sufficiently moved such that the needle pusher **116** is at the intermediate position, i.e., the ball **138***b* is engaged with the second detent **132***b* of the needle pusher **116** as discussed above. In this position, the blocking member **124** blocks the first aperture **126** resulting in a vacuum from the vacuum source (not shown) being applied to the suction channel **106***b* via the vacuum port **108**, and to the cavity **104**, via the suction channel **106***b*. As a result, the tissue **103** from the body is suctioned into and thereby captured by the cavity **104**. Subsequent, further advancement of the operating handle **118** causes the needle pusher **116**, and therefore the needle **112** and the suture **120**, to be pushed through the captured tissue **103** as shown in FIG. **1**K creating a stitch. Following full advancement of the operating handle **118** such the needle pusher **116** is at the fully advanced position, i.e., the ball **138***b* is engaged with the third detent **132***c* of the needle pusher **116** as discussed above, the entirety of the needle **112** (with the suture **120** attached thereto) passes through the suctioned tissue **103** captured within the cavity **104** and a second end of the needle **112** is captured by the needle capturing assembly **110** as shown in FIG. **1**L.

(83) Once the needle **112** and the suture **120** have been passed through the tissue **103** and the stitch has been made, the operating handle **118** is retracted such that the needle pusher **116** moves from the fully advanced position to the intermediate position while the needle **112** remains captured by the needle capturing assembly **110** and the tissue **103** remains captured by the cavity **104**. As a result, the needle **112** disengages from the needle pusher **116**. Full retraction of the operating handle **118** such that the needle pusher **116** moves from the intermediate position to the fully retracted position causes the blocking member **124** to also retract such that it no longer blocks the first aperture **126**. As a result, the vacuum is no longer applied to the cavity **104** and the suctioned tissue **103** is released from the cavity **104** while the suture **120** remains passed through the tissue **103** (as shown in FIG. **1**M). At this point, the suturing device **100** (with the suture still passed through the tissue **103**) is removed from the slit incision **139** of the patient as shown in FIG. **1**N. The user may then remove the needle **112** from the needle capturing assembly **110**, for example using a hemostat or forceps or another device known to those skilled in the art, and perform a second suture pass without the suturing device **100**, again, for example, using a conventional needle holder or another device known to those skilled in the art, in order to make one or more additional passes through the tissue **103** and/or another tissue. Alternatively, the user may remove the needle **112** from the needle capturing assembly **110** and reposition the needle **112** in the needle pusher **116**, again, for example, using forceps, and use the suturing device **100** in order to make one or more additional passes through the tissue **103** and/or another tissue as described above.

(84) FIG. **1**O illustrates an enlarged cross-sectional side view of the suturing device **100**, in accordance with an exemplary embodiment of the present disclosure. In a preferred embodiment, light from a light source (not shown) may be used to illuminate tissue (e.g., the tissue **103**) when

the suturing device **100** is inserted within a body. Such illumination can help the user guide the suturing device **100** within the body and ensure that the cavity **104** is in a desired position, for example, prior to application of a vacuum to the cavity **104**. For example, illumination of tissue may be desired/required in non-endoscopic procedures where the surgeon has limited or no visual contact with the area(s) at or near the desired suturing site. Preferably, a light channel **140** is included within the elongated member **102** and runs parallel to the suction channel **106***b* and along the length of the suturing device **100**, for example from the proximal end **102***a* to midway of the cavity **104**. In one embodiment, the light channel **140** is dimensioned to accommodate a light source within the light channel **140**. For example, a laser-emitting fiber optic cable running along a direction L.sub.1 through the length of the light channel **140** from a laser source (not shown) external to the suturing device **100** may be used. Alternatively, an LED may be positioned beneath the bottom surface of the cavity **104** (opposite the open side of the cavity **104**) with electrical connections running through the length of the light channel **140** to a power source (not shown) external to the suturing device **100**. Light from the light source is preferably directed in a direction L.sub.2 towards the open side of the cavity **104** such that the light exits the cavity **104** towards the tissue to be illuminated. Preferably, the properties (e.g., wavelength and/or power) of the emitted light are such that the light may be seen by the user of the suturing device **100** through the subject's skin indicating the location of the cavity **104** within the subject's body. In order to allow for the light from the light source to pass through the bottom surface of the cavity **104** (opposite the open side), at least the portion of the elongated member **102** forming the bottom surface of the cavity **104** should be constructed using a translucent or transparent material, such as a translucent or transparent glass, polymer, plastic, or the like. The material used could also be a light amplifying material or a lens. In a non-limiting example, as shown in FIG. **1**O, a right-angled fiber optic cable **142** may be used as the light source to shine light along the direction L.sub.2. The right-angled fiber optic cable **142** running along the direction L.sub.1 through the length of the light channel **140** shines light along the direction L.sub.2. In another non-limiting example, a lens/mirror arrangement may be installed below the bottom surface of the cavity **104** at a suitable angle so as to enable incident light to be reflected along the direction L.sub.2. Alternatively, the light channel **140** itself can be constructed as an optical waveguide to guide to carry light from an external light source (e.g., an LED) coupled to the end of the light channel **140** and direct the light along the direction L.sub.2.

(85) FIGS. **2**A-**2**D illustrate perspective, exploded, front perspective, and an enlarged rear perspective views, respectively, of an apparatus **200** for use with the suturing device **100** (with modifications to the suturing device **100** to accommodate the apparatus **200** as described below), in accordance with an exemplary embodiment of the present disclosure. The apparatus **200** may be used to release the needle **112** from the needle capturing assembly **110** of the suturing device **100** and reposition the needle **112** so as to be reengaged by the needle pusher **116** of the suturing device **100**. The apparatus **200** and its various parts may be made of a material or materials designed to ensure proper functioning of the apparatus **200** and clamping of the needle **112**. Such materials may include polymers, composites, metals or the like.

(86) The apparatus **200** includes a base **202** dimensioned to fit within the cavity **104** of the suturing device **100**, and a clamp **204** coupled to the base **202** so as to be moveable in directions X and X′. As described in more detail below, the clamp **204** is operable to clamp the end of the needle **112** extending from the needle capturing assembly **110** when the needle **112** is captured by the needle capturing assembly **110**. The base **202** may include a locking mechanism that facilitates secure lodging of the base **202** within the cavity **104**. In a non-limiting example, the base **202** is shown to include first and second locking members **206***a* and **206***b*. The first and second locking members **206***a* and **206***b* may be dimensioned to mate with corresponding structures formed on or carved into the surface of inside walls of the cavity **104** (for example, as described below in connection with FIG. **3**A), thereby locking the base **202** in the cavity **104** in a “snap-fit” fashion when the base

202 is pressed into the cavity **104**. Alternatively, the base **202** can be securely lodged in the cavity **104** using, for example, a pin and groove arrangement other structure(s) known to those skilled in the art.

(87) The clamp **204** includes a first lever **208***a* and a second lever **208***b*. The first lever **208***a* includes a jaw portion **210***a* and a handle portion **212***a* and the second lever **208***b* includes a jaw portion **210***b* and a handle portion **212***b*. The second lever **208***b* is secured to the first lever **208***a* by a pivot pin **214** such that the jaw portion **210***b* of the second lever **208***b* is rotatable about the axis of the pivot pin **214** enabling relative motion between the first and second levers **208***a* and **208***b*. By squeezing on the handle portions **212***a* and **212***b* of the first and second levers **208***a* and **208***b*, the jaw portions **210***a* and **210***b* may be operated to clamp the end of the needle **112**.

(88) In one embodiment, the jaw portion **210***a* of the first lever **208***a* and/or the jaw portion **210***b* of the second lever **208***b* has a profile that facilitates clamping of the needle **112** between the jaw portions **210***a* and **210***b*. For example, a profile **215** of the jaw portion **210***b* may be of curve shape as shown in FIG. **2**B. Alternatively, the profile **215** may be of any other shape that facilitates clamping of the end of the needle **112** by the jaw portions **210***a* and **210***b*. One or both of the jaw portion **210***a* and the jaw portion **210***b* may also include ridges or other surface textures and/or be made of certain materials, e.g., rubber, to facilitate clamping of the needle **112**. The first lever **208***a* is preferably designed to include a first channel **216***a* and a second channel **216***b*. The second channel **216***b* is preferably wider than the first channel **216***a* and is preferably aligned with the first channel **216***a* (as shown in FIG. **2**D). The first channel **216***a* is dimensioned and positioned to receive the needle **112** when the apparatus **200** is in use. The second channel **216***b* is dimensioned and positioned to receive the needle pusher **116** when the apparatus **200** is in use.

(89) As shown in FIG. **2**C, the first lever **208***a* includes a protrusion **218** that extends outwardly from a bottom surface of the first lever **208***a*. The protrusion **218** has a cross section that generally looks like the letter “T” (as shown in FIG. **2**D) and is provided with an extended pin **220**. The protrusion **218** is slidably positioned into a groove **222**, having a cross section that generally looks like the inverted letter “T”, formed on a top surface of the base **202**. Formed within the groove **222** is a guide channel **224** to accommodate the extended pin **220**. The guide channel **224** is dimensioned and positioned to allow the extended pin **220** to horizontally slide within the guide channel **224**. Although the protrusion **218** and the groove **222** are shown to have a “T” shaped cross-section, they may have a variety of other cross-sectional shapes to allow the clamp **204** to slide with respect to and remained engaged with the base **202**.

(90) The length of the guide channel **224** is selected to define a range of positions that the clamp **204** can occupy with respect to the base **202**. For example, the length of the guide channel **224** may be such that it allows the clamp **204** to be slid from a first position to a second position and vice-versa with respect to the base **202**. In the first position, the clamp **204** is positioned to be operable to clamp the end of the needle **112** extending from the needle capturing assembly **110**. The clamp **204**, while clamping the needle **112**, may be moved from the first position to the second position to disengage the needle **112** from the needle capturing assembly **110**.

(91) Operation of the apparatus **200** is explained in greater detail in conjunction with FIGS. **3**A-**3**E.

(92) As shown in FIG. **3**A, the needle **112** and suture **120** have been passed through the tissue **103** and the operating handle **118** has been retracted from the fully advanced position to the fully retracted position, thereby retracting the needle pusher **116** such that it disengages from the needle **112** while the needle **112** remains captured by the needle capturing assembly **110** and also thereby retracting the blocking member **124** such that it no longer blocks the first aperture **126**. As a result, the vacuum is no longer applied to the cavity **104** and the suctioned tissue **103** is released from the cavity **104** while the suture **120** remains passed through the tissue **103**. At this point, the suturing device **100** is removed from the body and the base **202** of the apparatus **200** is placed within the cavity **104**. It should be appreciated that, in the fully retracted position, the needle pusher **116** is sufficiently retracted so as to prevent the needle pusher **116** from interfering with the coupling

between the apparatus **200** and the cavity **104** when the base **202** of the apparatus **200** is inserted into the cavity **104**. Further, because the entirety of the needle **112** has passed across the second wall **104***b* of the cavity **104**, the needle **112** does not interfere with the coupling between the apparatus **200** and the cavity **104** when the base **202** of the apparatus **200** is inserted into the cavity **104**. When the base **202** of the apparatus **200** is placed in the cavity **104**, the first and second locking members **206***a* and **206***b* may interface with corresponding structures on and/or formed in walls of the cavity to securely lock the base **202** within the cavity **104** as described above. For example, the corresponding structures may be a first slot (not shown) and a second slot **302** formed in the side walls of the cavity **104** and dimensioned and positioned to engage with the first and second locking members **206***a* and **206***b*, respectively. FIG. **3**B illustrates a cross-sectional side view of the suturing device **100** when the base **202** of the apparatus **200** is placed in the cavity **104** and secured by the engagement of the first and second locking members **206***a* and **206***b* with the first slot and the second slot **302**, respectively

(93) FIG. **3**C illustrates an enlarged perspective view of the distal end **102***b* of the apparatus **200** coupled with the suturing device **100**, in accordance with an exemplary embodiment of the present disclosure. Once the base **202** is secured in the cavity **104**, a user of the suturing device **100** slides the clamp **204** with respect to the base **202** in the direction X′, for example by pushing on the first and second levers **208***a* and **208***b*. As the clamp **204** is moved in the direction X′, the end of the needle **112** extending from the needle capturing assembly **110** is received in the first channel **216***a* of the clamp **204** as shown in the enlarged diagram of FIG. **3**C. Once the end of the needle **112** extending from the needle capturing assembly **110** is positioned in the first channel **216***a* of the clamp **204**, the second lever **208***b* is moved relative to the first lever **208***a* such that the jaw portion **210***b* of the second lever **208***b* is moved relative to the jaw portion **210***a* of the first lever **208***a* to clamp the needle **112**. Once the needle **112** is clamped by the jaw portion **210***a* and the jaw portion **210***b* with sufficient clamping force, the clamp **204** may be moved with respect to the base **202** in the direction X, for example, by pulling on the first and second levers **208***a* and **208***b*, while maintaining the clamping force on the needle **112**. In this manner, the needle **112** may be extracted from the needle capturing assembly **110**.

(94) FIG. **3**D illustrates an enlarged view of the distal end **102***b* of the suturing device **100** coupled with the apparatus **200**, in accordance with an exemplary embodiment of the present disclosure. As shown in FIG. **3**D, the clamp **204** has been moved with respect to the base **202** in the direction X, for example, by pulling on the first and second levers **208***a* and **208***b* to extract the needle **112** from the needle capturing assembly **110**. The clamp **204** may then be further moved in the direction X to the second position to allow the needle pusher **116** to re-engage with the needle **112**.

(95) FIG. **3**E illustrates an enlarged perspective view of the distal end **102***b* of the apparatus **200** coupled with the suturing device **100** when the operating handle **118** has been moved to a partially advanced position subsequent to the extraction of the needle **112** from the needle capturing assembly **110** as described above in connection with FIGS. **3**C and **3**D. As shown in FIG. **3**E, once the needle **112** has been extracted from the needle capturing assembly **110**, the operating handle **118** may be progressively advanced from the fully retracted position towards the fixed handle **122** in the direction X, thereby advancing the needle pusher **116** until the needle pusher **116** is positioned with the second channel **216***b* and re-engages with the end of the needle **112** with the suture **120** attached thereto. Preferably, the needle pusher **116** is advanced until the second detent **132***b* of the needle pusher **116** engages with the ball **138***b* of the ball-spring detent mechanism **130** to create the audible and/or tactile feedback described above, such that the user is made aware that the needle pusher **116** has re-engaged the end of the needle **112**. Following re-engagement of the needle **112** with the needle pusher **116**, the operating handle **118** may be retracted towards the fully retracted position such that the needle **112** is returned to the position shown in FIG. **1**A. Once the needle **112** is in the position shown in FIG. **1**A, the user of the suturing device **100** may de-couple the apparatus **200** from the cavity **104**, reposition the suturing device **100** within the subject's body

through, for example, the same incision or another incision, and re-pass the needle **112** and the suture **120** through the tissue **103** previously sutured (or another tissue) and create a second stitch. It should be appreciated that by repeating the foregoing procedure, the suturing device **100** may be operated to make multiple passes of the needle **112** and the suture **120** through tissue **103** (or another tissue) and thereby make multiple stitches using the needle **112** and the suture **120**.

(96) FIGS. **4**A-**4**C illustrate top perspective, exploded, and rear perspective views, respectively, of an apparatus **400** for use with a suturing device **500** (see FIGS. **5**A and **5**B) to release the needle **112** from the needle capturing assembly **110** of the suturing device **500** and reposition the needle **112** so as to be reengaged by the needle pusher **116** of the suturing device **500** in accordance with an exemplary embodiment of the present disclosure. It should be appreciated that the suturing device **500** is structurally and functionally similar to the suturing device **100** of FIG. **1**A, only modified to accommodate the apparatus **400** as described below. The apparatus **400** comprises a base **402** and a clamp **404**. The clamp **404** is functionally similar to the clamp **204** of the apparatus **200**, but is structurally modified with respect to the clamp **204**, for example, in order to operate with the suturing device **500**.

(97) As shown in FIGS. **4**A and **4**B, the clamp **404** includes a first lever **408***a* and a second lever **408***b*. The first lever **408***a* includes a jaw portion **410***a* and a handle portion **412***a* and the second lever **408***b* includes a jaw portion **410***b* and a handle portion **412***b*. The second lever **408***b* is secured to the first lever **408***a* by a pivot pin **414** such that the jaw portion **410***b* of the second lever **408***b* is rotatable about the axis of the pivot pin **414** enabling relative motion between the first and second levers **408***a* and **408***b*. By squeezing on the handle portions **412***a* and **412***b* of the first and second levers **408***a* and **408***b*, the jaw portions **410***a* and **410***b* may be operated to clamp the end of the needle **112** as will be described in more detail below. In one embodiment, the jaw portion **410***a* of the first lever **408***a* and/or the jaw portion **410***b* of the second lever **408***b* has a profile that facilitates clamping of the end of the needle **112** between the jaw portions **410***a* and **410***b*. For example, a profile **415** of the jaw portion **410***b* may be of curve shape as shown in FIG. **4**B. Alternatively, the profile **415** may be of any other shape that facilitates clamping of the end of the needle **112** by the jaw portions **410***a* and **410***b*. One or both of the jaw portion **410***a* and the jaw portion **410***b* may also include ridges or other surface textures and/or be made of certain materials, e.g., rubber, to facilitate clamping of the needle **112**. The first lever **408***a* is preferably designed to include a first channel **416***a* and a second channel **416***b*. The second channel **416***b* is preferably wider than the first channel **416***a* and is preferably aligned with the first channel **416***a* (as shown in FIG. **4**C). The first channel **416***a* is dimensioned and positioned to receive the needle **112** when the clamp **404** is in use. The second channel **416***b* is dimensioned and positioned to receive the needle pusher **116** when the apparatus **400** is in use.

(98) As shown in FIG. **4**A, the first lever **408***a* further includes first and second arms **418***a* and **418***b* having first and second guide pins **406***a* and **406***b*, respectively, extending therefrom. As further shown in FIG. **4**A, the base **402** extends from a bottom surface of the first lever **408***a*. The base **402** is preferably dimensioned to fit within the cavity **104** of the suturing device **500** to allow sufficient room for the base **402** to slide within the cavity **104**, for example, between first wall **104***a* (as shown in FIG. **5**E) and second wall **104***b* (as shown in FIG. **5**G). The movement of the base **402** within the cavity **104** defines movement of the apparatus **400** for removing the needle **112** from the needle capturing assembly **110** and re-engaging the needle **112** with the needle pusher **116** as will be described in more detail below in connection with FIGS. **5**A-**5**H.

(99) FIGS. **5**A-**5**C illustrate a first perspective view, a second perspective view, and a cross-sectional side view, respectively, of the suturing device **500** with the apparatus **400** mounted thereto, in accordance with an exemplary embodiment of the present disclosure. As shown in FIGS. **5**A and **5**B, the apparatus **400** is in a resting position. The suturing device **500** is functionally and structurally similar to the suturing device **100** of the previous embodiments. Unlike the suturing device **100**, however, the suturing device **500** includes a first groove **502***a* and a second groove

502*b* both of which extend longitudinally along a peripheral surface of the elongated member **102**. The first groove **502***a* and the second groove **502***b* are preferably positioned parallel and diametrically opposite to each other. The suturing device **500** further includes first and second protuberances **504***a* and **504***b* that are positioned in proximity to the proximal end **102***a* of the elongated member **102**, and a bore **506** (as shown in FIG. **5**D) that is formed in the elongated member **102** in proximity to the first and second protuberances **504***a* and **504***b*. The first and second grooves **502***a* and **502***b* also extend longitudinally over the first and second protuberances **504***a* and **504***b*, respectively. The first and second protuberances **504***a* and **504***b* are dimensioned to allow the clamp **404** to securely rest on the elongated member **102** at the proximal end **102***a* of the suturing device **500** as shown in FIG. **5**A when the clamp **404** is not in use (i.e., when the clamp **404** is in the resting position). While in the resting position, the base **402** of the apparatus **400** sits within the bore **506** to further help secure the apparatus **400** in position. As shown in FIG. **5**A, the first and second guide pins **406***a* and **406***b* (shown in FIG. **4**B) of the clamp **404** extend inwardly into the first groove **502***a* and the second groove **502***b*, respectively, such that the clamp **404** may slide along the length of the elongated member **102** while the first and second guide pins **406***a* and **406***b* track respective ones of the first groove and the second groove **502***a* and **502***b*.

(100) Operation of the apparatus **400** will now be explained in greater detail in conjunction with FIGS. **5**D-**5**H.

(101) As shown in FIG. **5**D, the needle **112** and suture **120** have been passed through the tissue **103** and the operating handle **118** has been retracted from the fully advanced position to the fully retracted position, thereby retracting the needle pusher **116** such that it disengages from the needle **112** while the needle **112** remains captured by the needle capturing assembly **110** and also thereby retracting the blocking member **124** such that it no longer blocks the first aperture **126** (not shown). As a result, the vacuum is no longer applied to the cavity **104** and the suctioned tissue **103** is released from the cavity **104** while the suture **120** remains passed through the tissue **103**. At this point, the suturing device **500** is removed from the body and the apparatus **400** is lifted from its resting position and slid along towards the distal end **102***b* of the suturing device **500** in the direction X′ until the base **402** is aligned above the cavity, upon which the apparatus **400** is lowered such that the base **402** is positioned within the cavity. It should be appreciated that, in the fully retracted position, the needle pusher **116** is sufficiently retracted so as to prevent the needle pusher **116** from interfering with the coupling between the apparatus **400** and the cavity **104** when the base **402** of the apparatus **400** is inserted into the cavity **104**. Further, because the entirety of the needle **112** has passed across the second wall **104***b* of the cavity **104**, the needle **112** does not interfere with the coupling between the apparatus **400** and the cavity **104** when the base **402** of the apparatus **400** is inserted into the cavity **104**. As described below, when the apparatus **400** is in this position, the apparatus **400** may be operated to release the needle **112** from the needle capturing assembly **110** and repositioned the needle **112** so as to be reengaged by the needle pusher **116** to perform one or more successive suturing operations as described above.

(102) As shown in FIG. **5**E, when the base **402** of the apparatus **400** is initially positioned within the cavity **104**, the base **402** is against the first wall **104***a* of the cavity **104**. Thereafter, the apparatus **400** is further moved in the direction X′ towards the distal end **102***b* of the suturing device **500** until the base **402** is against the second wall **104***b* of the cavity **104**. In this position, the end of the needle **112** extending from the needle capturing assembly **110** is received by in the first channel **416***a* of the first lever **408***a* as shown in FIGS. **5**F and **5**G. Once the needle **112** is positioned within the first channel **416***a*, the user of the suturing device **500** may squeeze the first handle **412***a* and the second handle **412***b* to clamp the needle **112** as shown in FIG. **5**H. Once the needle **112** is clamped with a sufficient clamping force, the user of the suturing device **500** may slide the apparatus **400** in the direction X towards the proximal end **102***a* of the suturing device **500** until the base **402** of the apparatus **400** meets the first wall **104***a* of the cavity **104**, for example, by pulling on the first and second handles **412***a* and **412***b*, thereby extracting the needle **112** from the

needle capturing assembly **110** as shown in FIGS. **5**H and **5**I.
(103) Once the needle **112** has been extracted from the needle capturing assembly **110**, the operating handle **118** may be progressively advanced from the fully retracted position towards the fixed handle **122** in the direction X′, thereby advancing the needle pusher **116** until the needle pusher **116** is positioned with the second channel **416***b* and re-engages with the end of the needle **112**. Preferably, the needle pusher **116** is advanced until the second detent **132***b* of the needle pusher **116** engages with the ball **138***b* of the ball-spring detent mechanism **130** to create the audible and/or tactile feedback described above, such that the user is made aware that the needle pusher **116** has re-engaged the end of the needle **112**. Following re-engagement of the needle **112** with the needle pusher **116**, the operating handle **118** may be retracted towards the fully retracted position such that the needle **112** is returned to the position shown in FIG. **1**A. Once the needle **112** is in the position shown in FIG. **1**A, the user of the suturing device **500** may slide the apparatus **400** back to the resting position, reposition the suturing device **500** within the subject's body via the same incision or another incision, and re-pass the needle **112** and the suture **120** through the tissue **103** previously sutured or pass the needle **112** and the suture **120** through another tissue. It should be appreciated that by repeating the foregoing procedure, the suturing device **500** may be operated to make multiple passes of the needle **112** and the suture **120** through tissue **103** (or another tissue) and thereby make multiple stitches without having to replace the needle **112** or the suture **120**.
(104) FIG. **6**A illustrates perspective view of an apparatus **600** for use with a suturing device **700** (shown in FIG. **7**A), in accordance with an exemplary embodiment of the present disclosure. It should be appreciated that the suturing device **700** is structurally and functionally similar to the suturing device **100** of FIG. **1**A, only modified to accommodate the apparatus **600** as described below. The apparatus **600** may be used to release the needle **112** from the needle capturing assembly **110** of the suturing device **700** and reposition the needle **112** so as to be reengaged by the needle pusher **116** of the suturing device **700**.
(105) As shown in FIG. **6**A in accordance with an exemplary embodiment of the present disclosure, the apparatus **600** includes a sliding member **602** and a support handle **604**. The sliding member **602** is dimensioned to fit over the elongated member **102** of the suturing device **700**. For example, the sliding member **602** is shown in FIG. **6**A as an arc-shaped or semi-circular structure. In a non-limiting example, the sliding member **602** may be suitably configured to fit (as shown in FIGS. **7**A-**7**E) over the elongated member **102** in a “press-fit” or “snap-fit” fashion. The sliding member **602** further includes a clamping platform **606** that includes, therein, a channel **608***a* and a channel **608***b* (as shown in FIG. **7**B). The channel **608***b* is preferably wider than the channel **608***a* and is preferably aligned and overlapped with the channel **608***a*. The channel **608***a* is sized and positioned to receive the needle **112**. The channel **608***b* is sized and positioned to receive the needle pusher **116**. The clamping platform **606** is attached to a base **609**. The base **609** is preferably dimensioned to fit within the cavity **104** of the suturing device **700** to allow sufficient room for the base **609** to slide from one end of the cavity **104** to the other end of the cavity **104** as shown in FIGS. **7**C, **7**D, and **7**E. The sliding member **602** further includes a first pivot pin **610***a* (see FIG. **6**A) and a second pivot pin **610***b* (not shown, but on the opposite side of the sliding member **602**) that protrude from a peripheral surface of the sliding member **602**.
(106) The support handle **604** includes a handle bar **612** and a coupling member **614** that is attached to the handle bar **612**. The coupling member **614** includes first and second pivot holes **616***a* and **616***b*. The first and second pivot holes **616***a* and **616***b* are suitably configured to engage with the first and second pivot pins **610***a* and **610***b*, for coupling the support handle **604** to the sliding member **602** as shown in FIG. **6**B. The support handle **604** can be rotated about the first and second pivot pins **610**. In other words, the coupling between the support handle **604** and the sliding member **602** enables rotation of the support handle **604** along directions H and H′ relative to the sliding member **602**.
(107) The coupling member **614** further includes a first protruding member **618** that is configured

to clamp the needle **112** to the clamping platform **606** when the user rotates the support handle **604** along the direction H, while attempting to reposition the needle **112** in the channel **608***a* of the clamping platform **606**. The clamping platform **606** is designed to engage with the first protruding member **618** in order to clamp the needle **112** for removing the needle **112** from the needle capturing assembly **110**. The sliding member **602** further includes a first rail **620***a* and a second rail **620***b* that are positioned parallel and opposite to each other. The first and second rails **620***a* and **620***b* are protruded internally from bottom edges of the sliding member **602**. In one embodiment, the apparatus **600** and its various parts may be made of a material or materials designed to ensure proper functioning of the apparatus **600** and clamping of the needle **112**. Such materials may include polymers, composites, metals or the like.

(108) FIG. **7**A illustrates a perspective view of the suturing device **700** and the apparatus **600**, in accordance with an exemplary embodiment of the present disclosure. As shown in FIG. **7**A, the suturing device **700** is structurally and functionally similar to the suturing device **100** of the previous embodiments. Unlike the suturing device **100**, however, the suturing device **700** includes a first sliding track **702***a* and a second sliding track **702***b* (not shown) opposite the first sliding track **702***a* formed in the elongated member **102**. As shown in FIG. **7**A, the suturing device **700** has been removed from the body, the needle **112** has been captured by the needle capturing assembly **110** following the suturing of the suctioned tissue **103**, the operating handle **118** has been retracted from the fully advanced position to the fully retracted position, thereby retracting the needle pusher **116** and disengaging the needle pusher **116** from the needle **112** while the needle **112** remains captured by the needle capturing assembly **110**. It should be appreciated that the needle pusher **116** is sufficiently retracted so as to prevent the needle pusher **116** from interfering with the coupling between the apparatus **600** and the cavity **104** when the sliding member **602** is fitted to the suturing device **700**. The first and second rails **620***a* and **620***b* of the sliding member **602** engage slidably with the first sliding track **702***a* and the second sliding track **702***b*, respectively of the suturing device **700**. Further, it is assumed that the entirety of the needle **112** has passed across the second wall **104***b* of the cavity **104**, thereby preventing the needle **112** from interfering with the fitment of the sliding member **602** to the suturing device **700**.

(109) The sliding member **602** is suitably configured to slide, in directions X and X′, along the first sliding track **702***a* and the second sliding track **702***b*. The first sliding track **702***a* and the second sliding track **702***b*, in conjunction with the base **609**, define a range of positions that the sliding member **602** can occupy, relative to the suturing device **700**. For example, the length of the first sliding track **702***a* and the second sliding track **702***b* allows the sliding member **602** to be slid from a first position to a second position and vice-versa with respect to the elongated member **102**. When the sliding member **602** is in the first position, the clamping platform **606** is positioned to receive the first end of the needle **112** extending from the needle capturing assembly **110**. The user may clamp the needle **112** to the clamping platform **606** using the first protruding member **618** (as described earlier). While the needle **112** is clamped to the clamping platform **606** with sufficient clamping force, the sliding member **602** may be moved from the first position to the second position to disengage the needle **112** from the needle capturing assembly **110**.

(110) FIG. **7**C illustrates an enlarged view of the suturing device **700** and the apparatus **600**, in accordance with an exemplary embodiment of the present disclosure. The sliding member **602** is slid to the first position of the suturing device **700**. The needle **112** is captured by the needle capturing assembly **110** and the operating handle **118** is in the fully retracted position such that the needle **112** is disengaged from the needle pusher **116**. In order to extract the needle **112** from the needle capturing assembly **110** and reposition the needle **112** such that it is re-engaged by the needle pusher **116**, a user of the suturing device **700** may, using the handle bar **612**, move the support handle **604** downwards (i.e., along direction H) towards the clamping platform **606**. As the support handle **604** is moved in this manner, the first end of the needle **112** extending from the needle capturing assembly **110** is clamped in the channel **608***a* in the clamping platform **606**. Once

the needle **112** is positioned within the channel **608***a* in the clamping platform **606**, the user of the suturing device **700** may squeeze the handle bar **612** to hold the needle **112** within the channel **608***a* in the clamping platform **606**. Once the needle **112** is clamped with a sufficient clamping force, the user of the suturing device **700** may slide the apparatus **600** towards the fixed handle **122**, for example, by pulling the apparatus along the direction X, until the needle **112** is extracted from the needle capturing assembly **110**.

(111) FIG. **7**D illustrates an enlarged view of the apparatus **600** at the distal end **102***b* of the suturing device **700** when the apparatus **600** is retracted towards the fixed handle **122** (i.e., away from the distal end **102***b*) subsequent to the extraction of the needle **112** from the needle capturing assembly **110** as described above. In accordance with an exemplary embodiment of the present disclosure, once the needle **112** has been extracted from the needle capturing assembly **110**, the operating handle **118** may be progressively advanced from the fully retracted position towards the fixed handle **122**, thereby advancing the needle pusher **116** until the needle pusher **116** re-engages with the end of the needle **112**. The needle pusher **116** is received in the channel **608***b* of the clamping platform **606**.

(112) FIG. **7**E illustrates the needle **112** re-engaged with the needle pusher **116** following a completion of above procedure. Following the re-engagement of the needle **112** with the needle pusher **116**, the apparatus **600** may be detached from the suturing device **700**, for example, by pulling on the apparatus **600** such that it disengages from the first sliding track **702***a* and the second sliding track **702***b*, the operating handle **118** may be retracted towards the fully retracted position such that the needle **112** is in the position shown in FIG. **1**A, and the suturing device **700** and the apparatus **600** may be operated as described above to administer one or more additional passes of the needle **112** and suture **120** through tissue **103** (or another tissue) and thereby make multiple stitches without having to replace the needle **112** or the suture **120**.

(113) FIG. **8**A-**8**C illustrate perspective and exploded views of an apparatus **800** for use with a suturing device **900** (shown in FIG. **9**A), in accordance with an exemplary embodiment of the present disclosure. It should be appreciated that the suturing device **900** is structurally and functionally similar to the suturing device **100** of FIG. **1**A, only modified to accommodate the apparatus **800** as described below. The apparatus **800** may be used to release the needle **112** from the needle capturing assembly **110** of the suturing device **100** and reposition the needle **112** so as to be reengaged by the needle pusher **116** of the suturing device **900**.

(114) As shown in FIG. **8**A, the apparatus **800** includes a sliding member **802** and a lever **804**, as shown in an accordance with an embodiment of the invention. The sliding member **802** is dimensioned to fit over the elongated member **102** of the suturing device **900**. For example, the sliding member **802** is shown in FIG. **8**A as an arc-shaped or semi-circular structure. In a non-limiting example, the sliding member **802** may be suitably configured to fit (as shown in FIGS. **9**A-**9**J) over the elongated member **102** in a “press-fit” or “snap-fit” fashion. The sliding member **802** further includes, therein, a clamping platform **806** that includes, therein, a channel **808***a* and a channel **808***b* (shown in FIG. **8**B). The channel **808***b* is preferably wider than the channel **808***a* and is preferably aligned and overlapped with the channel **808***a*. The channel **808***a* is sized and positioned to receive the needle **112**. The channel **808***b* is sized and positioned to receive the needle pusher **116**. The clamping platform **806** is attached to a base **809** that is dimensioned to fit into the cavity **104** of the suturing device **900**. The base **809** is dimensioned such that sufficient room is allowed for the base **809** to slide from one end of the cavity **104** to the other end of the cavity **104** (i.e., from the first wall of the cavity to the second wall of the cavity), as shown in FIGS. **9**B and **9**F. The sliding member **802** further includes first and second pivot pins **810***a* and **810***b* (shown in FIG. **8**B) that protrude from a peripheral surface of the sliding member **802**. The sliding member **802** further includes first and second side support members **811***a* and **811***b*. The first and second side support members **811***a* and **811***b* are intended to provide ergonomic support to the user for moving the sliding member **802** over the elongated member **102** of the suturing device **900**. For

example, the user may choose to rest his thumb and index finger on the first and second side support members **811***a* and **811***b*, respectively, while moving the sliding member **802** over the elongated member **102**.

(115) The lever **804** includes a handle bar **812** and first and second arms **814***a* and **814***b* that extend from the handle bar **812**. As shown in FIG. **8**C, the first and second arms **814***a* and **814***b* include first and second pivot holes **816***a* and **816***b*, respectively. The first and second pivot holes **816***a* and **816***b* are suitably configured to engage with the first and second pivot pins **810***a* and **810***b*, for coupling the lever **804** to the sliding member **802** as shown in FIG. **8**A. The lever **804** can be rotated about the first and second pivot pins **810***a* and **810***b*. In other words, the coupling between the lever **804** and the sliding member **802** enables rotation of the lever **804** along the directions H and H′, relative to the sliding member **802**. In an embodiment, the lever **804** may be attached to the sliding member **802** through a living hinge. In this scenario, the apparatus **800** may be manufactured in entirety as a single unit with the use of a 3D printing machine.

(116) The lever **804** further includes a protruding member **818** that is configured to clamp the needle **112** to the clamping platform **806** when the user rotates the lever **804** along the direction H, while attempting to reposition the needle **112** in the channel **808***a* of the clamping platform **806**. The clamping platform **806** is designed to engage with the protruding member **818** in order to clamp the needle **112** for removing the needle **112** from the needle capturing assembly **110**. The lever **804** includes a snap ledge **820** that protrudes from a bottom surface thereof. The snap ledge **820** includes a mating surface **821** that is suitably configured to engage with a locking member **822**. The locking member **822** protrudes outwardly from a top support member **824** that is included in the sliding member **802**. The mating surface **821** of the snap ledge **820** and the locking member **822** are suitably dimensioned to enable the mating surface **821** to interlock with the locking member **822** in a snap-fit or press-fit fashion. The snap ledge **820** may be interlocked with the locking member **822** (as shown in FIG. **8**D) when the user applies sufficient force on the handle bar **812** along the direction H. When the snap ledge **820** is locked to or interlock with the locking member **822**, the protruding member **818** clamps the needle **112** to the clamping platform **806**, and the needle **112** remains clamped to the clamping platform **806** until the user disengages the snap ledge **820** from the locking member **822**. In other words, the needle **112** remains clamped to the clamping platform **806** until the user releases the snap ledge **820** from the locking member **822**. This allows user to effortlessly use the apparatus **800** for easy retraction and re-engagement of the needle **112**.

(117) The user may release the snap ledge **820** from the locking member **822** by applying sufficient force on the top support member **824** along the direction H. The user is required to apply the force along an edge of the top support member **824** that is opposite to the locking member **822**. Application of the force on the top support member **824** along the direction H causes an edge adjoined to the locking member to move along the direction H′, releasing the snap ledge **820** from the locking member **822**.

(118) The sliding member **802** further includes a first linear guide **826***a* and a second linear guide **826***b* that are positioned parallel and opposite to each other. The first and second linear guides **826***a* and **826***b* are protruded internally from bottom edges of the sliding member **802**. In one embodiment, the apparatus **800** and its various parts may be made of a material or materials designed to ensure proper functioning of the apparatus **800** and clamping of the needle **112**. Such materials may include polymers, composites, metals or the like.

(119) FIGS. **8**D, **8**E, and **8**F illustrate front perspective view, rear perspective view, and front view of the apparatus **800**, in accordance with an exemplary embodiment of the present disclosure. FIGS. **8**E and **8**D show the snap ledge **820** interlocked with (i.e., locked to) the locking member **822**.

(120) FIG. **8**G illustrates a bottom view of the apparatus **800**, in accordance with an exemplary embodiment of the present disclosure. FIG. **8**F illustrates the apparatus **800** as viewed from the

front of the apparatus **800**. As shown in FIG. **8**G, an inner surface of the sliding member **802** may include a groove **828**, engraved therein, for accommodating the suture **120** when the apparatus **800** is placed atop the elongated member **102** of the suturing device **900**. The groove **828** allows the suture **120** to extend out of the apparatus **800** without intervening with the operation of the apparatus **800**. Moreover, the groove **828** prevents any damage to the suture **120** during the operation of the apparatus **800**. The groove **828** may take various forms, including that shown in FIG. **8**G as well as a straight groove.

(121) FIGS. **9**A and **9**B illustrate a perspective view and an enlarged view of the suturing device **900** and the apparatus **800**, in accordance with an exemplary embodiment of the present disclosure. As shown in FIGS. **9**A and **9**B, the suturing device **900** is structurally and functionally similar to the suturing device **700** of FIG. **7**A. The suturing device **900** includes a first guide slot **902***a* and a second guide slot **902***b* (not shown) opposite the first guide slot **902***a* formed in the elongated member **102**. As shown in FIG. **9**A, the suturing device **900** has been removed from the body, the needle **112** has been captured by the needle capturing assembly **110** following the suturing of the suctioned tissue **103**, the operating handle **118** has been retracted from the fully advanced position to the fully retracted position, thereby retracting the needle pusher **116** and disengaging the needle pusher **116** from the needle **112** while the needle **112** remains captured by the needle capturing assembly **110**, and the suctioned tissue **103** has been released from the cavity **104**. It should be appreciated that the needle pusher **116** is sufficiently retracted so as to prevent the needle pusher **116** from interfering with the coupling between the apparatus **800** and the cavity **104** when the sliding member **802** is fitted to the suturing device **900**. The first and second linear guides **826***a* and **826***b* of the sliding member **802** engage slidably with the first guide slot **902***a* and the second guide slot **902***b*, respectively of the suturing device **900**. Further, it is assumed that the entirety of the needle **112** has passed across the second wall **104***b* of the cavity **104**, thereby preventing the needle **112** from interfering with the fitment of the sliding member **802** to the suturing device **900**. The sliding member **802** is suitably configured to slide, in the directions X and X′, along the first guide slot **902***a* and the second guide slot **902***b*. The first guide slot **902***a* and the second guide slot **902***b*, in conjunction with the base **809**, define a range of positions that the sliding member **802** can occupy, relative to the suturing device **900**. For example, the length of the first guide slot **902***a* and the second guide slot **902***b* allows the sliding member **802** to be slid from a first position to a second position and vice-versa with respect to the elongated member **102**. When the sliding member **802** is in the first position, the clamping platform **806** is positioned to receive the first end of the needle **112** extending from the needle capturing assembly **110**.

(122) FIGS. **9**C and **9**D illustrate a perspective view and an enlarged view of the suturing device **900** and the apparatus **800**, in accordance with an exemplary embodiment of the present disclosure. The sliding member **802** is slid to the first position of the suturing device **900**. The needle **112** is captured by the needle capturing assembly **110** and the operating handle **118** is in the fully retracted position such that the needle **112** is disengaged from the needle pusher **116**. FIG. **9**C shows the sliding member **802** in the first position and the clamping platform **806** positioned to receive the first end of the needle **112** extending from the needle capturing assembly **110**. As shown in FIG. **9**D, when the sliding member **802** is in the first position, the base **809** is in contact with the second wall **104***b*.

(123) FIGS. **9**E and **9**F illustrate a perspective view and an enlarged view of the suturing device **900** and the apparatus **800**, in accordance with an exemplary embodiment of the present disclosure. In order to extract the needle **112** from the needle capturing assembly **110** and reposition the needle **112** such that it is re-engaged by the needle pusher **116**, a user of the suturing device **900** may, using the handle bar **812**, move the lever **804** downwards (i.e., along the direction H) towards the clamping platform **806**. As the lever **804** is moved in this manner, the first end of the needle **112** extending from the needle capturing assembly **110** is clamped, by the protruding member **818**, in the channel **808***a* in the clamping platform **806**. Once the needle **112** is positioned within the

channel **808***a* in the clamping platform **806**, the user of the suturing device **900** may lock the snap ledge **820** with the locking member **822**. As shown in FIG. **9**F, the sliding member **802** in the first position and the needle **112** is clamped to the clamping platform **806** by the protruding member **818**.

(124) FIGS. **9**G and **9**H illustrate a perspective view and an enlarged view of the suturing device **900** and the apparatus **800**, in accordance with an exemplary embodiment of the present disclosure. Once the needle **112** is clamped with a sufficient clamping force, the user of the suturing device **900** may slide the apparatus **800** towards the fixed handle **122**, for example, by pulling the apparatus along the direction X, until the needle **112** is extracted from the needle capturing assembly **110**. As shown in FIG. **9**H, the sliding member **802** is in the second position and the needle **112** is clamped to the clamping platform **806** by the protruding member **818**.

(125) FIGS. **9**I and **9**J illustrate a perspective view and an enlarged view of the suturing device **900** and the apparatus **800**, in accordance with an exemplary embodiment of the present disclosure. In accordance with an exemplary embodiment of the present disclosure, once the needle **112** has been extracted from the needle capturing assembly **110**, the operating handle **118** may be progressively advanced from the fully retracted position towards the fixed handle **122**, thereby advancing the needle pusher **116** until the needle pusher **116** re-engages with the end of the needle **112**. As shown in FIGS. **91** and **9**J, the needle pusher **116** is received in the channel **808***b* of the clamping platform **806**. Following the re-engagement of the needle **112** with the needle pusher **116**, the user of the suturing device **900** may disengage the snap ledge **820** from the locking member **822**. In other words, the user may release the interlocking between the snap ledge **820** from the locking member **822** by moving in the direction H′ the back edge of the top support member **824**, that is opposite the locking member **822**. Upon disengaging the snap ledge **820** from the locking member **822**, the protruding member **818** no longer clamps the needle **112**.

(126) Subsequently, the operating handle **118** may be retracted towards the fully retracted position such that the needle **112** is in the position shown in FIG. **1**A. Then, the apparatus **800** may be detached from the suturing device **900**, and the suturing device **900** and the apparatus **800** may be operated as described above to administer one or more additional passes of the needle **112** and suture **120** through tissue **103** (or another tissue) and thereby make multiple suture passes.

(127) FIGS. **10**A-**10**C illustrate a perspective side view, a perspective top view, and a cross-sectional side view, respectively, of a suturing device **1000**, in accordance with an exemplary embodiment of the present disclosure. As shown in FIG. **10**A, the suturing device **1000** is structurally and functionally similar to the suturing device **100** of FIG. **1**. Differences between the suturing device **1000** and the suturing device **100** will be described below.

(128) As shown in FIGS. **10**A-**10**C, the suturing device **1000** includes an elongated member **1002** having a proximal end **1002***a* and a distal end **1002***b* (“proximal” and “distal” being from the perspective of a user of the suturing device **1000**). Like to the elongated member **102** of the suturing device **100**, the elongated member **1002** of the suturing device **1000** further includes a cavity **1004** for capturing tissue when a vacuum is applied to the cavity **1004**. Preferably, the cavity **1004**, like the cavity **104** of the suturing device **100**, is dimensioned to suit a particular application and to accommodate the type and amount of tissue that is to be captured. For example, the cavity **1004** may include a first wall **1004***a* (i.e., a front wall from the perspective of the user of the suturing device **1000**; shown in FIG. **10**C) at a first end of the cavity **1004** and a second wall **1004***b* (i.e., a rear wall from the perspective of the user of the suturing device **1000** shown in FIG. **10**C) at a second end of the cavity **1004** parallel and opposite to the first wall **1004***a*. As was the case with the cavity **104**, the cavity **1004** may have other shapes, such as an ovoid, cylindrical, cuboid, pyramidal, parabolic, conical, or free-form shape.

(129) However, unlike the elongated member **102** of the suturing device **100**, the elongated member **1002** of the suturing device **1000** further includes a guide structure **1006** provided between the cavity **1004** and the needle capturing assembly **110**. As will be explained in more detail below,

the guide structure **1006** maintains alignment of the needle pusher **116** and the needle **112** as they pass through tissue captured by the cavity **1004** and as the needle **112** is captured by the needle capturing assembly **110**. The guide structure **1006** also maintains alignment of the needle pusher **116** and the needle **112** as the needle **112** is extracted from the needle capturing assembly **110** and repositioned to be carried by the needle pusher **116** after the needle **112** has been captured by the needle capturing assembly **110** and the needle pusher **116** and the needle **112** have been separated. The guide structure **1006** also serves to limit the linear movement of the needle pusher **116** (and thus the needle **112** when it is carried by the needle pusher **116**) in the direction of the needle capturing assembly **110**.

(130) Preferably, the guide structure **1006** is formed such that the second wall **1004***b* of the cavity **1004** defines a first end surface of the guide structure **1006** (shown in FIGS. **10**D-**10**F) and a wall **1006***a* (shown in FIGS. **10**D-**10**F) that is opposite to the second wall **1004***b* defines a second end surface of the guide structure **1006**. The guide structure **1006** includes a first channel **1008***a* (shown in FIGS. **10**D-**10**H) extending from the second wall **1004***b* of the cavity **1004** towards, but not through, the wall **1006***a*. The guide structure **1006** also includes a second channel **1008***b* (shown in FIGS. **10**D-**10**F) extending from the wall **1006***a* towards the second wall **1004***b* until it meets with the first channel **1008***a*. Preferably, the first channel **1008***a* and the second channel **1008***b* are concentric (e.g., coaxial) and a path defined by the first channel **1008***a* and the second channel **1008***b* forms an extension of the working channel **106***a*.

(131) The first channel **1008***a* is preferably dimensioned such that the needle pusher **116** can be moved axially through the first channel **1008***a* with minimal friction with walls of the first channel **1008***a* while maintaining a desired amount of concentric alignment with the first channel **1008***a*, taking into account tolerances of materials used in the design of the suturing device **1000**. Further, the first channel **1008***a* is preferably wider at the second wall **1004***b* than it is at a point where the first channel **1008***a* meets the second channel **1008***b*. To accommodate this change in the diameter of the first channel **1008***a*, a portion of the first channel **1008***a* proximate the second wall **1004***b* may be shaped in a form of a frustum of a cone. Alternatively, the first channel **1008***a*, for its entire length, may be shaped in the form of a frustum of a cone. By increasing the diameter of the first channel **1008***a* at the second wall **1004***b* with respect to the diameter of the first channel **1008***a* at the point where it meets the second channel **1008***b*, one can minimize the chance that the distal tip of the needle pusher **116** (or the distal tip of the needle **112**, when carried by the needle pusher **116**), when being moved in the direction X′, strikes the second wall **1004***b*, and facilities the unobstructed movement of both the needle pusher **116** and the needle **112** through the first channel **1008***a* in the direction X′.

(132) The second channel **1008***b* is preferably dimensioned such that the needle **112** can be moved axially through the second channel **1008***b* with minimal friction with walls of the second channel **1008***b* while maintaining a desired amount of concentric alignment with the second channel **1008***b*, taking into account tolerances of materials used in the design of the suturing device **1000**. Further, preferably the diameter of the second channel **1008***b* is less than the diameter of the needle pusher **116**. It should be appreciated that when the diameter of the second channel **1008***b* is less than the diameter of the needle pusher **116**, a junction **1010** between the first channel **1008***a* and the second channel **1008***b* (shown in FIGS. **10**D and **10**G) acts as a stop for the needle pusher **116** when the needle pusher **116** is moved towards the distal end **1002***b* of the elongated member **1002**. In other words, the needle pusher **116** may pass through the first channel **1008***a* until it reaches the second channel **1008***b*. As a result, only the needle **112** may pass through the second channel **1008***b*.

(133) Preferably, the first channel **1008***a* includes an opening **1012** (shown in FIGS. **10**D, **10**E, and **10**I) that extends along a length of the first channel **1008***a* to allow the suture **120** to exit the first channel **1008***a* as the needle pusher **116** and the needle **112** move through the first channel **1008***a* and the second channel **1008***b*. In another embodiment, the opening **1012** may also extend along a length of the second channel **1008***b*.

(134) In addition, a top surface **1006***b* of the guide structure **1006** further includes a first recessed portion **1014***a* and a second recessed portion **1014***b* that are dimensioned to facilitate the use of an apparatus (e.g., a hemostat, forceps, needle holder, or the like) for extracting the needle **112** from the needle capturing assembly **110** as will be described in more detail below. Preferably, each of the first recessed portion **1014***a* and the second recessed portion **1014***b* is an angular recess formed on either side of the opening **1012** as shown. Also, the elongated member **1002** preferably includes an opening **1016** formed between the guide structure **1006** and the needle capturing assembly **110** to further facilitate the use of an apparatus (e.g., a hemostat, forceps, needle holder, or the like) for extracting the needle **112** from the needle capturing assembly **110** and positioning the needle **112** into the needle pusher **116** during operation of the suturing device **1000**. A bottom surface of the opening **1016** may also include a third recessed portion **1014***c* and a fourth recessed portion **1014***d* (shown in FIGS. **10**B, **10**D, and **10**G-**10**I) to accommodate such an apparatus.
(135) The elongated member **1002** further includes a third channel **1008***c* extending from a third wall **1018** towards the needle capturing assembly **110** (shown in FIG. **10**G). Preferably, the first channel **1008***a*, the second channel **1008***b*, and the third channel **1008***c* are concentric (e.g., coaxial) with respect to the working channel **106** such that the first channel **1008***a*, the second channel **1008***b*, and the third channel **1008***c* form an extension of the working channel **106***a*.
(136) The third channel **1008***c* is preferably dimensioned such that the needle **112** can be moved axially through the third channel **1008***c* with minimal friction with walls of the third channel **1008***c* while maintaining a desired amount of concentric alignment with the third channel **1008***c*, taking into account tolerances of materials used in the design of the suturing device **1000**. Further, the third channel **1008***c* is preferably wider at the third wall **1018** than it is at a point where the third channel **1008***c* meets the opening **113** housing the needle capturing assembly **110**. To accommodate this change in the diameter of the third channel **1008***c*, the third channel **1008***c* may, for part of its length proximate the third wall **1018**, be shaped in a form of a frustum of a cone as was the case with the embodiment of the first channel **1008***a* described above. Alternatively, the third channel **1008***c* may, for its entire length, be shaped in the form of a frustum of a cone as was the case with the embodiment of the first channel **1008***a*. By increasing the diameter of the third channel **1008***c* at the third wall **1018** with respect to the diameter of the third channel **1008***c* at the point where it meets the opening **113**, one can minimize the chance that the distal tip of the needle **112** when being moved in the direction X′, strikes the third wall **1018** and facilities the unobstructed movement of the needle **112** through the third channel **1008***c* in the direction X′.
(137) During operation of the suturing device **1000**, the user may push and/or pull the operating handle **118**, using the fixed handle **122** as leverage, to control the movement of the needle pusher **116** within the working channel **106***a*. Prior to such movement, the user may position the suture **120** in one or more of a set of cutouts including a first cutout **1020***a* and a second cutout **1020***b* (labelled in FIG. **10**B) formed in the fixed handle **122** and the operating handle **118**, respectively, to avoid entanglement of the suture **120** during operation of the suturing device **1000**. As was the case with the other embodiments described above, the user operating the suturing device **1000** may move the operating handle **118** from the fully retracted position towards the fixed handle **122** of the suturing device **1000**, until the operating handle **118** reaches its fully advanced position. FIGS. **10**A-**10**C illustrate the suturing device **1000** when the operating handle **118** is at the fully advanced position. When the operating handle **118** is in the fully advanced position, the operating handle **118** is preferably in contact with the fixed handle **122**. The longitudinal advancement of the operating handle **118** towards the fixed handle **122** forces the needle pusher **116**, and, consequently, the needle **112** and the suture **120**, to advance longitudinally from a current position towards the distal end **1002***b* of the elongated member **1002**. As the needle pusher **116**, the needle **112**, and the suture **120** are advanced, the needle **112**, the suture **120**, and the needle pusher **116** pass over the cavity **1004**. In doing so, the needle pusher **116**, the needle **112** and the suture **120** may penetrate the tissue **103** that has been suctioned into the cavity **1004** by the vacuum applied to the suction

channel **106***b* as described above in connection with the other embodiments.
(138) Eventually, the needle pusher **116**, the needle **112** and the suture **120** will pass through the first channel **1008***a* until the needle pusher **116** reaches the junction **1010** between the first channel **1008***a* and the second channel **1008***b*. At this point, only the needle **112** and the suture **120** (but not the needle pusher **116**) have passed through the second channel **1008***b* and the third channel **1008***c*, and needle **112** has been captured by the needle capturing assembly **110**. Preferably, once the needle **112** is captured by the needle capturing assembly **110**, the needle **112** extends from the needle capturing assembly **110** through the entirely of the third channel **1008***c*, the entirety of the second channel **1008***b*, and at least part way into the first channel **1008***a*.
(139) Once the needle **112** has been captured by the needle capturing assembly **110**, the operating handle **118** is retracted in the direction X such that the needle pusher **116** moves from the fully advanced position to the intermediate position while the needle **112** remains captured by the needle capturing assembly **110** and the tissue **103** remains captured in the cavity **1004**. As a result, the needle **112** disengages from the needle pusher **116**. Full retraction of the operating handle **118**, such that the needle pusher **116** moves from the intermediate position to the fully retracted position, causes the blocking member **124** to also retract such that it no longer blocks the first aperture **126**. As a result, the vacuum is no longer applied to the cavity **1004** and the suctioned tissue **103** is released from the cavity **1004** while the suture **120** remains passed through the tissue **103**. The user may then remove the suturing device **1000** from the patient's body.
(140) Once the suturing device **1000** has been removed from the patient's body, the operating handle **118** may be progressively advanced from the fully retracted position towards the fixed handle **122** in the direction X′, thereby advancing the needle pusher **116** until the needle pusher **116** is positioned within the first channel **1008***a* and re-engages with the portion of the needle **112** that was left to extend into the first channel **1008***a* as described above. Preferably, the needle pusher **116** is advanced until the second detent **132***b* of the needle pusher **116** engages with the ball **138***b* of the ball-spring detent mechanism **130** to create the audible and/or tactile feedback described above, such that the user is made aware that the needle pusher **116** has re-engaged the needle **112**.
(141) Once the needle pusher **116** has reengaged the needle **112**, the operating handle **118** may be retracted in the direction X so as to disengage the needle **112** from the needle capturing assembly **110**. And, when the operating handle **118** is in the fully retracted position, the needle pusher **116** and the needle **112** are in position to repeat the foregoing operation and create another stitch. However, if the user of the suturing device **1000** is unable to release the needle **112** from the needle capturing assembly **110** simply by retracting the operating handle **118** in the direction X, for example, in the event that the gripping force exerted by the needle pusher **116** on the needle **112** after the needle pusher **116** has reengaged the needle **112** is not sufficient to maintain engagement of the needle by the needle pusher **116** while the needle **112** is still captured by the needle capturing assembly **110**, the user of the suturing device **1000** may employ an apparatus, such as a hemostat, forceps, needle holder, or the like, to release the needle **112** from the needle capturing assembly **110**. Preferably, the needle **112** is released from the needle capturing assembly **110** while the end of the needle **112** remains engaged with the needle pusher **116** such that the as the needle **112** is moved in the direction X, the needle pusher **116** also moves in the direction X. Once the needle **112** is released from the needle capturing assembly **110**, the apparatus should no longer be needed and both the needle pusher **116** and the needle **112** may be fully retracted by simply retracting the operating handle **118** in the direction X.
(142) Various types of apparatus may be used by the user for extracting the needle **112** from the needle capturing assembly **110**. For example, a needle holder with a first jaw and a second jaw may be used to extract the needle **112** from the needle capturing assembly **110**. The first jaw and the second jaw of the needle holder may include, respectively, a first angled portion and a second angled portion. The first angled portion of the first jaw may be inclined at an angle with respect to a remaining portion of the first jaw. Similarly, the second angled portion of the second jaw may be

inclined at an angle with respect to a remaining portion of the second jaw. The first angled portion and the second angled portion may include, respectively, a first tip of the first jaw and a second tip of the second jaw. The needle holder may be held by the user in a manner such that the first angled portion and the second angled portion rest on the first recessed portion **1014***a* and the second recessed portion **1014***b*, respectively, and the needle **112** is held between the first jaw and the second jaw. In other words, the needle **112** is gripped or clamped between the first jaw and the second jaw of the needle holder. When the needle **112** is clamped between the first jaw and the second jaw with sufficient clamping force, the needle holder may be moved in a direction X (away from the distal end **1002***b*) so that the first angled portion and the second angled portion move or slide with respect to the first recessed portion **1014***a* and the second recessed portion **1014***b*. In this manner, the needle **112** may be extracted from the needle capturing assembly **110**.

(143) Once the needle pusher **116** and the needle **112** are in position to repeat the foregoing operation and create another stitch, the user may reposition the suturing device **1000** within the subject's body and re-pass the needle **112** and the suture **120** through the tissue **103** previously sutured or pass the needle **112** and the suture **120** through another tissue. It should be appreciated that by repeating the foregoing procedure, the suturing device **1000** may be operated to make multiple passes of the needle **112** and the suture **120** through tissue **103** (or another tissue) and thereby make multiple stitches without having to utilize a second needle or suture. It should be appreciated that relative dimensions and arrangement of the working channel **106**, the first channel **1008***a*, the second channel **1008***b*, the third channel **1008***c*, the needle pusher **116** and the needle **112**, as described above, ensure that the needle pusher **116** and the needle **112** remain axially aligned throughout the entire operation of the suturing device **1000**.

(144) FIG. **10**D illustrates an enlarged view of the distal end **1002***b* of the suturing device **1000** when the operating handle **118** is in a partially advanced position, in accordance with an exemplary embodiment of the present disclosure. In FIG. **10**D, the needle **112** is shown to pass over the cavity **1004**.

(145) FIG. **10**E illustrates an enlarged view of the distal end **1002***b* of the suturing device **1000** when the operating handle **118** is in the fully advanced position, in accordance with an exemplary embodiment of the present disclosure. Further, the needle pusher **116** is shown to have passed through the first channel **1008***a*, and the needle **112** is shown to have passed through the second channel **1008***b* so as to be captured by the needle capturing assembly **110**.

(146) FIG. **10**F illustrates an enlarged cross sectional side view of the distal end **1002***b* of the suturing device **1000** when the operating handle **118** is moved to the fully advanced position, in accordance with an exemplary embodiment of the present disclosure. In FIG. **10**F, the needle pusher **116** is shown to have passed through the first channel **1008***a* and the needle **112** is shown to have been captured by the needle capturing assembly **110**.

(147) FIG. **10**G illustrates an enlarged cross sectional side view of the distal end **1002***b* of the suturing device **1000**, in accordance with an exemplary embodiment of the present disclosure. In FIG. **10**G, the first channel **1008***a*, the second channel **1008***b*, and the third channel **1008***c* are shown.

(148) FIG. **10**H illustrates an enlarged top view of the distal end **1002***b* of the suturing device **1000** when the operating handle **118** is moved to the fully advanced position, in accordance with an exemplary embodiment of the present disclosure. In FIG. **10**H, the needle pusher **116** is shown to have passed through the first channel **1008***a* and the needle **112** is shown to have been captured by the needle capturing assembly **110**.

(149) FIG. **10**I illustrates an enlarged view of the distal end **1002***b* of the suturing device **1000** when the operating handle **118** is moved from the fully advanced position to the intermediate position, in accordance with an exemplary embodiment of the present disclosure. In FIG. **10**I, the needle **112** is shown to have been captured by the needle capturing assembly **110**. Further, in FIG. **10**I, the needle **112** is shown to have disengaged from the needle pusher **116** while a portion of the

needle **112** extends into the first channel **1008***a*.
(150) FIGS. **11**A-**11**C illustrate a perspective view, an enlarged view, and a cross-sectional side view, respectively, of a suturing device **1100**, in accordance with an exemplary embodiment of the present disclosure. The suturing device **1100** is structurally and functionally similar to the suturing device **1000**. However, in contrast to the elongated member **1002** of the suturing device **1000**, an elongated member **1102** of the suturing device **1100** additionally includes a dividing structure **1104** in the cavity **1004**. The dividing structure **1104** divides the cavity **1004** into a first cavity portion **1106** and a second cavity portion **1108**. Preferably, the dividing structure **1104** includes a fourth channel **1105** (shown in FIGS. **11**B and **11**D) that extends through the entirety of the dividing structure **1104** as shown.
(151) The fourth channel **1105** is preferably dimensioned such that the needle pusher **116** can be moved axially through the fourth channel **1105** with minimal friction with walls of the fourth channel **1105** while maintaining a desired amount of concentric alignment with the fourth channel **1105**, taking into account tolerances of materials used in the design of the suturing device **1100**. Further, the fourth channel **1105** is preferably wider at a wall **1104***a* of the dividing structure **1104** than it is at a point where the fourth channel **1105** meets the wall **1104***b* of the dividing structure **1104**. To accommodate this change in diameter, the fourth channel **1105**, for a portion of its length proximate the wall **1104***a*, may be shaped in a form of a frustum of a cone as was the case with the embodiment of the first channel **1008***a*. Alternatively, the fourth channel **1105** may, for its entire length, be shaped in the form of a frustum of a cone as was the case with the embodiment of the first channel **1008***a*.
(152) By increasing the diameter of the fourth channel **1105** at the wall **1104***b* as compared to the diameter of the fourth channel **1105** at the wall **1104***b*, one can minimize a chance that the distal tip of the needle pusher **116** (or the distal tip of the needle **112**, when carried by the needle pusher **116**), when being moved in the direction X′, strikes the wall **1104***a*, and facilities the unobstructed movement of both the needle pusher **116** and the needle **112** through the fourth channel **1105** in the direction X′. Preferably, the fourth channel **1105** includes an opening **1110** (shown in FIGS. **11**B-**11**D) that extends along its length to allow the suture **120** to exit the fourth channel **1105** as the needle pusher **116** and the needle **112** move through the fourth channel **1105**.
(153) In a non-limiting example, during operation of the suturing device **1100**, a vacuum is always simultaneously applied to both the first cavity portion **1106** and the second cavity portion **1108**. This may be accomplished, for example, by providing an opening **1112** at the base of dividing structure **1104** as shown in FIGS. **11**B-**11**D. With this configuration, when a vacuum is applied to the first cavity portion **1106** via the suction channel **106***b*, it is also applied to the second cavity portion **1108** through the opening **1112**. Alternatively, the first cavity portion **1106** and the second cavity portion **1108** may be independently connected to the suction channel **106***b*. In such a scenario, vacuum may be simultaneously applied at the first cavity portion **1106** and the second cavity portion **1108** when the blocking member **124** blocks the second aperture **136**.
(154) In another non-limiting example, during operation of the suturing device **1100**, application of a vacuum to the first cavity portion **1106** and application of a vacuum to the second cavity portion **1108** may be independently controlled such that a vacuum may be applied to only one of the first cavity portion **1106** and the second cavity portion **1108** or a vacuum may be simultaneously applied to both the first cavity portion **1106** and the second cavity portion **1108**. This may be accomplished, for example, by connecting the first cavity portion **1106** and the second cavity portion **1108** to separate, independently operated vacuum sources.
(155) It should be appreciated that by providing the elongated member **1102** with the first cavity portion **1106** and the second cavity portion **1108**, multiple (in this case, two) portions of contiguous portions of the tissue **103** may be suctioned into and captured by the first cavity portion **1106** and the second cavity portion **1108** such that a single pass of the needle pusher **116** and needle **112** (and, thereby, the suture **120**) over the first cavity portion **1106** and the second cavity portion **1108**

results in a suturing of both the first portion and the second portion of the tissue **103**. Furthermore, additional (i.e., more than one) dividing structures may be provided in order to create additional (i.e., more than two) cavity portions. Also, the distances between cavity portions may be selected so as to ensure that the desired portions of the tissue **103** are suctioned into the cavities and sutured.
(156) An operation of the suturing device **1100** may be substantially similar to the operation of the suturing device **1000** explained in the foregoing description of FIGS. **10**A-**10**F. The operation of the suturing device **1100** is not explained to avoid a repetition of the foregoing descriptions of FIGS. **10**A-**10**F.
(157) FIG. **11**D illustrates an enlarged cross-sectional side view of the distal end **1100***b* of the suturing device **1100**, in accordance with an exemplary embodiment of the present disclosure. In FIG. **11**D, the suction channel **106***b*, the first channel **1008***a*, the second channel **1008***b*, the third channel **1008***c*, and the fourth channel **1105** are shown. Further, in FIG. **11**D, the first cavity portion **1106**, the second cavity portion **1108**, and the opening **1112** at the base of the dividing structure **1104** are shown.
(158) FIGS. **12**A-**12**D illustrate a perspective side view, another perspective side view, an enlarged view, and a cross-sectional side view, respectively, of a suturing device **1200**, in accordance with an exemplary embodiment of the present disclosure. As shown in FIG. **12**A, the suturing device **1200** is structurally and functionally similar to the suturing device **1100** of FIGS. **11**A-**11**C. Differences between the suturing device **1200** and the suturing device **1100** will be explained below. FIG. **12**A illustrates the suturing device **1200** when the operating handle **118** is partially advanced. FIGS. **12**C-**12**D illustrate the suturing device **1200** when the operating handle **118** is at the fully advanced position.
(159) As shown in FIGS. **12**A-**12**D, the suturing device **1200** includes an elongated member **1202** having a proximal end **1202***a* and a distal end **1202***b* ("proximal" and "distal" being from the perspective of a user of the suturing device **1200**). Like the elongated member **1102** of the suturing device **1100**, the elongated member **1202** of the suturing device **1200** includes a first cavity **1204** and a second cavity **1206** for capturing a first portion and a second portion, respectively, of the tissue **103** (e.g., portions of contiguous tissue) when a vacuum is applied to the first cavity **1204** and the second cavity **1206**.
(160) Preferably, the first cavity **1204** and the second cavity **1206**, like the cavity **104** of the suturing device **100**, are dimensioned to suit a particular application and to accommodate the type and amount of tissue that is to be captured. For example, the first cavity **1204** may include a fourth wall **1204***a* (i.e., a front wall of the first cavity **1204** from the perspective of the user of the suturing device **1200**; shown in FIG. **12**B) at a first end of the first cavity **1204** and a fifth wall **1204***b* (i.e., a rear wall from the perspective of the user of the suturing device **1200** shown in FIG. **12**B) at a second end of the first cavity **1204** parallel and opposite to the fourth wall **1204***a*. The second cavity **1206** may include a sixth wall **1206***a* (i.e., a front wall of the second cavity **1206** from the perspective of the user of the suturing device **1200**; shown in FIG. **12**B) at a first end of the second cavity **1206** and a seventh wall **1206***b* (i.e., a rear wall from the perspective of the user of the suturing device **1200** shown in FIG. **12**B) at a second end of the second cavity **1206** parallel and opposite to the sixth wall **1206***a*.
(161) The elongated member **1202** further includes a dividing structure **1208** that separates the first cavity **1204** and the second cavity **1206**. The dividing structure **1208** is formed in between (i.e., formed by the) the fifth wall **1204***b* and the sixth wall **1206***a*. In other words, the dividing structure **1208** extends from the fifth wall **1204***b* of the first cavity **1204** to the sixth wall **1206***a* of the second cavity **1206**. Therefore, the fifth wall **1204***b* and the sixth wall **1206***a* form a first end surface and a second end surface of the dividing structure **1208**, respectively. Preferably, the dividing structure **1208** includes a fifth channel **1210** (shown in FIGS. **12**A, **12**C, and **12**E-**12**F) that extends through the entirety of the dividing structure **1208**. The fifth channel **1210** is concentric (e.g., coaxial) with respect to the first channel **1008***a*, the second channel **1008***b*, and the

third channel **1008***c*. A path defined by the fifth channel **1210** forms an extension of the working channel **106***a*.

(162) In contrast to the needle pusher assembly **114** of the suturing device **1100**, the suturing device **1200** includes a needle pusher assembly **1212**. The needle pusher assembly **1212** is structurally and functionally similar to the needle pusher assembly **114** of the suturing device **1100**. Differences between the needle pusher assembly **1212** of the suturing device **1200** and the needle pusher assembly **114** of the suturing device **1100** are explained below.

(163) The needle pusher assembly **1212** (shown in FIG. **12**G) includes the operating handle **118** and a needle pusher **1214**. The needle pusher **1214** is structurally and functionally similar to the needle pusher **116** of the suturing device **100**. Like the first through third detents **132***a*-**132***c* included in the needle pusher **116** (shown in FIG. **1**E) of the suturing device **100**, the needle pusher **1214** preferably includes the first through fourth detents **1216***a*-**1216***d*. The first through fourth detents **1216***a*-**1216***d* of the suturing device **1200** are structurally and functionally similar to the first through third detents **132***a*-**132***c* included in the needle pusher **116** of the suturing device **100**. Significance of the first through fourth detents **1216***a*-**1216***d* is explained below.

(164) A first blocking member **1218***a* and a second blocking member **1218***b* are attached to the needle pusher assembly **1212** as shown in FIGS. **12**A and **12**H. The first blocking member **1218***a* and the second blocking member **1218***b* of the suturing device **1200** are structurally and functionally similar to the blocking member **124** of the suturing device **100** (shown in FIG. **1**A). The first blocking member **1218***a* attached to the needle pusher assembly **1212**, in combination with the first aperture **126** and the vacuum control channel **106***c* (hereinafter, designated and referred to as "the first vacuum control channel **106***c*") formed in the elongated member **1202**, may be provided to control application of the vacuum to the first cavity **1204** just through normal operation of the suturing device **1200** without having to manually turn the vacuum source on and off. The first blocking member **1218***a* comprises an elongated member coupled to the operating handle **118** and arranged parallel and adjacent to the needle pusher **1214**. The second blocking member **1218***b* attached to the needle pusher assembly **1212**, in combination with a third aperture **1220** and a second vacuum control channel (not shown) formed in the elongated member **1202**, may be provided to control application of the vacuum to the second cavity **1206** through normal operation of the suturing device **1200** without having to manually turn the vacuum source on and off.

(165) The second blocking member **1218***b* comprises an elongated member coupled to the operating handle **118** and arranged parallel and adjacent to the needle pusher **1214**. Preferably, the second blocking member **1218***b* and the first blocking member **1218***a* are placed on either side of the needle pusher **1214** (as shown in FIGS. **12**A and **12**B). In a non-limiting example, the third aperture **1220** that is included in the elongated member **1202** is offset in the direction X′, with respect to the first aperture **126**. In other words, the third aperture **1220** is located farther away from the proximal end **1202***a* in the X′ direction with respect to the first aperture **126**.

(166) In one embodiment, the diameter of the first blocking member **1218***a* may vary across a length of the first blocking member **1218***a*. Preferably, the first blocking member **1218***a* includes a first portion **1222***a* with a first diameter, a second portion **1222***b* with a second diameter, and a third portion **1222***c* with the first diameter (as shown in FIG. **12**H). The second portion **1222***b* of the first blocking member **1218***a* includes a step-down in diameter in comparison to the first portion **1222***a* and the third portion **1222***c* of the first blocking member **1218***a* (as shown in FIG. **12**H). In other words, the second diameter of the second portion **1222***b* is less than the first diameter of the first portion **1222***a* and the second portion **1222***b* of the first blocking member **1218***a*. Preferably, a diameter of the second blocking member **1218***b* is consistent throughout a length of the second blocking member **1218***b*.

(167) The elongated member **1202** is provided with a first suction channel **1224***a* and a second suction channel **1224***b* (as shown in FIGS. **12**D-**12**G). The first suction channel **1224***a* and the

second suction channel **1224***b* are structurally and functionally similar to the suction channel **106***b* of the suturing device **1000** (shown in FIG. **11**C). A first end of the first suction channel **1224***a* has the vacuum port **108** that may be coupled to the vacuum source (not shown). A second end of the first suction channel **1224***a* is coupled to the first cavity **1204** such that the first cavity **1204**, the first suction channel **1224***a*, and the vacuum source are in fluidic communication. A first end of the second suction channel **1224***b* has the vacuum port **108** that may be coupled to the vacuum source (not shown). A second end of the second suction channel **1224***b* is coupled to the second cavity **1206** such that the second cavity **1206**, the second suction channel **1224***b*, and the vacuum source are in fluidic communication.

(168) Preferably, the fifth channel **1210** includes an opening **1226** (shown in FIGS. **12**B, **12**C, **12**E, and **12**F) that extends along a length of the fifth channel **1210** to allow the suture **120** to exit the fifth channel **1210** as the needle pusher **1214** and the needle **112** move through the fifth channel **1210**.

(169) The fifth channel **1210** is preferably dimensioned such that the needle pusher **1214** and the needle **112** can be moved axially through the fifth channel **1210** with minimal friction with walls of the fifth channel **1210** while maintaining a desired amount of concentric alignment with the fifth channel **1210**, taking into account tolerances of materials used in the design of the suturing device **1200**. Further, the fifth channel **1210** is preferably wider at the fifth wall **1204***b* than it is at a point where the fifth channel **1210** meets the sixth wall **1206***a*. To accommodate this change in the diameter of the fifth channel **1210**, the fifth channel **1210** may, for part of its length proximate the fifth wall **1204***b*, be shaped in a form of a frustum of a cone as was the case with the embodiment of the first channel **1008***a*. Alternatively, the fifth channel **1210** may, for its entire length, be shaped in the form of a frustum of a cone as was the case with the embodiment of the first channel **1008***a*. By increasing the diameter of the fifth channel **1210**, one can minimize the chance that a distal tip of the needle pusher **1214** (or the distal tip of the needle **112**, when carried by the needle pusher **1214**), when being moved in the direction X′, strikes the seventh wall **1206***b* and facilities the unobstructed movement of both the needle pusher **1214** and the needle **112** through the fifth channel **1210** in the direction X′.

(170) During the operation of the suturing device **1200**, advancement or retraction of the operating handle **118** translates to a corresponding movement of the first blocking member **1218***a* through the first vacuum control channel **106***c* and a corresponding movement of the second blocking member **1218***b* through the second vacuum control channel (not shown) included in the elongated member **1202**. The length of the second vacuum control channel is preferably shorter than the length of the working channel **106***a*. Such movement of the first blocking member **1218***a* within the first vacuum control channel **106***c*, in turn, opens or blocks the first aperture **126**. Similarly, such movement of the second blocking member **1218***b* within the second vacuum control channel, in turn, opens or blocks the third aperture **1220**. Because the first aperture **126** is in fluidic communication with the first vacuum control channel **106***c*, which is further in fluidic communication with the first suction channel **1224***a*, opening of the first aperture **126** releases any vacuum pressure created within the first cavity **1204**. Similarly, blocking the first aperture **126** maintains any vacuum pressure created within the first cavity **1204**. Similarly, since the third aperture **1220** is in fluidic communication with the second vacuum control channel, which is further in fluidic communication with the second suction channel **1224***b*, opening of the third aperture **1220** releases any vacuum pressure created within the second cavity **1206**. Blocking the third aperture **1220** maintains any vacuum pressure created within the second cavity **1206**.

(171) Advancing the operating handle **118** (from the fully retracted position) results in advancement of the first blocking member **1218***a* such that the first portion **1222***a* of the first blocking member **1218***a* blocks the first aperture **126**, thereby maintaining a vacuum at the first cavity **1204** such that the first portion of the tissue **103** may be captured. Preferably, the first blocking member **1218***a* and the second blocking member **1218***b* are dimensioned in a manner that

when the first portion **1222***a* of the first blocking member **1218***a* blocks the first aperture **126**, the third aperture **1220** is not yet blocked by the second blocking member **1218***b*. In other words, when the operating handle **118** is partially advanced in the direction X′ and the first portion **1222***a* of the first blocking member **1218***a* has blocked the first aperture **126**, the second blocking member **1218***b* has not yet reached or blocked the third aperture **1220** that is offset in the direction X′ with respect to the first aperture **126**. In such a scenario, it will be appreciated that vacuum is created or maintained at the first cavity **1204**, suctioning the first portion of the tissue into the first cavity **1204**. However, vacuum is not yet created at the second cavity **1206**. Preferably, when the operating handle **118** is advanced further in the direction X′ towards the fixed handle **122**, the second portion **1222***b* of the first blocking member **1218***a* reaches the first aperture **126** and the second blocking member **1218***b* reaches the third aperture **1220** and blocks the third aperture **1220**.
(172) It will be appreciated that since the second diameter of the second portion **1222***b* of the first blocking member **1218***a* is less than the first diameter of the first portion **1222***a* of the first blocking member **1218***a*, the second portion **1222***b* does not block the first aperture **126**, resulting in a release of the vacuum created in the first cavity **1204**. The second blocking member **1218***b* blocks the third aperture **1220**, creating a vacuum at the second cavity **1206**, causing the second portion of the tissue to be suctioned into the second cavity **1206**. Further advancement of the operating handle **118** in the direction X′ will result in corresponding advancement of the first blocking member **1218***a* and the second blocking member **1218***b* (and the needle pusher **1214**). Based on further advancement of the operating handle **118** in the direction X′, an entirety of the second portion **1222***b* of the first blocking member **1218***a* may advance past the first aperture **126**, and the third portion **1222***c* with the first diameter may reach and block the first aperture **126**. This may cause generation of vacuum in the first cavity **1204**, and the first portion of the tissue **103** may be captured (i.e., recaptured) or suctioned into the first cavity **1204**. It will be appreciated that the third aperture **1220** remains blocked by the second blocking member **1218***b*, and, therefore, the vacuum at the second cavity **1206** is maintained. It will be appreciated that any further advancement of the operating handle **118** towards the fully advanced position will result in continual blocking of the first aperture **126** and the third aperture **1220** by the third portion **1222***c* of the first blocking member **1218***a* and the second blocking member **1218***b*, respectively. Therefore, the vacuum at the first cavity **1204** and the second cavity **1206** is maintained.
(173) It should be appreciated that provision of the first blocking member **1218***a*, the second blocking member **1218***b*, the first aperture **126**, the third aperture **1220**, the first vacuum control channel **106***c*, the second vacuum control channel, the first suction channel **1224***a*, and the second suction channel **1224***b* avoids the need to manually turn the vacuum source on/off. It also enables synchronization of the application of the vacuum to the first cavity **1204** and the second cavity **1206** with the passage of the needle **112** and the suture **120** through the first portion and the second portion of the tissue during normal operation of the suturing device **1200**. As an alternative to the first blocking member **1218***a* and the second blocking member **1218***b*, the user of the suturing device **1200** may manually cover/uncover the first aperture **126** and/or the third aperture **1220**, for example, with his/her finger, to control the application of the vacuum to the first cavity **1204** and/or the second cavity **1206**. However, in that situation, the user must be aware of the timing of covering/uncovering the first aperture **126** and/or the third aperture **1220** such that application of the vacuum to the first cavity **1204** and/or the second cavity **1206** is properly synchronized with the movement of the needle **112** and the suture **120**.
(174) Like the suturing device **100** of FIGS. **1**A and **1**F, the suturing device **1200** may include the ball-spring detent mechanism **130**. However, in contrast to the suturing device **100**, the suturing device **1200** may include the first through fourth detents **1216***a*-**126***d*. As described in the foregoing, the first through fourth detents **1216***a*-**126***d* of the suturing device **1200** are structurally and functionally similar to the first through third detents **132***a*-**132***c* of the suturing device **100**. In order to prepare the suturing device **1200** for use, the needle pusher **1214** (with the needle **112** and

the suture **120** engaged) is inserted into the proximal end **1202***a* of the elongated member **1202** and pushed towards the fixed handle **122** until the first detent **1216***a* aligns with the second aperture **136**, causing the ball **138***b* to engage with the first detent **1216***a*. When the ball **138***b* is engaged with the first detent **1216***a*, the ball-spring detent mechanism **130** generates a first audible click sound and holds the needle pusher **1214** in position. Preferably, the first audible click and/or tactile feedback caused by the engagement of the ball **138***b* with the first detent **1216***a* indicates that the needle pusher **1214** is in the fully retracted position and that the suturing device **1200** is ready for use. Moreover, because the first blocking member **1218***a* does not block the first aperture **126** when the needle pusher **1214** is in a fully retracted position, the first audible click and/or the tactile feedback caused by the engagement of the ball **138***b* with the first detent **1216***a* also indicate that no vacuum is being applied to the first cavity **1204** or the second cavity **1206**.

(175) Upon application of a requisite force to the operating handle **118** pushing it towards the fixed handle **122**, the ball **138***b* is disengaged from the first detent **1216***a* and pushed back into the bore **134** towards the spring **138***a*. If the user continues to push on the operating handle **118**, the needle pusher **1214** continues to advance through the working channel **106***a* until the second detent **1216***b* aligns with the second aperture **136** and engages with the ball **138***b* generating a second audible click sound and holding the needle pusher **1214** in an intermediate position. The second audible click and/or a tactile feedback caused by the engagement of the ball **138***b* with the second detent **1216***b* indicates that the needle pusher **1214** is in a first intermediate position and that needle **112** is in a preparatory position to be passed through the first portion of the tissue **103**. Moreover, because the first portion **1222***a* of the first blocking member **1218***a* blocks the first aperture **126** when the needle pusher **1214** is in the first intermediate position, the second audible click and/or the tactile feedback caused by the engagement of the ball **138***b* with the second detent **1216***b* also indicates that the vacuum is being applied to the first cavity **1204** (via the first suction channel **1224***a*).

(176) When the operating handle **118** is further advanced by the user in the direction X′ to a second intermediate position, the third detent **1216***c* eventually becomes aligned with the second aperture **136** and engaged with the ball **138***b*, generating a third audible click sound and holding the needle pusher **1214** in position. The third audible click and/or the tactile feedback caused by the engagement of the ball **138***b* with the third detent **1216***c* indicates that the first portion **1222***a* of the first blocking member **1218***a* has advanced past the first aperture **126** and that the second portion **1222***b* of the first blocking member **1218***a* has reached the first aperture **126**, thereby, releasing the vacuum at the first cavity **1204**. Further, the third audible click and/or the tactile feedback caused by the engagement of the ball **138***b* with the third detent **1216***c* indicates that the second blocking member **1218***b* is blocking the third aperture **1220** and that vacuum is created at the second cavity **1206**. Further, the third audible click and/or the tactile feedback caused by the engagement of the ball **138***b* with the third detent **1216***c* indicates that the needle pusher **1214** has advanced past the fifth wall **1204***b* of the first cavity **1204**.

(177) When the operating handle **118** is further advanced by the user to the fully advanced position, the fourth detent **1216***d* eventually becomes aligned with the second aperture **136** and engaged with the ball **138***b*, generating a fourth audible click sound and holding the needle pusher **1214** in position. The fourth audible click and/or the tactile feedback caused by the engagement of the ball **138***b* with the fourth detent **1216***d* indicate that the needle pusher **116** is in the fully advanced position, i.e., that the needle pusher **1214** has advanced past the seventh wall **1206***b* of the second cavity **1206** towards the distal end **1202***b* such that the entirety of the needle **112** has passed through the first portion and the second portion of the tissue, the suture **120** has passed through first portion and the second portion of the tissue, and the needle **112** has been captured by the needle capturing assembly **110**.

(178) An operation of the suturing device **1200** may be substantially similar to the operation of the suturing device **1000** explained in the foregoing description of FIGS. **10**A-**10**F. The operation of the suturing device **1200** is not explained to avoid a repetition of the foregoing descriptions of

FIGS. **10**A-**10**F.
(179) FIG. **12**E illustrates an enlarged cross-sectional view of the distal end **1202***b* of the suturing device **1200** when the operating handle **118** is moved to the fully advanced position, in accordance with an exemplary embodiment of the present disclosure. In FIG. **12**E, the first cavity **1204**, the second cavity **1206**, the dividing structure **1208**, the first suction channel **1224***a*, and the second suction channel **1224***b*, the needle pusher **1214**, and the needle **112** are shown.
(180) FIG. **12**F illustrates an enlarged cross-sectional view of the distal end **1202***b* of the suturing device **1200**, in accordance with another exemplary embodiment of the present disclosure. In FIG. **12**F, the first cavity **1204**, the second cavity **1206**, the dividing structure **1208**, the fifth channel **1210**, the first suction channel **1224***a*, and the second suction channel **1224***b* are shown. The needle pusher **1214**, the needle **112**, and the suture **120** are not shown in FIG. **12**F in order to clearly illustrate the first channel **1008***a*, the second channel **1008***b*, the third channel **1008***c*, and the fifth channel **1210**.
(181) FIG. **12**G illustrates a cross-sectional top view of the suturing device **1200**, in accordance with an exemplary embodiment of the present disclosure. In FIG. **12**G, the first suction channel **1224***a* and the second suction channel **1224***b* are shown.
(182) FIG. **12**H illustrates a perspective view of the needle pusher assembly **1212** of the suturing device **1200**, in accordance with an exemplary embodiment of the present disclosure. In FIG. **12**H, shown are the operating handle **118** and the needle pusher **1214** that includes the first through fourth detents **1216***a*-**1216***d*. In FIG. **12**H, also shown are the second blocking member **1218***b* and the first blocking member **1218***a* that includes the first portion **1222***a*, the second portion **1222***b*, and the third portion **1222***c*.
(183) It should be appreciated that by providing the elongated member **1202** with the first cavity **1204** and the second cavity **1206**, multiple (in this case, two) portions of contiguous portions of the tissue **103** may be suctioned into and captured by the first cavity **1204** and the second cavity **1206** such that a single pass of the needle pusher **1214** and needle **112** (and, thereby, the suture **120**) over the first cavity **1204** and the second cavity **1206** results in a suturing of both the first portion and the second portion of the tissue **103**. Furthermore, additional (i.e., more than one) dividing structures may be provided in order to create additional (i.e., more than two) cavities. Also, the distances between cavities may be selected so as to ensure that the desired portions of the tissue **103** are suctioned into the cavities and sutured.
(184) In another embodiment, a vacuum applied to each of the first cavity **1204** and the second cavity **1206** may be individually controlled. In other words, the vacuum applied to each of the first cavity **1204** and the second cavity **1206** may be switched on or off individually. The suturing device **1200** to facilitate such a scenario may include a separate vacuum port for each suction channel (e.g., the first suction channel **1224***a* and the second suction channel **1224***b*). Therefore, the first suction channel **1224***a* and the second suction channel **1224***b* may each have a different vacuum port (not shown). Preferably, at least one of the first blocking member **1218***a* and the second blocking member **1218***b* may be adjustable in length. Preferably, a length of the first blocking member **1218***a* and the second blocking member **1218***b* may be adjusted before the needle pusher assembly **1212** is inserted in the proximal end **1202***a* of the suturing device **1200**. Further, the third aperture **1220** may not be offset with respect to the first aperture **126** in the direction X′. In other words, the first aperture **126** and the third aperture **1220** may be equidistant from the proximal end **1202***a* of the elongated member **1202**. Based on the length of the first blocking member **1218***a* and the length of the second blocking member **1218***b*, the user of the suturing device **1200** may control or select an order in which vacuum is applied to the first cavity **1204** and the second cavity **1206**. For example, if the length of the first blocking member **1218***a* is greater than the length of the second blocking member **1218***b*, when the operating handle **118** is advanced from the fully retracted position, the first blocking member **1218***a* may block the first aperture **126** before the second blocking member **1218***b* blocks the third aperture **1220**. Therefore, vacuum is

applied to the first cavity **1204** and no vacuum is applied to the second cavity **1206** unless the operating handle **118** is advanced further and the second blocking member **1218***b* blocks the third aperture **1220**. Similarly, if the length of the first blocking member **1218***a* is less than the length of the second blocking member **1218***b*, when the operating handle **118** is advanced from the fully retracted position, the second blocking member **1218***b* may block the third aperture **1220** before the first blocking member **1218***a* blocks the first aperture **126**. Therefore, vacuum is applied to the second cavity **1206** and no vacuum is applied to the first cavity **1204** unless the operating handle **118** is advanced further and the first blocking member **1218***a* blocks the first aperture **126**.

(185) Similarly, if the length of the first blocking member **1218***a* is equal to the length of the second blocking member **1218***b*, when the operating handle **118** is advanced from the fully retracted position, the first blocking member **1218***a* and the second blocking member **1218***b* may simultaneously block the first aperture **126** and the third aperture **1220**, respectively. Therefore, vacuum is applied to the first cavity **1204** and the second cavity **1206** simultaneously.

(186) It should be appreciated that the embodiments disclosed herein allow for easy retraction of the needle **112** from the needle capturing assembly **110** and re-engagement of the needle **112** with the needle pusher **116** following each pass of the needle **112** through the tissue **103**. This translates into more seamless administration of multiple stiches, enhancing speed and convenience of medical personnel conducting medical procedures (e.g., cosmetic surgery, bariatric surgery, orthopedic, general surgical, gynecologic, urologic, or the like). The embodiments disclosed herein also allow existing suturing devices to be optimized for multiple suturing at minimal cost. Thus, the disclosure also allows for easy enhancement of existing suturing devices, in addition to offering an improved design for manufacturing of new suturing devices.

(187) While various exemplary embodiments of the disclosed suturing devices, apparatus, and clamps have been described above it should be understood that they have been presented for purposes of example only, not limitations. It is not exhaustive and does not limit the disclosure to the precise form disclosed. Modifications and variations are possible in view of the above teachings or may be acquired from practicing of the disclosure, without departing from the breadth or scope of the present disclosure.

(188) In the claims, the words ‘comprising’, ‘including’ and ‘having’ do not exclude the presence of other elements or steps then those listed in a claim. The terms “a” or “an,” as used herein, are defined as one or more than one. Unless stated otherwise, terms such as “first” and “second” are used to arbitrarily distinguish between the elements such terms describe. Thus, these terms are not necessarily intended to indicate temporal or other prioritization of such elements. The fact that certain measures are recited in mutually different claims does not indicate that a combination of these measures cannot be used to advantage.

(189) While various embodiments of the present disclosure have been illustrated and described, it will be clear that the present disclosure is not limited to these embodiments only. Numerous modifications, changes, variations, substitutions, and equivalents will be apparent to those skilled in the art, without departing from the spirit and scope of the present disclosure. For example, one or more features of each of the various embodiments described herein may be used with the other embodiments to provide the benefits of those features to the other embodiments.

Claims

1. A suturing device comprising: an elongated member dimensioned for insertion into a body including tissue, the elongated member including a proximal end, a distal end opposite the proximal end, a cavity formed in a surface of the elongated member between the proximal end of the elongated member and the distal end of the elongated member, an opening formed in the surface of the elongated member between the cavity and the distal end of the elongated member, a working channel extending axially through the elongated member to the cavity, and a suction

channel in fluid communication with the cavity; a needle capturing assembly disposed between the opening and the distal end of the elongated member; a guide structure disposed between the cavity and the opening formed in the surface of the elongated member, the guide structure including at least a first channel coaxially aligned with the working channel; and a needle pusher having a first end configured to releasably engage a needle having a first end and a second end, wherein the working channel is dimensioned to allow the needle pusher to move axially through the working channel, wherein the working channel, the guide structure, the needle pusher, the cavity and the needle capturing assembly are configured such that (i) when the needle is engaged by the needle pusher and the tissue is captured by the cavity, the needle pusher is moveable through the working channel in a first direction towards the distal end of the elongated member to move the needle through the working channel in the first direction such that each of the first end of the needle and the second end of the needle passes through the tissue, at least a portion of the needle remains within the first channel of the guide structure and the first end of the needle is captured by the needle capturing assembly and (ii) when the needle is engaged by the needle pusher and the first end of the needle is captured by the needle capturing assembly, the needle pusher is further moveable through the working channel in a second direction towards the proximal end of the elongated member such that the needle is disengaged from the needle pusher and the first end of the needle remains captured by the needle capturing assembly, wherein the guide structure includes a second channel adjacent to the first channel and the first channel and the second channel are coaxially aligned, and wherein the first channel and the second channel are dimensioned such that the needle pusher and the needle can be moved axially through the first channel, the needle can move axially through the second channel, and the needle pusher cannot move axially through the second channel.

2. The suturing device of claim 1, wherein the guide structure is configured to maintain an alignment of the needle pusher and the needle as the needle is extracted from the needle capturing assembly and repositioned to be carried by the needle pusher after the needle has been captured by the needle capturing assembly and the needle is disengaged from the needle pusher, and wherein the guide structure is further configured to maintain an alignment of the needle pusher and the needle as the needle pusher and the needle pass through the tissue when the tissue is captured by the cavity and as the needle is captured by the needle capturing assembly.

3. The suturing device of claim 1, wherein the guide structure includes an opening extending from an outer surface of the guide structure to the first channel and extending along an entire length of the guide structure and wherein the outer surface of the guide structure includes first recessed portion adjacent to a first side of the opening and a second recessed portion adjacent to a second side of the opening opposite the first side of the opening.

4. The suturing device of claim 1, wherein a bottom surface of the opening includes at least one recessed portion extending longitudinally between the needle capturing assembly and the guide structure in a direction of a longitudinal axis of the first channel of the guide structure.

5. The suturing device of claim 1, further comprising a dividing structure within the cavity, the dividing structure dividing the cavity into a first cavity portion and a second cavity portion and including a dividing structure channel extending through the dividing structure from the first cavity portion to the second cavity portion, a diameter of the dividing structure channel at an interface between the dividing structure channel and the first cavity portion being larger than a diameter of the dividing structure channel at an interface between the dividing structure channel and the second cavity portion, wherein each of the first cavity portion and the second cavity portion is in fluid communication with the suction channel and wherein the first cavity portion and the second cavity portion are in fluid communication.

6. The suturing device of claim 1, further comprising a dividing structure within the cavity, the dividing structure dividing the cavity into a first cavity portion and a second cavity portion and including a dividing structure channel extending through the dividing structure from the first cavity

portion to the second cavity portion, a diameter of the dividing structure channel at an interface between the dividing structure channel and the first cavity portion being larger than a diameter of the dividing structure channel at an interface between the dividing structure channel and the second cavity portion, wherein each of the first cavity portion and the second cavity portion is in fluid communication with the suction channel and wherein the first cavity portion and the second cavity portion are not in fluid communication.

7. The suturing device of claim 1, further comprising a dividing structure within the cavity, the dividing structure dividing the cavity into a first cavity portion and a second cavity portion and including a dividing structure channel extending through the dividing structure from the first cavity portion to the second cavity portion, a diameter of the dividing structure channel at an interface between the dividing structure channel and the first cavity portion being larger than a diameter of the dividing structure channel at an interface between the dividing structure channel and the second cavity portion, wherein when a vacuum is applied to the suction channel, application of the vacuum to the first cavity portion and the second cavity portion may be independently controlled.

8. The suturing device of claim 1, further comprising a dividing structure within the cavity, the dividing structure dividing the cavity into a first cavity portion and a second cavity portion and including a dividing structure channel extending through the dividing structure from the first cavity portion to the second cavity portion, a diameter of the dividing structure channel at an interface between the dividing structure channel and the first cavity portion being larger than a diameter of the dividing structure channel at an interface between the dividing structure channel and the second cavity portion, wherein application of a vacuum to the suction channel causes the vacuum to be simultaneously applied to the first cavity portion and the second cavity portion.

9. A suturing device comprising: an elongated member dimensioned for insertion into a body including tissue, the elongated member including a proximal end, a distal end opposite the proximal end, a cavity formed in a surface of the elongated member between the proximal end of the elongated member and the distal end of the elongated member, an opening formed in the surface of the elongated member between the cavity and the distal end of the elongated member, a working channel extending axially through the elongated member to the cavity, and a suction channel in fluid communication with the cavity; a needle capturing assembly disposed between the opening and the distal end of the elongated member; and a guide structure disposed between the cavity and the opening formed in the surface of the elongated member, the guide structure including at least a first channel coaxially aligned with the working channel and a second channel adjacent to the first channel, wherein the first channel and the second channel are coaxially aligned and the first channel has a diameter larger than a diameter of the second channel.

10. The suturing device of claim 9, further comprising a needle pusher, the needle pusher having a first end configured to releasably engage a needle having a first end and a second end, wherein the working channel is dimensioned to allow the needle pusher to move axially through the working channel, and wherein the working channel, the guide structure, the needle pusher, the cavity and the needle capturing assembly are configured such that (i) when the needle is engaged by the needle pusher and the tissue is captured by the cavity, the needle pusher is moveable through the working channel in a first direction towards the distal end of the elongated member to move the needle through the working channel in the first direction such that each of the first end of the needle and the second end of the needle passes through the tissue, at least a portion of the needle remains within the first channel of the guide structure and the first end of the needle is captured by the needle capturing assembly and (ii) when the needle is engaged by the needle pusher and the first end of the needle is captured by the needle capturing assembly, the needle pusher is further moveable through the working channel in a second direction towards the proximal end of the elongated member such that the needle is disengaged from the needle pusher and the first end of the needle remains captured by the needle capturing assembly.

11. The suturing device of claim 10, wherein the first channel and the second channel are

dimensioned such that the needle pusher and the needle can be moved axially through the first channel, the needle can move axially through the second channel, and the needle pusher cannot move axially through the second channel.

12. The suturing device of claim 10, wherein the guide structure is configured to maintain an alignment of the needle pusher and the needle as the needle is extracted from the needle capturing assembly and repositioned to be carried by the needle pusher after the needle has been captured by the needle capturing assembly and the needle is disengaged from the needle pusher, and wherein the guide structure is further configured to maintain an alignment of the needle pusher and the needle as the needle pusher and the needle pass through the tissue when the tissue is captured by the cavity and as the needle is captured by the needle capturing assembly.

13. The suturing device of claim 9, wherein the guide structure includes an opening extending from an outer surface of the guide structure to the first channel and extending along an entire length of the guide structure and wherein the outer surface of the guide structure includes a first recessed portion adjacent to a first side of the opening and a second recessed portion adjacent to a second side of the opening opposite the first side of the opening.

14. The suturing device of claim 9, wherein a bottom surface of the opening includes at least one recessed portion extending longitudinally between the needle capturing assembly and the guide structure in a direction of a longitudinal axis of the first channel of the guide structure.

15. The suturing device of claim 9, further comprising a dividing structure within the cavity, the dividing structure dividing the cavity into a first cavity portion and a second cavity portion and including a dividing structure channel extending through the dividing structure from the first cavity portion to the second cavity portion, a diameter of the dividing structure channel at an interface between the dividing structure channel and the first cavity portion being larger than a diameter of the dividing structure channel at an interface between the dividing structure channel and the second cavity portion, wherein each of the first cavity portion and the second cavity portion is in fluid communication with the suction channel and wherein the first cavity portion and the second cavity portion are in fluid communication.

16. The suturing device of claim 9, further comprising a dividing structure within the cavity, the dividing structure dividing the cavity into a first cavity portion and a second cavity portion and including a dividing structure channel extending through the dividing structure from the first cavity portion to the second cavity portion, a diameter of the dividing structure channel at an interface between the dividing structure channel and the first cavity portion being larger than a diameter of the dividing structure channel at an interface between the dividing structure channel and the second cavity portion, wherein each of the first cavity portion and the second cavity portion is in fluid communication with the suction channel and wherein the first cavity portion and the second cavity portion are not in fluid communication.

17. The suturing device of claim 9, further comprising a dividing structure within the cavity, the dividing structure dividing the cavity into a first cavity portion and a second cavity portion and including a dividing structure channel extending through the dividing structure from the first cavity portion to the second cavity portion, a diameter of the dividing structure channel at an interface between the dividing structure channel and the first cavity portion being larger than a diameter of the dividing structure channel at an interface between the dividing structure channel and the second cavity portion, wherein when a vacuum is applied to the suction channel, application of the vacuum to the first cavity portion and the second cavity portion may be independently controlled.

18. The suturing device of claim 9, further comprising a dividing structure within the cavity, the dividing structure dividing the cavity into a first cavity portion and a second cavity portion and including a dividing structure channel extending through the dividing structure from the first cavity portion to the second cavity portion, a diameter of the dividing structure channel at an interface between the dividing structure channel and the first cavity portion being larger than a diameter of the dividing structure channel at an interface between the dividing structure channel and the second

cavity portion, wherein application of a vacuum to the suction channel causes the vacuum to be simultaneously applied to the first cavity portion and the second cavity portion.

19. A suturing device comprising: an elongated member dimensioned for insertion into a body including tissue, the elongated member including a proximal end, a distal end opposite the proximal end, a cavity formed in a surface of the elongated member between the proximal end of the elongated member and the distal end of the elongated member, an opening formed in the surface of the elongated member between the cavity and the distal end of the elongated member, a working channel extending axially through the elongated member to the cavity, and a suction channel in fluid communication with the cavity; a needle capturing assembly disposed between the opening and the distal end of the elongated member; and a guide structure disposed between the cavity and the opening formed in the surface of the elongated member, the guide structure including at least a first channel coaxially aligned with the working channel and a second channel coaxially aligned with the first channel, wherein the first channel and the second channel are dimensioned such that a needle pusher and a needle releasably engaged by the needle pusher can move axially through the first channel, the needle can move axially through the second channel, and the needle pusher cannot move axially through the second channel.

20. The suturing device of claim 19, wherein the first channel and the second channel are further dimensioned to: maintain an alignment of the needle pusher and the needle as the needle is extracted from the needle capturing assembly and repositioned to be carried by the needle pusher after the needle has been captured by the needle capturing assembly and the needle is disengaged from the needle pusher, and maintain an alignment of the needle pusher and the needle as the needle pusher and the needle pass through the tissue when the tissue is captured by the cavity and as the needle is captured by the needle capturing assembly.

21. The suturing device of claim 19, wherein a second wall of the cavity defines a first surface of the guide structure and a wall that is opposite to the second wall of the cavity defines a second end surface of the guide structure.

22. The suturing device of claim 19, wherein the guide structure further includes a second channel coaxially aligned with the first channel of the guide structure such that a path defined by the first channel of the guide structure and the second channel of the guide structure forms an extension of the working channel.

23. The suturing device of claim 19, wherein the guide structure includes an opening extending from an outer surface of the guide structure to the first channel and extending along an entire length of the guide structure and wherein the outer surface of the guide structure includes a first recessed portion adjacent to a first side of the opening and a second recessed portion adjacent to a second side of the opening opposite the first side of the opening.

24. The suturing device of claim 19, wherein a bottom surface of the opening includes at least one recessed portion extending longitudinally between the needle capturing assembly and the guide structure in a direction of a longitudinal axis of the first channel of the guide structure.

25. The suturing device of claim 19, further comprising a dividing structure within the cavity, the dividing structure dividing the cavity into a first cavity portion and a second cavity portion and including a dividing structure channel extending through the dividing structure from the first cavity portion to the second cavity portion, a diameter of the dividing structure channel at an interface between the dividing structure channel and the first cavity portion being larger than a diameter of the dividing structure channel at an interface between the dividing structure channel and the second cavity portion, wherein each of the first cavity portion and the second cavity portion is in fluid communication with the suction channel and wherein the first cavity portion and the second cavity portion are in fluid communication.

26. The suturing device of claim 19, further comprising a dividing structure within the cavity, the dividing structure dividing the cavity into a first cavity portion and a second cavity portion and including a dividing structure channel extending through the dividing structure from the first cavity

portion to the second cavity portion, a diameter of the dividing structure channel at an interface between the dividing structure channel and the first cavity portion being larger than a diameter of the dividing structure channel at an interface between the dividing structure channel and the second cavity portion, wherein each of the first cavity portion and the second cavity portion is in fluid communication with the suction channel and wherein the first cavity portion and the second cavity portion are not in fluid communication.

27. The suturing device of claim 19, further comprising a dividing structure within the cavity, the dividing structure dividing the cavity into a first cavity portion and a second cavity portion and including a dividing structure channel extending through the dividing structure from the first cavity portion to the second cavity portion, a diameter of the dividing structure channel at an interface between the dividing structure channel and the first cavity portion being larger than a diameter of the dividing structure channel at an interface between the dividing structure channel and the second cavity portion, wherein when a vacuum is applied to the suction channel, application of the vacuum to the first cavity portion and the second cavity portion may be independently controlled.

28. The suturing device of claim 19, further comprising a dividing structure within the cavity, the dividing structure dividing the cavity into a first cavity portion and a second cavity portion and including a dividing structure channel extending through the dividing structure from the first cavity portion to the second cavity portion, a diameter of the dividing structure channel at an interface between the dividing structure channel and the first cavity portion being larger than a diameter of the dividing structure channel at an interface between the dividing structure channel and the second cavity portion, wherein application of a vacuum to the suction channel causes the vacuum to be simultaneously applied to the first cavity portion and the second cavity portion.