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Lim et al.

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(54) **SUBCUTANEOUS IMPLANT DELIVERY APPARATUS AND METHOD OF DELIVERING A SUBCUTANEOUS IMPLANTABLE DEVICE FOR ACCESSING A VASCULAR SITE**

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See application file for complete search history.

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Primary Examiner — Nathan R Price

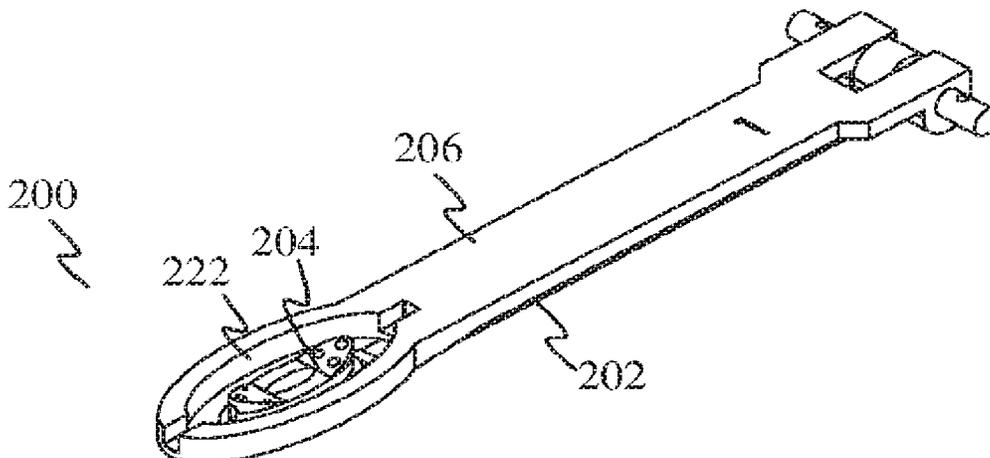
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(57) **ABSTRACT**

According to embodiments of the present invention, a subcutaneous implant delivery apparatus is provided. The apparatus includes a receiving portion configured to receive a subcutaneous implantable device; and a stabilizing portion configured to cooperate with the receiving portion to hold the subcutaneous implantable device in a fixed position. The receiving portion and the stabilizing portion are movable relative to each other between a released configuration, wherein the receiving portion and the stabilizing portion are

(Continued)



configured to move apart from each other to allow the receiving portion to be inserted under a skin layer, and a closed configuration, wherein the receiving portion and the stabilizing portion are configured to move toward each other to allow the subcutaneous implantable device to be held adjacent to the skin layer. According to further embodiments of the present invention, a method of delivering a subcutaneous implantable device for accessing a vascular site is also provided.

20 Claims, 12 Drawing Sheets

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- A61M 25/06* (2006.01)
- A61B 17/00* (2006.01)

- A61M 39/02* (2006.01)
- A61B 90/00* (2016.01)
- (52) **U.S. Cl.**
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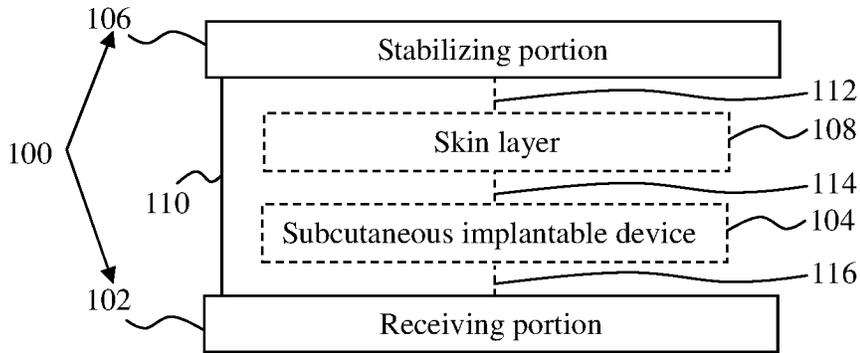


FIG. 1A

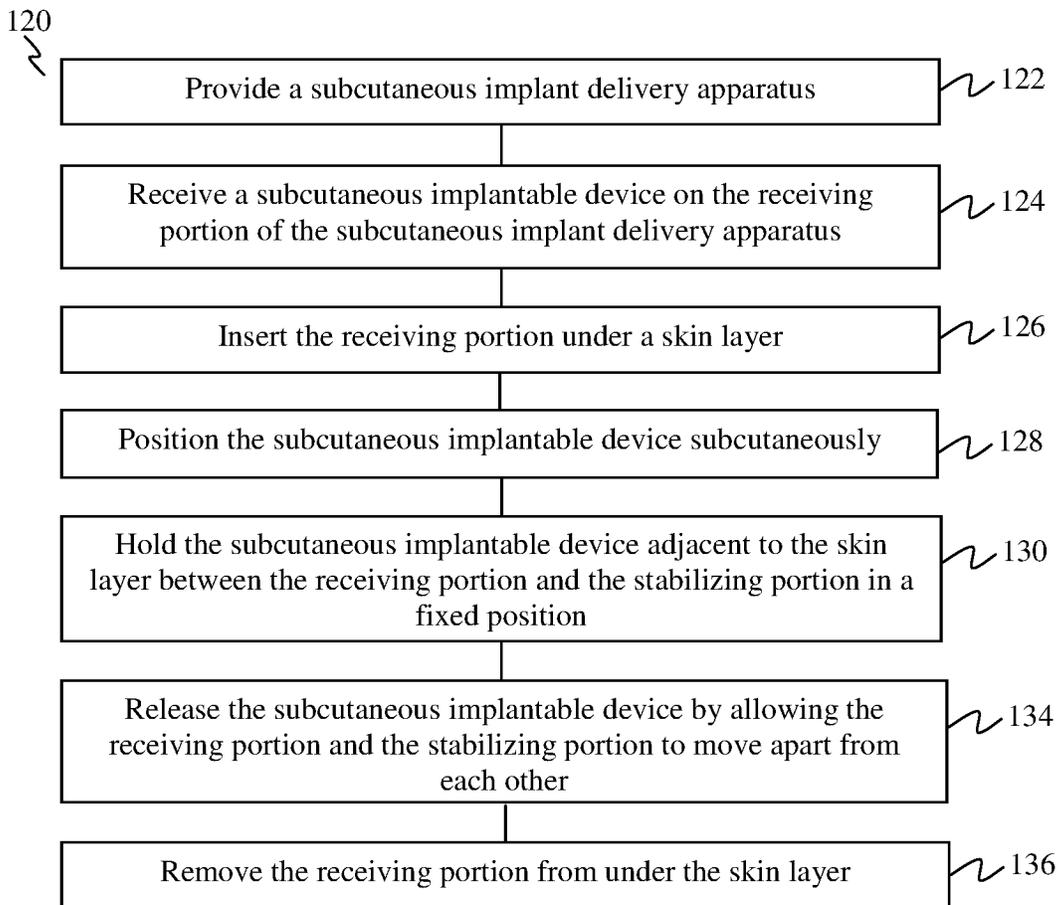
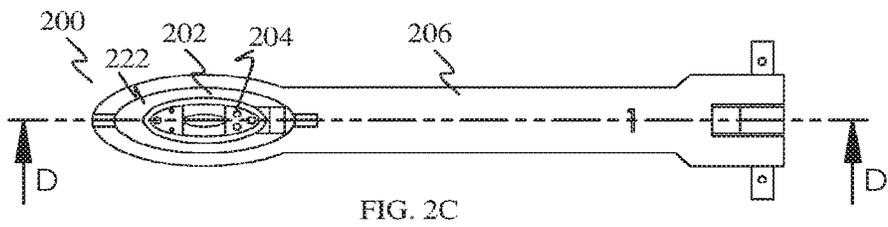
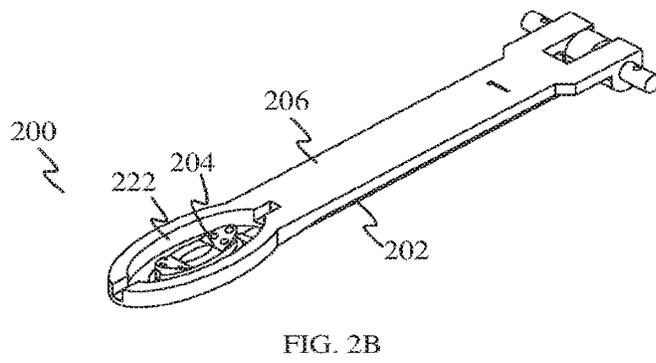
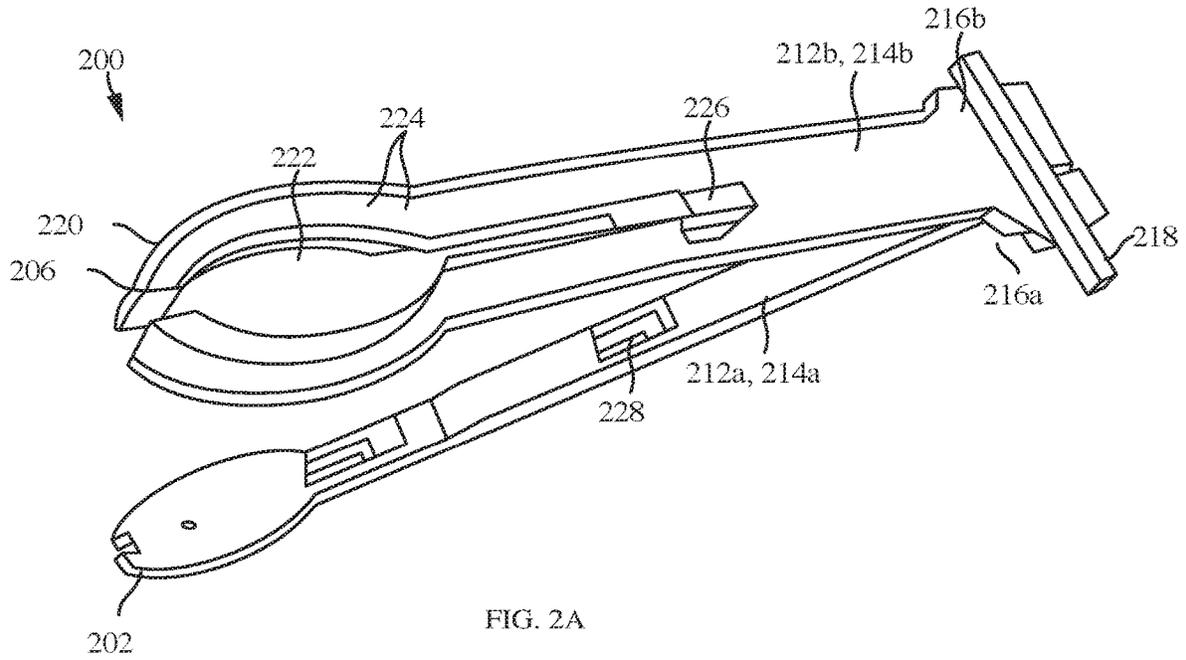


FIG. 1B



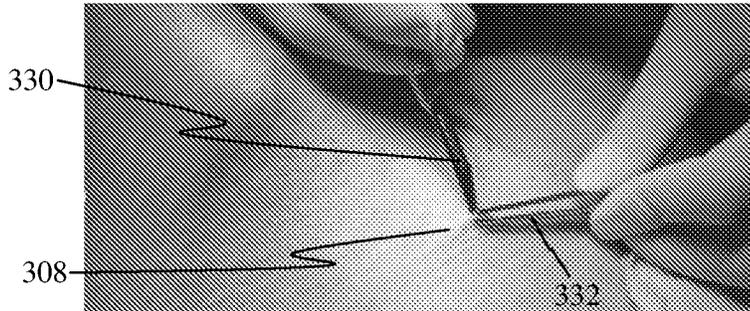


FIG. 3A

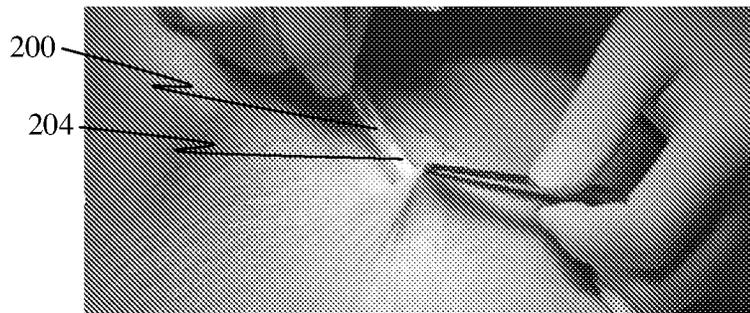


FIG. 3B

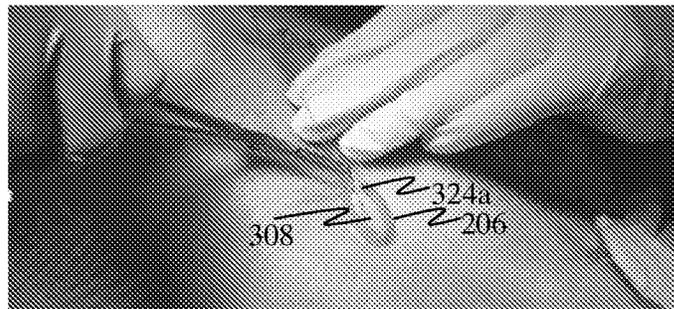


FIG. 3C

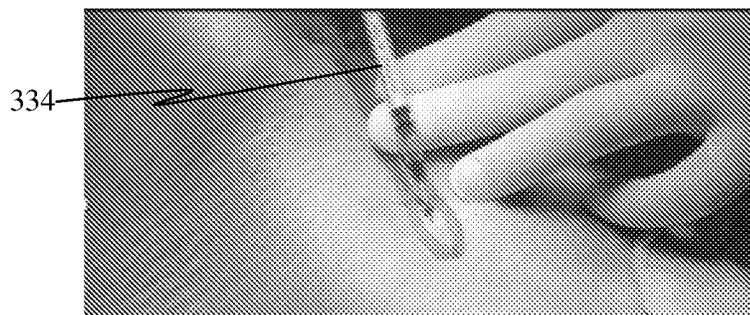


FIG. 3D



FIG. 3E

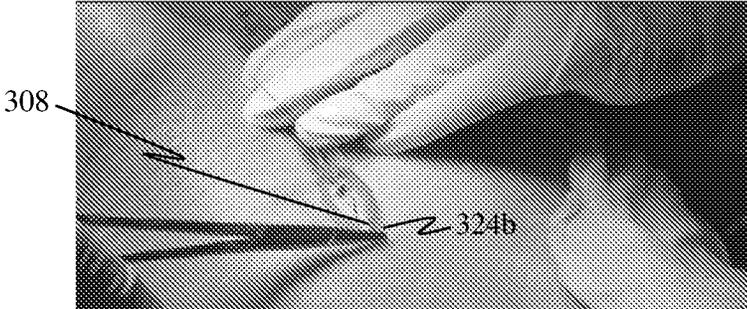


FIG. 3F

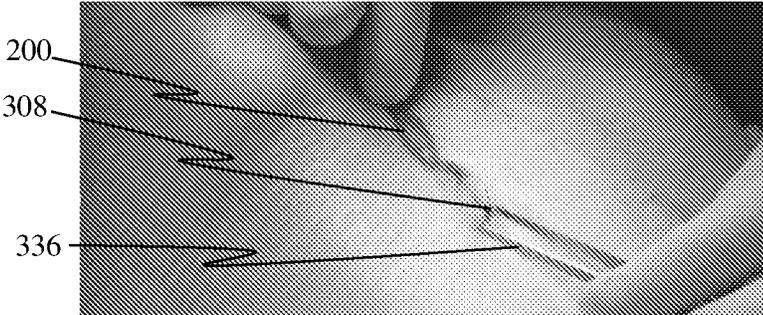


FIG. 3G

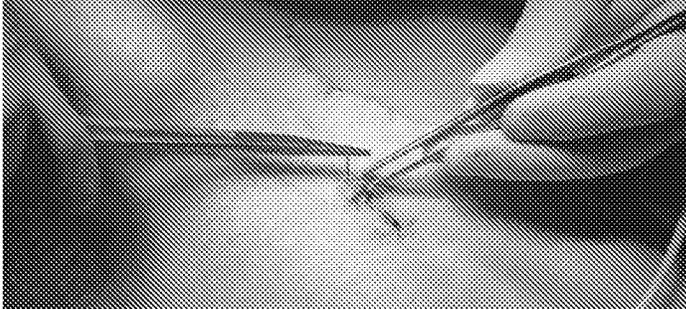


FIG. 3H

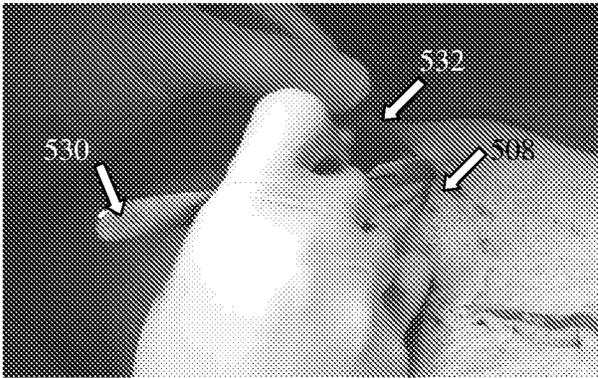


FIG. 5A

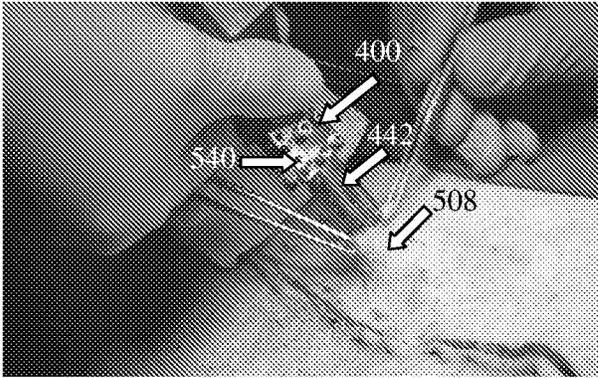


FIG. 5B

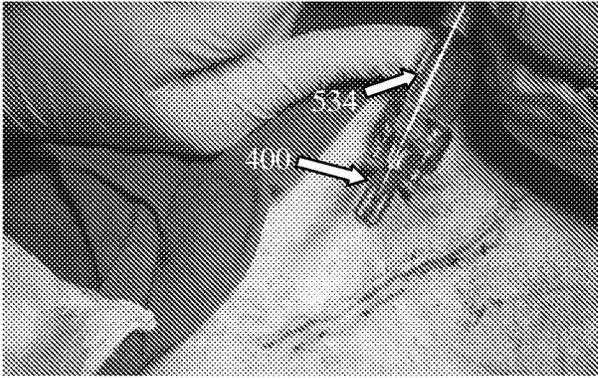


FIG. 5C

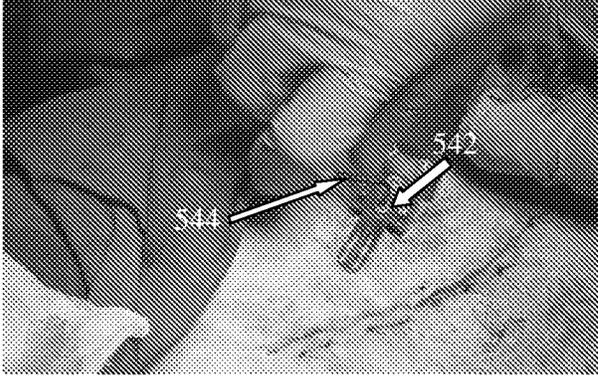


FIG. 5D

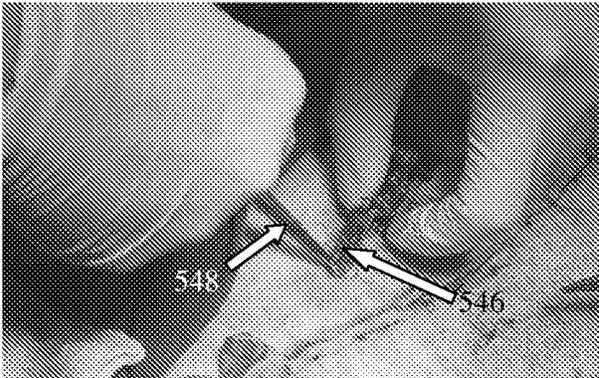


FIG. 5E

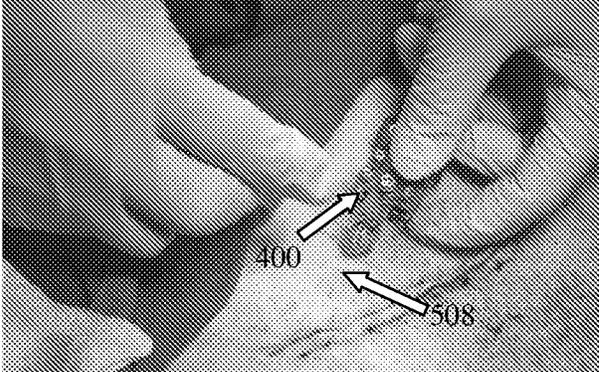


FIG. 5F

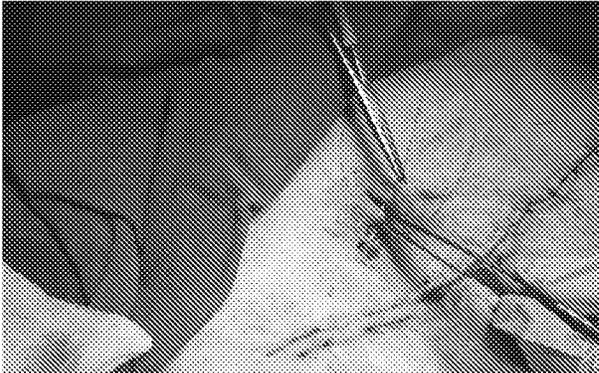


FIG. 5G

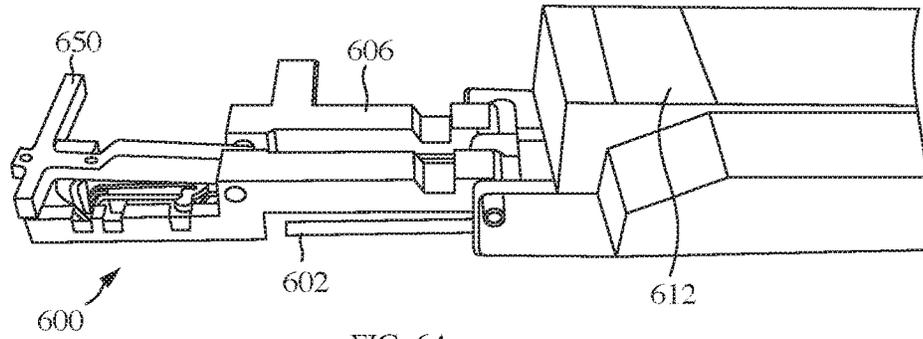


FIG. 6A

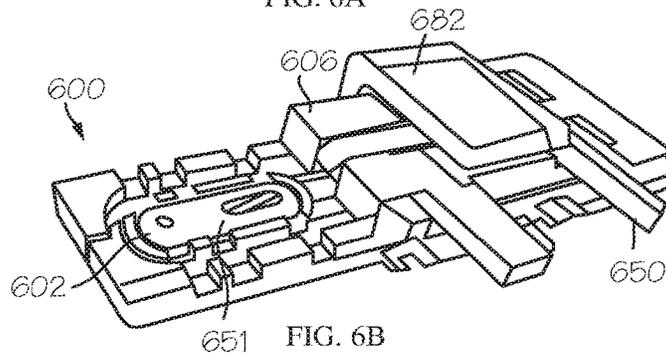


FIG. 6B

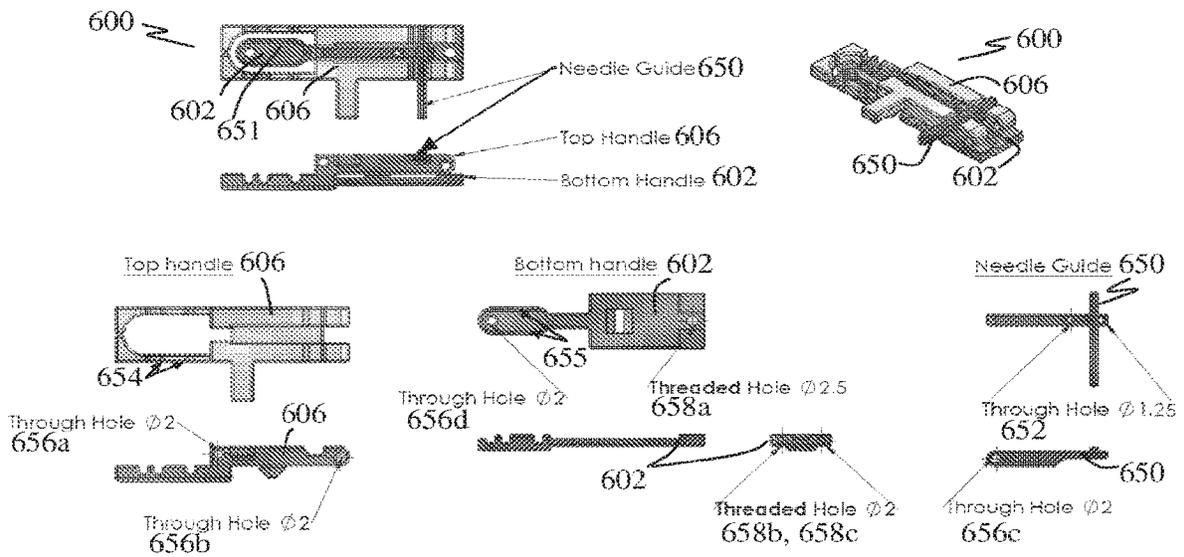


FIG. 6C

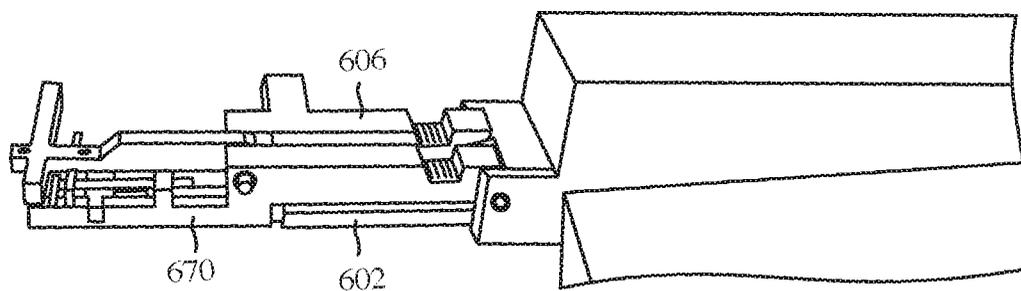


FIG. 6D

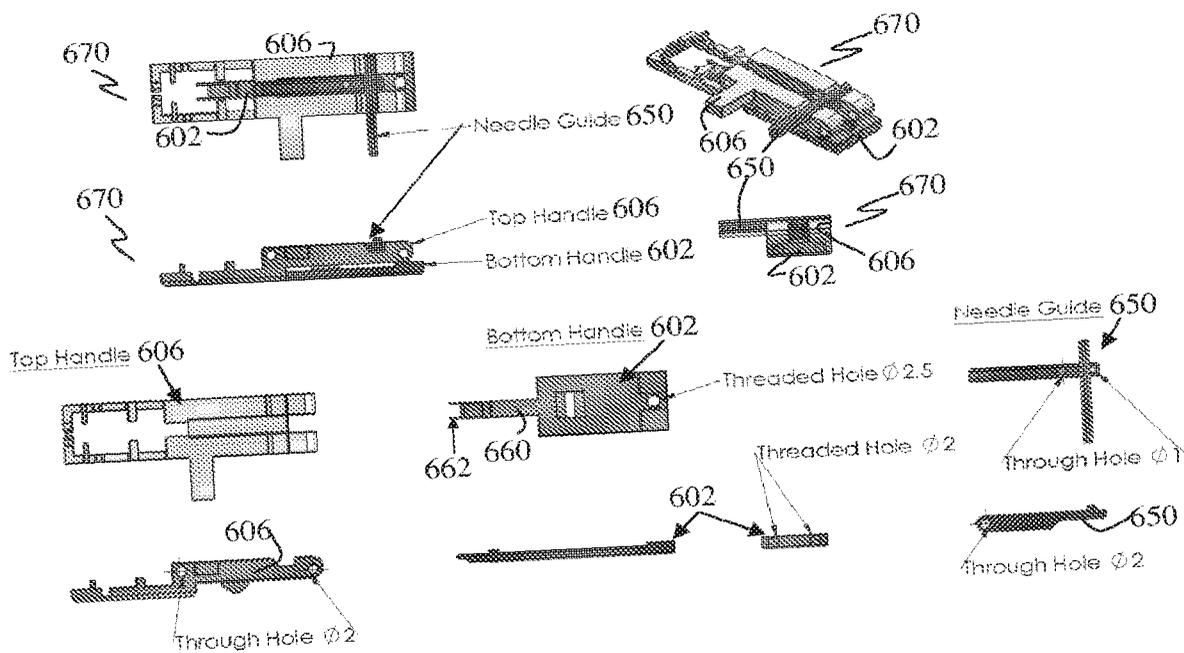


FIG. 6E

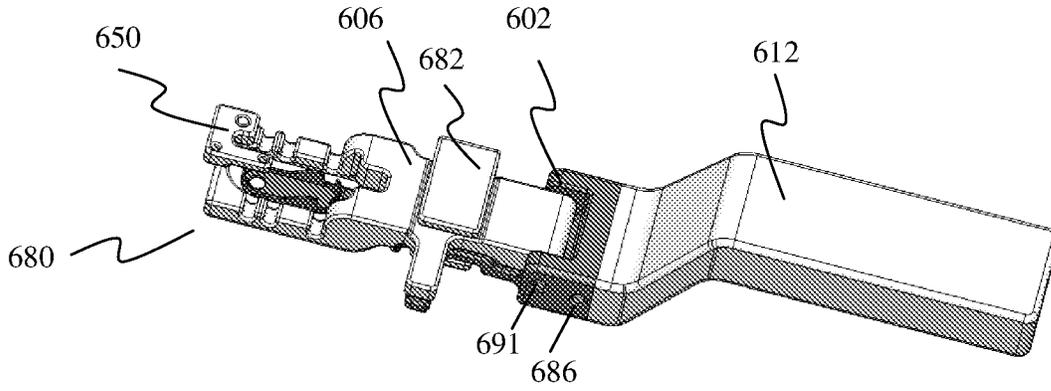


FIG. 6F

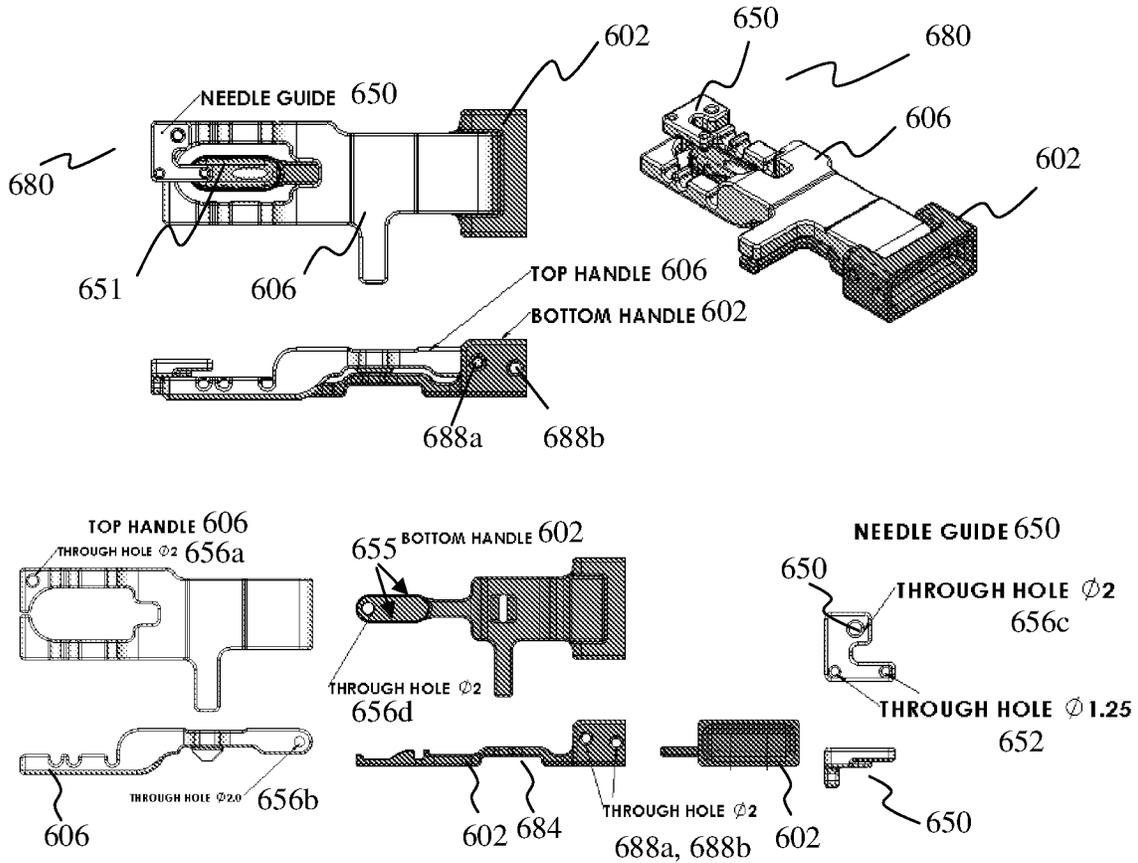


FIG. 6G

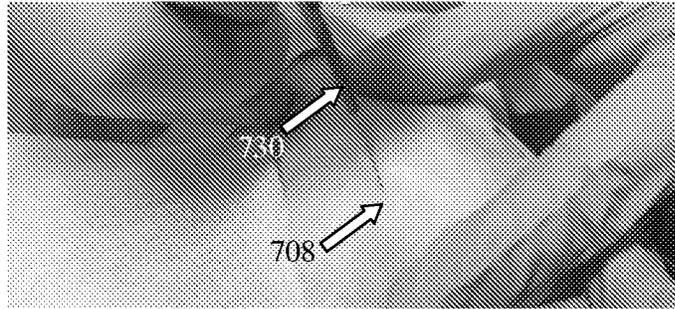


FIG. 7A

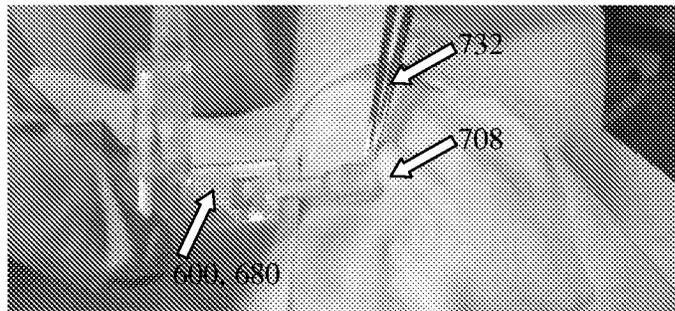


FIG. 7B

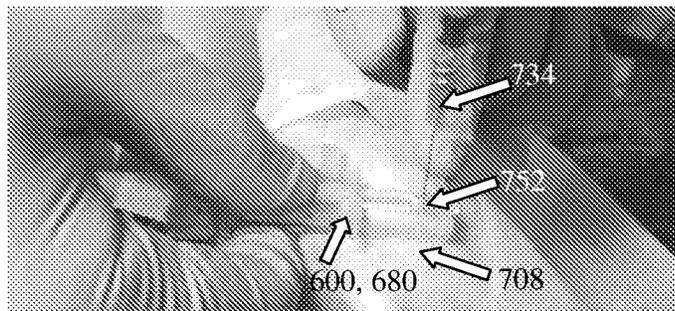


FIG. 7C

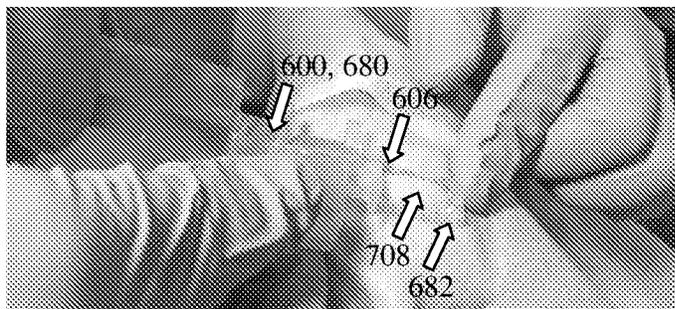


FIG. 7D

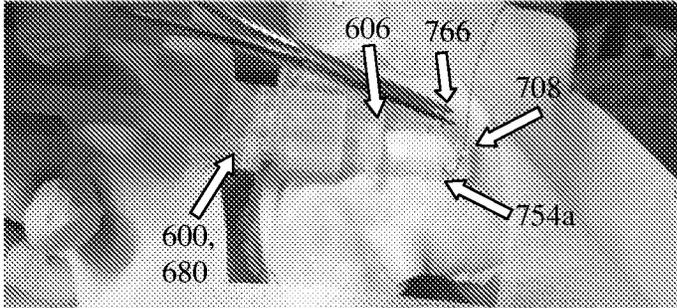


FIG. 7E

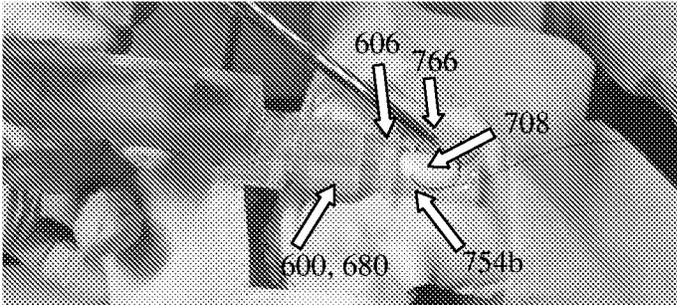


FIG. 7F

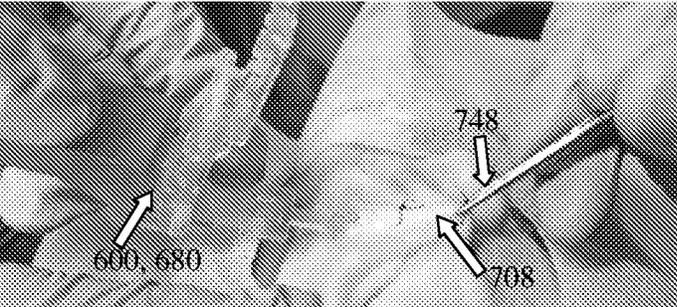


FIG. 7G

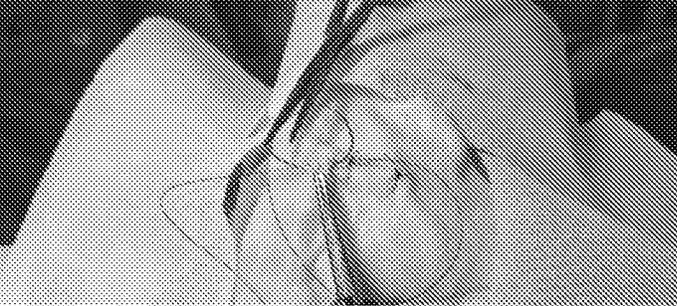


FIG. 7H

**SUBCUTANEOUS IMPLANT DELIVERY
APPARATUS AND METHOD OF
DELIVERING A SUBCUTANEOUS
IMPLANTABLE DEVICE FOR ACCESSING A
VASCULAR SITE**

CROSS-REFERENCE TO RELATED
APPLICATION

This application claims the benefit of priority of Singapore patent application No. 10201500143S, filed on 8 Jan. 2015, the content of it being hereby incorporated by reference in its entirety for all purposes.

TECHNICAL FIELD

Various embodiments relate to a subcutaneous implant delivery apparatus and a method of delivering a subcutaneous implantable device for accessing a vascular site.

BACKGROUND

End Stage Renal Disease (ESRD) is a debilitating and financially crippling chronic disease costing healthcare systems approximately a staggering \$67 B annually to treat, with incidence growing at an unmanageable rate. Hemodialysis (HD) is the predominant choice of treatment for about 85% of ESRD patients. As much as 38% of a patient's HD expenditure may not be due to dialysis but rather, due to vascular access. Vascular access remains the Achilles heel and one of the biggest unmet needs of HD.

Currently, there are three ways to obtain HD vascular access. Arteriovenous fistula (AVF) remains the gold standard with the lowest risk of complications. An arteriovenous graft (AVG) is the second option with shorter lifespan and higher risk of complication. A central catheter (CC) is often the last resort, meant only for temporary use with risk of serious complications leading to mortality. As such, preserving the health of an AVF, reducing the use of AVGs and CCs and their associated surgeries, is one of the best strategies to reduce overall cost of ESRD.

Surveying the competitive landscape, there is a missing gap in innovations impacting AVF health at the "Wear & Tear" phase—the mid stage of an AVF lifespan after the stage where it is successfully created and matured, and before the stage of onset of deterioration requiring repair interventions. Impacting AVF health at the "Wear & Tear" stage addresses fundamental mechanisms to effectively preserve AVFs than salvage downstream effects. This is also the stage where most number of preventable complications occurs due to poor cannulation.

Thus, there is a need for a delivery device for easy implantation of a subcutaneous vascular access device under the skin, and above, though not in contact with an arteriovenous fistula (referred to as AV fistula or AVF).

SUMMARY

According to an embodiment, a subcutaneous implant delivery apparatus is provided. The subcutaneous implant delivery apparatus may include a receiving portion configured to receive a subcutaneous implantable device; and a stabilizing portion configured to cooperate with the receiving portion to hold the subcutaneous implantable device in a fixed position, wherein the receiving portion and the stabilizing portion are movable relative to each other between a released configuration and a closed configuration;

wherein in the released configuration, the receiving portion and the stabilizing portion are configured to move apart from each other to allow the receiving portion to be inserted under a skin layer and the subcutaneous implantable device to be positioned subcutaneously; and wherein in the closed configuration, the receiving portion and the stabilizing portion are configured to move toward each other to allow the subcutaneous implantable device to be held adjacent to the skin layer, between the receiving portion and the stabilizing portion in the fixed position.

According to an embodiment, a method of delivering a subcutaneous implantable device for accessing a vascular site is provided. The method may include providing a subcutaneous implant delivery apparatus, according to various embodiments; receiving a subcutaneous implantable device on the receiving portion of the subcutaneous implant delivery apparatus; inserting the receiving portion under a skin layer; positioning the subcutaneous implantable device subcutaneously; holding the subcutaneous implantable device adjacent to the skin layer between the receiving portion and the stabilizing portion in a fixed position; releasing the subcutaneous implantable device by allowing the receiving portion and the stabilizing portion to move apart from each other; and removing the receiving portion from under the skin layer.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings, like reference characters generally refer to like parts throughout the different views. The drawings are not necessarily to scale, emphasis instead generally being placed upon illustrating the principles of the invention. In the following description, various embodiments of the invention are described with reference to the following drawings, in which:

FIG. 1A shows a schematic cross-sectional view of a subcutaneous implant delivery apparatus, according to various embodiments.

FIG. 1B shows a flow chart illustrating a method of delivering a subcutaneous implantable device for accessing a vascular site, according to various embodiments.

FIG. 2A shows a perspective view of a simplified version of a delivery device for implantation of a subcutaneous implant, in accordance with various embodiments.

FIGS. 2B and 2C respectively show a perspective view and a plan view of the delivery device of FIG. 2A in a closed configuration, in accordance with various embodiments.

FIGS. 3A to 3H show diagrams illustrating a method of utilizing the simplified delivery device of FIG. 2A to implant a subcutaneous implant, such as a vascular access device for arteriovenous fistula (AVF or AV fistula), in accordance with various embodiments.

FIG. 4A shows a perspective view of a self-suturing delivery device for implantation of a subcutaneous implant, in accordance with various embodiments.

FIG. 4B shows a photograph illustrating a prototype realization of the self-suturing delivery device of FIG. 4A, in accordance with various embodiments.

FIG. 4C shows schematic drawings (plan view, side view, and perspective view) illustrating the self-suturing delivery device of FIG. 4A and its components, in accordance with various embodiments.

FIGS. 5A to 5G show diagrams illustrating a method of utilizing the self-suturing delivery device of FIG. 4A to implant a subcutaneous implant, such as a vascular access device for arteriovenous fistula (AVF or AV fistula), in accordance with various embodiments.

FIG. 6A shows a perspective view of a subcutaneous implant delivery device, in accordance with various embodiments, wherein the delivery device provides guided suturing, guided implant orientation test channels, and additional arteriovenous fistula (AV fistula) safety of a protection base plate, in accordance with various embodiments.

FIG. 6B shows a perspective view of the subcutaneous implant delivery device of FIG. 6A (without a handle) where a needle guide is positioned over a top handle of the subcutaneous implant delivery device of FIG. 6A, away from the area where a subcutaneous implant is being held, in accordance with various embodiments.

FIG. 6C shows schematic drawings (plan view, side view, and perspective view) illustrating the subcutaneous implant delivery device of FIG. 6A and its components, in accordance with various embodiments.

FIG. 6D shows a perspective view of a subcutaneous implant delivery device, which is a similar variation of the subcutaneous implant delivery device of FIG. 6A, with added quick implant release mechanism, in accordance with various embodiments.

FIG. 6E shows schematic drawings (plan view, side view, and perspective view) illustrating the subcutaneous implant delivery device of FIG. 6D and its components, in accordance with various embodiments.

FIG. 6F shows a perspective view of another subcutaneous implant delivery device, which is a similar variation of the subcutaneous implant delivery device of FIG. 6A, with improved design and fastening mechanism, in accordance with various embodiments.

FIG. 6G shows schematic drawings (plan view, side view, and perspective view) illustrating the subcutaneous implant delivery device of FIG. 6F and its components, in accordance with various embodiments.

FIGS. 7A to 7H show diagrams illustrating a method of utilizing the delivery device of FIG. 6A or the variation thereof (i.e., the delivery device of FIG. 6F) to implant a subcutaneous implant, such as a vascular access device for arteriovenous fistula (AVF or AV fistula), in accordance with various embodiments.

DETAILED DESCRIPTION

The following detailed description refers to the accompanying drawings that show, by way of illustration, specific details and embodiments in which the invention may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice the invention. Other embodiments may be utilized and structural, logical, and electrical changes may be made without departing from the scope of the invention. The various embodiments are not necessarily mutually exclusive, as some embodiments can be combined with one or more other embodiments to form new embodiments.

Embodiments described in the context of one of the methods or devices are analogously valid for the other methods or devices. Similarly, embodiments described in the context of a method are analogously valid for a device, and vice versa.

Features that are described in the context of an embodiment may correspondingly be applicable to the same or similar features in the other embodiments. Features that are described in the context of an embodiment may correspondingly be applicable to the other embodiments, even if not explicitly described in these other embodiments. Furthermore, additions and/or combinations and/or alternatives as

described for a feature in the context of an embodiment may correspondingly be applicable to the same or similar feature in the other embodiments.

In the context of various embodiments, the articles “a”, “an” and “the” as used with regard to a feature or element include a reference to one or more of the features or elements.

In the context of various embodiments, the phrase “at least substantially” may include “exactly” and a reasonable variance.

In the context of various embodiments, the term “about” or “approximately” as applied to a numeric value encompasses the exact value and a reasonable variance.

As used herein, the term “and/or” includes any and all combinations of one or more of the associated listed items.

As used herein, the phrase of the form of “at least one of A or B” may include A or B or both A and B. Correspondingly, the phrase of the form of “at least one of A or B or C”, or including further listed items, may include any and all combinations of one or more of the associated listed items.

Various embodiments provide a delivery device for implantation of a subcutaneous implant.

The delivery device may provide stability and accuracy in positioning a vascular access device. The delivery device may further assist a user (or an operator) to properly anchor the access device to and from beneath the skin via sutures. The delivery device may also feature safety functions that may prevent the user from injuring the arteriovenous fistula (referred to as AV fistula or AVF) during the implantation process.

Various embodiments may provide an apparatus that stabilizes a subcutaneous implant (or a vascular access device or a subcutaneous implantable device) and guides a subcutaneous implant (or a vascular access device or a subcutaneous implantable device) to be implanted in the right orientation. The apparatus may include a base plate that holds the subcutaneous implant in place, and blocks erroneous suturing that may invade a target vessel. The apparatus may further include a suture mechanism that facilitates easy suturing of the subcutaneous implant onto the dermis layer of a subject’s skin.

FIG. 1A shows a schematic cross-sectional view of a subcutaneous implant delivery apparatus **100**, according to various embodiments. The subcutaneous implant delivery apparatus **100** includes a receiving portion **102** configured to receive a subcutaneous implantable device **104**; and a stabilizing portion **106** configured to cooperate with the receiving portion **102** to hold the subcutaneous implantable device **104** in a fixed position, wherein the receiving portion **102** and the stabilizing portion **106** are movable relative to each other between a released configuration and a closed configuration; wherein in the released configuration, the receiving portion **102** and the stabilizing portion **106** are configured to move apart from each other to allow the receiving portion **102** to be inserted under a skin layer **108** and the subcutaneous implantable device **104** to be positioned subcutaneously; and wherein in the closed configuration, the receiving portion **102** and the stabilizing portion **106** are configured to move toward each other to allow the subcutaneous implantable device **104** to be held adjacent to the skin layer **108**, between the receiving portion **102** and the stabilizing portion **106** in the fixed position.

In other words, the subcutaneous implant delivery apparatus **100** may include the receiving portion **102** and the stabilizing portion **106**, coupled to each other, as represented by a line **110** so as to work in cooperation with each other. For example, the receiving portion **102** and the stabilizing

portion **106** may be coupled mechanically via, but not limited to, a pivot point or a spring mechanism (not shown in FIG. 1A) so that the receiving portion **102** and the stabilizing portion **106** may move apart or move toward each other under different configurations. In some examples, the receiving portion **102** and the stabilizing portion **106** may be coupled to or attached to each other via a threadless press fit rod hinge (e.g., **686** of FIG. 6G). Using the threadless press fit rod hinge may advantageously reduce the risk of residual sterilization ethylene oxide (EtO) entrapment which occurs in screw threads. The stabilizing portion **106** and the receiving portion **102** may be complementary to each other. The receiving portion **102** may be shaped to receive or hold the subcutaneous implantable device **104**, as represented by a dotted line **116**. For example, the receiving portion **102** may include a recess in which the subcutaneous implantable device **104** or at least part thereof may be placed. The subcutaneous implantable device **104** or at least part thereof may be placed onto the receiving portion **102** when the subcutaneous implant delivery apparatus **100** is in the released configuration. The receiving portion **102**, along with the subcutaneous implantable device **104** (which is received on the receiving portion **102**) may be inserted under the skin layer **108**, as represented by a dotted line **114**, through an incision on the skin layer **108**. The stabilizing portion **106** may remain above the skin layer **108**. This means that the stabilizing portion **106** is a non-invasive part and is not inserted under the skin layer **108**. In the closed configuration, the receiving portion **102** and the stabilizing portion **106** may be configured to move toward each other such that the stabilizing portion **106** may be in contact with the skin layer **108** (i.e., on the skin layer **108** or on the skin surface) or may be brought adjacent to the skin layer **108** (i.e., over the skin layer **108** or over the skin surface), as represented by a dotted line **112**. At the same time, the subcutaneous implantable device **104** may move toward and may be brought in contact with underneath the skin layer **108**. This way, the skin layer **108** and the subcutaneous implantable device **104** may be held in alignment (or sandwiched) between the receiving portion **102** and the stabilizing portion **106**. In this closed configuration, the subcutaneous implantable device **104** being in contact with the skin layer **108** may be held firmly (non-movable) adjacent to the (underneath) skin layer **108**, for example, by exerting an external compressing force onto the receiving portion **102** and the stabilizing portion **106** to allow the receiving portion **102** and the stabilizing portion **106** to move toward each other, thereby allowing temporarily locking of the subcutaneous implantable device **104** in place (in the fixed position).

In the context of various embodiments, the term “fixed position” may mean in an at least substantially non-movable and/or non-orientable state.

In the context of various embodiments, the term “adjacent to” may mean in contact with, or next to, or at least substantially near to.

The subcutaneous implant delivery apparatus **100** in accordance with various embodiments may allow implantation accuracy problems for the subcutaneous implantable device (e.g., **104**) to be solved. It should be appreciated that implanting a subcutaneous device (e.g., **104**), especially ones for accessing a blood vessel accurately, cannot afford to have position and/or orientation error, even though the error may be considered slight. In other words, there may be significantly low error tolerance (e.g., zero error tolerance). If a subcutaneous implantable device (e.g., **104**) is placed at a wrong angle, or not directly above a vessel (vascular site), there may be a risk that a needle may not be able to

accurately puncture the precise and consistent location of a target vessel. The subcutaneous implant delivery apparatus **100** in accordance with various embodiments may provide the following functions of temporarily locking the implant (e.g., **104**) in place, checking the positional and angular accuracy of the implant (e.g., **104**), and confirming/determining sutures catching the implant (e.g., **104**) hidden under the skin (e.g., **108**), all through real-time direct visualization. This may advantageously provide a cost-effective solution to the problems mentioned herein. Further, the integration of the aforesaid functions into one single apparatus (e.g., **100**) may enable the problems mentioned herein to be solved without a need for sophisticated imaging technology despite the implant (e.g., **104**) being hidden under the skin (e.g., **108**).

In various embodiments, the receiving portion **102** and the stabilizing portion **106** may be movable relative to each other about a pivoting point.

In various embodiments, the subcutaneous implant delivery apparatus **100** may further include at least one position indicator configured to facilitate a visual indication of at least one of a position or an angular orientation of the subcutaneous implantable device **104** when received by the receiving portion **102** and held adjacent to the skin layer **108**.

In various embodiments, the (at least one) position indicator may include a needle guide configured to receive a needle upon alignment of the subcutaneous implantable device **104** to at least one of a desired position or a desired angular orientation with respect to the receiving portion **102**.

In other words, the position indicator may include a needle guide for determining the correct position and angular orientation of the subcutaneous implantable device **104**.

In various embodiments, the needle guide may be configured to be coupled to the stabilizing portion **106** and activated by a rotation about a pivot positioned at a substantially mid-point of the stabilizing portion **106**. The needle guide may rotate away from a plane of the stabilizing portion **106** and towards a plane perpendicular to the plane of the stabilizing portion **106** about the pivot. In reverse, the needle guide may rotate away from the plane perpendicular to the plane of the stabilizing portion **106** and towards the plane of the stabilizing portion **106** about the pivot. In other words, the needle guide may rotate in an upward-downward motion with respect to the plane of the stabilizing portion **106**. An example of this needle guide activated by rotation about the pivot may be illustrated in FIGS. 6A to 6C.

In other embodiments, the needle guide may be configured to be coupled to the stabilizing portion **106** and activated by a swing rotation to move laterally along the stabilizing portion **106**. The swing rotation may be about a pivot positioned at a distal end of the stabilizing portion **106**. The swing rotation may be a side-to-side motion along the plane of the stabilizing portion **106** or along a plane parallel to the plane of the stabilizing portion **106** about the distal pivot. An example of this needle guide activated by swing rotation may be illustrated in FIGS. 6F and 6G. Having the needle guide activated by swing rotation may provide an advantage of not needing a locking mechanism (e.g., U-clamp **682** of FIG. 6F) to be removed and re-inserted when the needle is deployed through the needle guide, since the locking mechanism is not positioned overlying the needle guide or at least part of the needle guide (as compared to the example described in FIG. 6A).

In various embodiments, the subcutaneous implant delivery apparatus **100** may further include at least one anchor

guide configured to facilitate the subcutaneous implantable device **104** to be anchored to the skin layer **108**.

For example, the at least one anchor guide may include a suture guide marking.

In other words, various embodiments may provide the subcutaneous implant delivery apparatus **100** including: the receiving portion **102** configured to receive the subcutaneous implantable device **104**; the stabilizing portion **106** to temporarily lock the subcutaneous implantable device **104** in a fixed position, wherein the receiving portion **102** and the stabilizing portion **106** are movable relative to each other between a released configuration and a closed configuration; wherein in the released configuration, the receiving portion **102** and the stabilizing portion **106** are moved apart from each other to allow the receiving portion **102** to be inserted under the skin layer **108** and the subcutaneous implantable device **104** to be positioned subcutaneously; and wherein in the closed configuration, the receiving portion **102** and the stabilizing portion **106** are moved toward each other to allow the implantable device **104** to be held firmly adjacent to the (underneath) skin layer **108**, between the receiving portion **102** and the stabilizing portion **106**; at least one (or a plurality of) position indicator(s) to visually confirm said implantable device **104** is in the correct position and/or orientation (angular orientation); and an or a plurality of anchor guide(s) to assist and visually confirm the implantable device **104** is correctly anchored to the skin **108**.

In the context of various embodiments, the term “temporarily lock” may mean releasably secure, or lock/secure with a form of release mechanism. As a non-limiting example, the stabilizing portion **106** may temporarily lock the subcutaneous implantable device **104** via a continuous compressing force being applied between the stabilizing portion **106** and the receiving portion **102**, or via a latching mechanism.

Other examples for “temporarily lock” may be in forms of a U-clamp with male and female interlocks, screw locks with rotational screw threads and magnetic locking mechanism to align and lock top and bottom shafts.

In the context of various embodiments, the term “held firmly” may mean held with an applied force, for example, to minimize or avoid movement.

In the context of various embodiments, the term “correct position and/or orientation” may mean a desired position and/or orientation (angular orientation) in accordance with medical professionals’ practices. For example, the correct position and/or orientation in this context may refer to a position and/or orientation of the implantable device **104** under the skin **108**, and above, though not in contact with an arteriovenous fistula.

The integration of various components of the subcutaneous implant delivery apparatus described herein, in accordance with various embodiments (e.g., **100**) may create synergy that solves an implantation accuracy problem that existing vascular access devices may meet. This is because the subcutaneous implant delivery apparatus described herein, in accordance with various embodiments may solve a non-trivial problem of implanting a subcutaneous device (e.g., the subcutaneous implantable device **104**) that cannot afford to have slight position and/or orientation (angular orientation) error. If the subcutaneous device (e.g., the subcutaneous implantable device **104**), or may be referred to as a vascular access implant is placed at a slightly wrong (incorrect) angle, or not directly above a vessel, there runs the risk of a needle not being able to accurately puncture the precise and consistent location of the target vessel. The subcutaneous implant delivery apparatus described herein, in accordance with various embodiments, may combine the

features of ‘temporarily locking the implant (e.g., **104**) in place’, ‘checking positional and angular accuracy’, and ‘confirming sutures catches the implant (e.g., **104**) hidden under the skin (e.g., **108**)’ all through real-time direct visualization. The subcutaneous implant delivery apparatus described herein, in accordance with various embodiments is the most low cost solution to solve the non-trivial problem. It is believed that at least one of the combination/integration of the abovementioned three features into one device (e.g., **100**), and the ability of the device (e.g., **100**) to solve the problem without needing sophisticated imaging technology despite the implant (e.g., **104**) being hidden under the skin (e.g., **108**) constitutes a demonstration of an inventive effort.

In various embodiments, the receiving portion **102** may include a blocking base plate on which the subcutaneous implantable device **104** is to be placed, wherein the blocking base plate is configured to form a shield for an anatomy or a tissue underneath the subcutaneous implantable device **104**.

In other words, the receiving portion **102** may include a blocking base plate on which tissue/blood vessels beneath the subcutaneous implantable device **104** is shielded. It should be appreciated that the blocking base plate is a safety feature to eradicate a possibility that a surgeon may accidentally pierce the vessel (vascular site) under the implant **104** (or any other tissue under the implant **104**) during a procedure. The blocking base plate may also eradicate a possibility of the surgeon accidentally suturing the implant **104** together with the vessel, consequently risking the implant **104** compressing and causing stenosis on the vessel.

In particular, various embodiments may provide a subcutaneous implant delivery apparatus including: a receiving portion **102** configured to receive a subcutaneous implantable device **104**; a stabilizing portion **106** configured to cooperate with the receiving portion **102** to hold the subcutaneous implantable device **104** in a fixed position; and a blocking base plate on which the subcutaneous implantable device **104** is to be placed, wherein the blocking base plate is configured to form a shield for an anatomy or a tissue underneath the subcutaneous implantable device **104**, wherein the receiving portion and the stabilizing portion are movable relative to each other between a released configuration and a closed configuration; wherein in the released configuration, the receiving portion and the stabilizing portion are configured to move apart from each other to allow the receiving portion to be inserted under a skin layer and the subcutaneous implantable device to be positioned subcutaneously; and wherein in the closed configuration, the receiving portion and the stabilizing portion are configured to move toward each other to allow the subcutaneous implantable device to be held adjacent to the skin layer, between the receiving portion and the stabilizing portion in the fixed position. The receiving portion **102** may include the blocking base plate.

In various embodiments, the receiving portion **102** may include a releasable attachment mechanism to which the subcutaneous implantable device **104** is to be releasably attached. For example, the releasable attachment mechanism may include a clamp. In another example, the releasable attachment mechanism may include a retaining clip.

In various embodiments, the subcutaneous implant delivery apparatus **100** may further include a handle extending from at least one of the receiving portion **102** or the stabilizing portion **106**.

The handle may form part of the at least one of the receiving portion **102** or the stabilizing portion **106**. In other

words, the handle may be an integral part of the at least one of the receiving portion **102** or the stabilizing portion **106**. Alternatively, the handle may be a separate part that may be coupled or attached to the at least one of the receiving portion **102** or the stabilizing portion **106**.

In other embodiments, the subcutaneous implant delivery apparatus **100** may further include a handle extending from each of the receiving portion **102** and the stabilizing portion **106**.

The handle may form part of each of the receiving portion **102** and the stabilizing portion **106**. In other words, the handle may be an integral part of each of the receiving portion **102** and the stabilizing portion **106**. Alternatively, the handle may be a separate part that may be coupled or attached to each of the receiving portion **102** and the stabilizing portion **106**.

In various embodiments, the handle(s) may be made of plastic. Generally, the handle(s) may be made of any material suitable for facilitating holding of a hand-held device (e.g., the subcutaneous implant delivery apparatus **100**) and for sterile use (e.g., to facilitate or for surgery purpose).

In various embodiments, the handles may be configured to move toward each other upon exerting an external force thereon to correspondingly allow the receiving portion **102** and the stabilizing portion **106** to be moveable toward each other in the closed configuration.

In various embodiments, the handle or the handles may be dimensioned and/or shaped in a manner to allow for at least one of a reduction in the weight of the subcutaneous implant delivery apparatus **100**, an improved balance and/or user comfort in handling the subcutaneous implant delivery apparatus **100**, and a reduction in manufacturing cost of the subcutaneous implant delivery apparatus **100**.

In various embodiments, the subcutaneous implant delivery apparatus **100** may further include at least one needle arranged to self suture through the subcutaneous implantable device **104** when received by the receiving portion **102**, to the skin layer **108** upon moving the receiving portion **102** and the stabilizing portion **106** toward each other.

In other words, the apparatus **100** may further include needles that self sutures through the subcutaneous implantable device **104** in the receiving portion **102**, to the skin **108** upon moving the receiving portion **102** and the stabilizing portion **106** closer to each other.

In the context of various embodiments, the term “self suture” may mean a capability of performing suturing without a user’s direct influence. In other words, “self suture” in this context is different from a user using a needle to perform suturing.

For example, in this case, by moving the receiving portion **102** and the stabilizing portion **106** closer to each other, the at least one needle (or the needles) is able to perform suturing (on its own) without a user manually operating (holding, pushing, or pulling) the at least one needle (or the needles).

In various embodiments, the receiving portion **102** and the stabilizing portion **106** may be made of a material selected from plastic, austenitic molybdenum-containing stainless steel, and medical grade titanium. For example, the receiving portion **102** may be made of a material same as that for the stabilizing portion **106**. In other examples, the receiving portion **102** may be made of a material different from that for the stabilizing portion **106**. Generally, each of the receiving portion **102** and the stabilizing portion **106** may be made of any other rigid material suitable for sterile use (e.g., to facilitate or for surgery purpose).

In various embodiments, the subcutaneous implant delivery apparatus **100** may further include a locking mechanism arranged to releasably lock the receiving portion **102** and the stabilizing portion **106** in the closed configuration.

Each of the receiving portion **102** and the stabilizing portion **106** may include a screw hole, and the locking mechanism may include a screw arranged through the screw holes.

For example, the locking mechanism may include a U-lock (or a U-shaped lock) or a U-clamp.

In various embodiments, the receiving portion **102** may include a groove for receiving the locking mechanism (e.g., U-clamp **682** of FIG. 6F) such that the locking mechanism may be flushed with a bottom surface of the receiving portion **102** to prevent skin from being pinched when the locking mechanism is engaged to temporarily lock the stabilizing portion **106** and the receiving portion **102** together.

FIG. 1B shows a flow chart illustrating a method **120** of delivering a subcutaneous implantable device for accessing a vascular site, according to various embodiments. The subcutaneous implantable device may be described in the same or similar context with the subcutaneous implantable device **104** of FIG. 1A. At **122**, a subcutaneous implant delivery apparatus as herein described (e.g., **100** of FIG. 1A) may be provided. At **124**, a subcutaneous implantable device (e.g., **104**) may be received on the receiving portion **102** of the subcutaneous implant delivery apparatus **100**. At **126**, the receiving portion **102** may be inserted under a skin layer (e.g., **108** of FIG. 1A). At **128**, the subcutaneous implantable device **104** may be positioned subcutaneously. At **130**, the subcutaneous implantable device **104** may be held adjacent to the skin layer **108** between the receiving portion **102** and the stabilizing portion **106** in a fixed position. At **134**, the subcutaneous implantable device **104** may be released by allowing the receiving portion **102** and the stabilizing portion **106** to move apart from each other. At **136**, the receiving portion **102** may be removed from under the skin layer **108**.

In various embodiments, the subcutaneous implantable device **104** may be sutured to the skin layer **108** in the fixed position, for example, prior to the step **134**. In this case, the sutured subcutaneous implantable device **104** may be released by allowing the receiving portion **102** and the stabilizing portion **106** to move apart from each other.

In other words, the method **120** of delivering the subcutaneous implantable device (e.g., **104**) for accessing a vascular site, according to various embodiments may include placing the subcutaneous implantable device **104** onto the receiving portion **102** of the subcutaneous implant delivery apparatus **100**, and inserting the receiving portion **102**, along with the subcutaneous implantable device **104** (which is received on the receiving portion **102**) under the skin layer **108** through an incision on the skin layer **108** to position the subcutaneous implantable device **104** subcutaneously. With the stabilizing portion **106** of the subcutaneous implant delivery apparatus **100** remaining above the skin layer **108**, the method **120** may further include moving the receiving portion **102** and the stabilizing portion **106** toward each other, for example, by exerting an external compressing force onto the receiving portion **102** and the stabilizing portion **106**, such that the stabilizing portion **106** may be in contact with the skin layer **108** (i.e., on the skin layer **108** or on the skin surface) or may be brought adjacent to the skin layer **108** (i.e., over the skin layer **108** or over the skin surface). At the same time, the method **120** may include moving the subcutaneous implantable device **104** toward and brought in contact with underneath the skin layer **108**,

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allowing the skin layer **108** and the subcutaneous implantable device **104** to be held in alignment (or sandwiched) between the receiving portion **102** and the stabilizing portion **106**. This allows temporarily locking of the subcutaneous implantable device **104** in place (in the fixed position). With the subcutaneous implantable device **104** held in the fixed position with respect to the (underneath) skin layer **108** by the subcutaneous implant delivery apparatus **100**, the method **120** may include suturing the subcutaneous implantable device **104** to the skin layer **108** so as to secure the subcutaneous implantable device **104** to the skin layer **108** in the fixed position. The subcutaneous implant delivery apparatus **100** may then be removed in its entirety by allowing the receiving portion **102** and the stabilizing portion **106** to move apart from each other, for example, by removing the applied compressing force or by releasing a releasable locking of the receiving portion **102** and the stabilizing portion **106** in the closed configuration, to release the sutured subcutaneous implantable device **104** from the receiving portion **102** and to remove the receiving portion **102** from under the skin layer **108** through the incision.

While the method described above is illustrated and described as a series of steps or events, it will be appreciated that any ordering of such steps or events are not to be interpreted in a limiting sense. For example, some steps may occur in different orders and/or concurrently with other steps or events apart from those illustrated and/or described herein. In addition, not all illustrated steps may be required to implement one or more aspects or embodiments described herein. Also, one or more of the steps depicted herein may be carried out in one or more separate acts and/or phases.

The subcutaneous implantable device and the subcutaneous implant delivery apparatus (as described in FIG. 1B) may include the same or like elements or components as those of the subcutaneous implantable device **104** and the subcutaneous implant delivery apparatus **100** of FIG. 1A, respectively, and as such, the same numerals are assigned and the like elements may be as described in the context of the subcutaneous implantable device **104** and the subcutaneous implant delivery apparatus **100** of FIG. 1A, and therefore the corresponding descriptions are omitted here.

In various embodiments, the method **120** may further include facilitating a visual indication of at least one of a position or an angular orientation of the subcutaneous implantable device **104** when received by the receiving portion **102** and held adjacent to the skin layer **108**.

For example, the step of facilitating the visual indication may include providing a needle guide for receiving a needle upon alignment of the subcutaneous implantable device **104** to at least one of a desired position or a desired angular orientation with respect to the receiving portion **102**.

In various embodiments, the method **120** may further include facilitating the subcutaneous implantable device **104** to be anchored to the skin layer **108**.

In various embodiments, the method **120** may further include providing or forming a shield for an anatomy or a tissue underneath the subcutaneous implantable device **104**. For example, the method **120** may include providing a blocking base plate on which the subcutaneous implantable device is to be placed to form a shield for an anatomy or a tissue underneath the subcutaneous implantable device. The receiving portion may include the blocking base plate. In other words, the method **120** may provide implanting the subcutaneous implantable device **104** (or any device) above a vein subcutaneously in a safe way with the blocking base plate shielding the vein.

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In particular, various embodiments may provide a method of delivering a subcutaneous implantable device for accessing a vascular site, the method including: providing a subcutaneous implant delivery apparatus as herein described (e.g., **100** of FIG. 1A); receiving a subcutaneous implantable device (e.g., **104**) on the receiving portion **102** of the subcutaneous implant delivery apparatus **100**; providing a blocking base plate on which the subcutaneous implantable device **104** is to be placed to form a shield for an anatomy or a tissue underneath the subcutaneous implantable device **104**; inserting the receiving portion **102** under a skin layer (e.g., **108** of FIG. 1A); positioning the subcutaneous implantable device **104** subcutaneously; holding the subcutaneous implantable device **104** adjacent to the skin layer **108** between the receiving portion **102** and the stabilizing portion **106** in a fixed position; releasing the subcutaneous implantable device **104** by allowing the receiving portion **102** and the stabilizing portion **106** to move apart from each other; and removing the receiving portion **102** from under the skin layer **108**.

In various embodiments, the method **120** may further include providing a handle extending from each of the receiving portion **102** and the stabilizing portion **106**, and moving the handles toward each other upon exerting an external force thereon to correspondingly allow the receiving portion **102** and the stabilizing portion **106** to be moveable toward each other in the closed configuration.

In various embodiments, the method **120** may further include self suturing through the subcutaneous implantable device **104** when received by the receiving portion **102**, to the skin layer **108** upon moving the receiving portion **102** and the stabilizing portion **106** toward each other.

In various embodiments, the method **120** may further include releasably locking the receiving portion **102** and the stabilizing portion **106** in the closed configuration.

Examples of the subcutaneous implant delivery apparatus in accordance with various embodiments and the method of delivering a subcutaneous implantable device for accessing a vascular site, according to various embodiments will be described as follow.

FIG. 2A shows a perspective view of a simplified version of a delivery device **200** for implantation of a subcutaneous implant (not shown), in accordance with various embodiments. For example, the delivery device **200** may be a simplified subcutaneous implant delivery device. The delivery device **200** and the subcutaneous implant may include the same or like elements or components as those of the subcutaneous implant delivery apparatus **100** and the subcutaneous implantable device **104** of FIG. 1A, respectively, and as such, the same numerals are assigned and the like elements may be as described in the context of the subcutaneous implant delivery apparatus **100** and the subcutaneous implantable device **104** of FIG. 1A, and therefore the corresponding descriptions may be omitted here.

FIGS. 2B and 2C respectively show a perspective view and a plan view of the delivery device **200** in a closed configuration, in accordance with various embodiments.

As seen in FIG. 2A, the device **200** may include (i) a spoon-shaped bottom holder member **202** designed to hold a subcutaneous implant (not shown in FIG. 2A) and insertable into a limited space within a subcutaneous tissue (not shown in FIG. 2A); (ii) a top stabilizer member **206** designed to be pressed down above the skin (not shown in FIG. 2A) to secure the subcutaneous implant, that may be held by the spoon-shaped bottom holder member **202**, temporarily in a fixed position under and against the skin; and (iii) a handle member **212a**, **212b**, each connecting the

bottom holder **202** and the top stabilizer **206** proximally to each other to form respective shaft **214a**, **214b**. A free end **216a**, **216b** of each of the respective shaft **214a**, **214b** may be movably hinged together, for example, via a hinging element **218** (e.g., a pivoting point or a pivot). The device **200** as shown in FIG. 2A is in a released (or open) configuration. The spoon-shaped bottom holder member **202** and the top stabilizer member **206** of the delivery device **200** may operate like a pair of tongs.

The spoon-shaped bottom holder member **202** and the top stabilizer member **206** of FIG. 2A may include the same or like elements or components as those of the receiving portion **102** and the stabilizing portion **106** of FIG. 1A, respectively, and as such, the same numerals are assigned and the like elements may be as described in the context of the the receiving portion **102** and the and the stabilizing portion **106** of FIG. 1A, and therefore the corresponding descriptions may be omitted here.

The distal end **220** of the top stabilizer **206** has a gap **222** designed to allow the top handle **212b** to expand flexibly based on the thickness of the skin.

There may be groove markers **224** on the top stabilizer **206** to guide suture needles (not shown in FIG. 2A) to find or local both the proximal and distal ends of the subcutaneous implant when the subcutaneous implant is hidden under the skin, and then to suture through the implant to anchor against the skin.

The handle **212a**, **212b** may be configured to allow the two shafts **214a**, **214b** to be hinged and aligned adjacent and parallel to each other to allow an operator to hold on to the delivery device **200**.

The top stabilizer **206** and the spoon-shaped bottom holder **202** may be configured to have a protrusion **226** and an indentation **228** (complementary to the protrusion **226**), respectively, to allow the two parts **206**, **202** to be aligned properly during closure (as seen in FIG. 2B), where a central longitudinal axis of the top stabilizer **206** and a central longitudinal axis of the spoon-shaped bottom holder **202** may be in alignment with each other along a line D-D' of FIG. 2C. In another example (not shown here), the top stabilizer **206** and the spoon-shaped bottom holder **202** may be configured to have an indentation and a protrusion (complementary to the indentation), respectively, to allow the two parts **206**, **202** to be aligned properly during closure. Other possible alternatives to achieve "proper alignment" of the two parts **206**, **202** may be by using electronic touch sensors with light emitting diode (LED) indicators that lights up when the top shaft **214b** and the bottom shaft **214a** are aligned properly. Alternate to the LED indicators, an alarm system may also be used to confirm that the top shaft **214b** and the bottom shaft **214a** are aligned properly, e.g., via "beep" alarms. Yet another variation to the LED indicators may be the use of magnetic locking mechanisms that align and lock the top and bottom shafts **214b**, **214a** respectively.

A subcutaneous implant **204** may be positioned within or in alignment with a circumferential peripheral of the gap **222** as seen in FIGS. 2B and 2C. The subcutaneous implant **204** may be described in the same or similar context with the subcutaneous implantable device **104** of FIG. 1A.

FIGS. 3A to 3H show diagrams illustrating a method of utilizing the simplified delivery device **200** of FIG. 2A to implant a subcutaneous implant, such as a vascular access device for arteriovenous fistula (AVF or AV fistula).

As seen in FIG. 3A which illustrates creating an incision, a cut down incision between about 1 cm to about 3 cm long may be created on a skin **308**. The incision may be created using a surgical knife **330**. A forcep or tweezer **332** may be

used to hold onto the skin **308** during the incision procedure. The incision may allow access to a space below the dermis and a thin layer of subcutaneous tissue. A tunnel along the subcutaneous tissue under the skin **308** may be created. The tunnel may be about 2-3 mm below the top surface of the skin **308** (or about 1 mm below the bottom layer of the skin **308**), running parallel with the AV fistula (not shown) in a longitudinal direction.

As seen in FIG. 3B (which illustrates insertion of an implant **204**) and FIG. 3C (which illustrates suturing a proximal end of the implant **204** to the skin **308**), an access device (e.g., the subcutaneous implant **204** of FIGS. 2B and 2C) may be inserted using the delivery device **200** into the incision created, and slipped along and into the subcutaneous tissue tunnel in the longitudinal direction parallel with the AV fistula. The depth of insertion may depend on the incision created or at the depth as indicated on the delivery device **200**. The top stabilizer **206** of the delivery device **200** may close in a downward direction and may hold on to the skin **308** and the access device **204** (that is hidden underneath the skin **308**) firmly. The proximal end of the access device **204** may be sutured onto the skin **308**. The location of suture may be guided by a landmark groove **324a** shown at the proximal end of the top stabilizer **206**. As seen in FIG. 3C, suturing may be performed manually.

The orientation of the access device **204** may be confirmed by using a test needle **334**, which may be smaller in size than a typical dialysis needle (such as 21 G to 25 G), to access the AV fistula, as seen in FIG. 3D (which illustrates confirmation of implant orientation via flash back of the test needle **334**). The device orientation may be confirmed upon seeing blood flash back in the test needle **334**.

As seen in FIG. 3E (which illustrates application of pressure for hemostasis), after the test needle **334** (or may be referred to as a guiding needle) is removed, a small amount of pressure may be applied at the access device area briefly to ensure hemostasis of the AV fistula as per a typical medical professional (e.g., nurse) workflow.

Upon confirmation of the orientation of the device **204**, the distal end (or remaining suture ports) of the device **204** may be sutured onto the skin **308**, as seen in FIG. 3F (which illustrates suturing of distal end of the implant **204** to the skin **308**). The location of suture may be guided by a landmark groove **324b** shown at the distal end of the top stabilizer **206**.

As seen in FIG. 3G which illustrates the removal of the delivery device **200**, the skin **308** on top of the distal end of the access device **204** may be held by a tool **336** (e.g., a forcep or tweezer) and the delivery device **200** may be removed by depressing slightly.

As seen in FIG. 3H (where the incision site is sutured close), the incision site may be sutured closed after the procedure (method) for healing. Dialysis may be commenced after about 5-14 days, after the implant **204** is encapsulated by its surrounding subcutaneous tissue. The skin sutures may be removed at this point if the operator wishes to. Dialysis may include inserting a needle through the access device **204** to a vascular site. Once dialysis is completed, the needle may be removed and pressure may be applied on the area to achieve hemostasis as per usual work protocol.

FIG. 4A shows a perspective view of a self-suturing delivery device **400** for implantation of a subcutaneous implant (not shown), in accordance with various embodiments. For example, the self-suturing device **400** may be a subcutaneous implant delivery device with self suturing mechanisms. FIG. 4B shows a photograph illustrating a

prototype realization of the self-suturing delivery device **400** of FIG. **4A**. FIG. **4C** shows schematic drawings (plan view, side view, and perspective view) illustrating the self-suturing delivery device **400** of FIG. **4A** and its components. For example, the self-suturing delivery device **400** and the subcutaneous implant may include the same or like elements or components as those of the subcutaneous implant delivery apparatus **100** and the subcutaneous implantable device **104** of FIG. **1A**, respectively, and as such, the same numerals are assigned and the like elements may be as described in the context of the subcutaneous implant delivery apparatus **100** and the subcutaneous implantable device **104** of FIG. **1A**, and therefore the corresponding descriptions may be omitted here.

As seen in FIGS. **4A** to **4C**, the delivery device **400** may include (i) a top handle metal member **440** (e.g., stainless steel S316 or medical grade titanium) which may be connected to a handle **412**. The handle may be made from a different material (e.g., hard plastics like polyvinyl chloride (PVC), acrylonitrile butadiene styrene (ABS), or polycarbonate). The delivery device **400** may include (ii) an implant holder member **442** that acts as a base to hold an implantable device (e.g., the subcutaneous implant). The implant holder **442** may be held in place by a combination of fixed and moveable screws (e.g., positions of which may be as indicated by **M2** and/or **M3** through holes or threaded holes). The fixed screws may hold the implant holder **442** and the top handle **440** in place, while the moveable screw may allow the implant holder **442** to be moveable upwards to close the gap between the top handle **440** and the implant holder **442**.

For example, the implant holder member **442** and the top handle **440** may include the same or like elements or components as those of the receiving portion **102** and the stabilizing portion **106** of the subcutaneous implant delivery apparatus **100** of FIG. **1A**, respectively, and therefore the corresponding descriptions may be omitted here.

The delivery device **400** may further include (iii) a needle holder member **444**, that may be placed below the implant holder **442**, used for holding a plurality of straight needles (not shown in FIGS. **4A** to **4C**) loaded with sutures in place. The needle holder **444** has a slit **446** to align sutures properly. The needle holder **444** may be secured to the top handle **440** with a combination of fixed and moveable screws (e.g., positions of which may be as indicated by **M2** and/or **M3** through holes or threaded holes). The fixed screws may hold the needle holder **444** and the top handle **440** in place, while the moveable screw may allow the needle holder **444** to be moveable upwards to close the gap between the needle holder **440** and the implant holder **442**. The needle holder **440** and the implant holder **442** may be loosely fitted to each other. The delivery device **400** may include (iv) the handle member **412** that allows the operator to hold on to the delivery device **400**.

The top handle member **440** may include a long slit **448** in the center to guide a small test needle, e.g., sized 21 G-25 G, to access a vasculature below the implant (or implantable) device (e.g., the subcutaneous implantable device **104** of FIG. **1A**) to confirm that the implantable device is correctly positioned and orientated above the vasculature.

There may be needles and sutures of sufficient lengths (about 4 sets of sutures with 8 needles) held by the needle holder **444**. For example, the needle length may be between about 4 mm to about 17 mm. The suture length may be between about 15 mm to about 30 mm.

The needles, upon moving the needle holder **444** upwards, may trigger the needles to travel through the implantable

device, piercing through the skin above the delivery device **400**, and emerge from the top handle **440**.

Movements of the implant holder **442** and the needle holder **444** may be made manually by the operator turning the screw threads, or by an electro-motor mechanism that may be incorporated to the delivery device **400**.

The top handle **440** and the implant holder **442** when fully closed by the screw thread levers, may be configured to have a gap inbetween. This may be so to ensure that the skin and the subcutaneous tissue over the implantable device is not overly compressed, especially during the procedure when the top handle **440** may be required to close down to clamp on the skin to lock the implantable device in position.

The distal end of the implant holder **442** may also be configured to include a lowered step for holding the implant device in place (not shown), but yet may allow for easy removal of the delivery device **400** once the implant device is sutured onto the skin.

FIGS. **5A** to **5G** show diagrams illustrating a method of utilizing the self-suturing delivery device **400** of FIG. **4A** to implant a subcutaneous implant, such as a vascular access device for AV fistula.

As seen in FIG. **5A** which illustrates creation of cut down incision, a cut down incision between about 1 cm to about 3 cm long may be created on a skin **508**. The incision may be created using a surgical knife **530**. A forcep or tweezer **532** may be used to hold onto the skin **508** during the incision procedure. The incision may allow access to a space below the dermis and a thin layer of subcutaneous tissue. A tunnel along the subcutaneous tissue under the skin **508** may be created. The tunnel may be about 2-3 mm below the top layer of the skin **508** (or about 1 mm below the bottom layer of the skin **508**), running parallel with the AV fistula (not shown) in a longitudinal direction.

As seen in FIG. **5B** (which illustrates insertion of the self-suturing delivery device **400** and tightening of implant holder **442** to secure the delivery device **400** with the skin **508**), an access device (e.g., the subcutaneous implantable device **104** of FIG. **1A**) may be inserted using the delivery device **400** into the incision created, and slipped along and into the subcutaneous tissue tunnel in the longitudinal direction parallel with the AVF. The depth of insertion may depend on the incision created or at the depth as indicated by the delivery device **400**. Insertion of the self-suturing delivery device **400** and tightening of screw **540** at the implant holder **442** to move the access device **104** (that is hidden underneath the skin **508**) upward and secure said device **104** in position against the skin **508** and the subcutaneous tissue above the device **104**.

The orientation of the access device **104** may be confirmed by using a test needle **534**, which may be smaller in size than a typical dialysis needle (such as 21 G to 25 G), to access the AV fistula, as seen in FIG. **5C** (which illustrates confirmation of implant orientation with small test needle **534**). The device orientation may be confirmed upon seeing blood flash back in the test needle **534**.

As seen in FIG. **5D** (which illustrates tightening of needle holder plates **444** to trigger suture needles pre-loaded in the implant **104** and the delivery device **400**), a second screw **542** connected to the needle holder **444** (that is hidden underneath the skin **508**) may be tightened to trigger the suture needles (not shown in FIG. **5D**) pre-loaded in the implant **104** and the delivery device **400**. For example, tightening of the second screw **542** may be carried out using an alien key **544**. The suture needles, upon trigger by the needle holder **444**, may move upwards and automatically pierce through the skin **508** from beneath the needle holder

444. This way, self-suturing may be performed and this is different to the manual suturing as described in FIGS. 3C and 3F.

As seen in FIG. 5E (which illustrates retrieval of needles 546 that is fired through and from below the skin 508, securing sutures to anchor the implant 104 to the skin 508), needles 546 may be retrieved from the implant 104 (that is hidden underneath the skin 508) by means of grabbing and pulling the needle tip exposed from the skin 508. For example, the needle tip may be grabbed by a forcep or tweezer 548. In this case, the sutures may be secured firmly for all four pairs of sutures to anchor the implant 104 to the skin 508.

As seen in FIG. 5F (which illustrates removal of the delivery device 400), the skin 508 on top of the distal end of the access device 104 may be held by a tool (not shown in FIG. 5F) and the delivery device 400 may be removed by depressing slightly.

As seen in FIG. 5G (which illustrates closure of the cut-down incision), the incision site may be sutured closed after the procedure (method) for healing. Suturing to close the incision may be performed manually. Dialysis may be commenced after about 5-14 days of encapsulation after the implant 104 is encapsulated by its surrounding subcutaneous tissue. The skin sutures may be removed at this point if the operator wishes to. Dialysis may be performed as described above.

FIG. 6A shows a perspective view of a subcutaneous implant delivery device 600, in accordance with various embodiments, wherein the delivery device 600 may provide guided suturing, guided implant orientation test channels, and additional AV fistula safety of a protection base plate. For example, the subcutaneous implant delivery device 600 may be a subcutaneous implant delivery device, with advance implant orientation guide and AVF safety protection base. In FIG. 6A, a needle guide 650 of the subcutaneous implant delivery device 600 may be positioned over an area of a bottom handle member 602 which is arranged to hold a subcutaneous implant (not shown). The subcutaneous implant delivery device 600 may include a handle 612 that allows an operator to hold on to the subcutaneous implant delivery device 600. FIG. 6B shows a perspective view of the subcutaneous implant delivery device 600 (without the handle 612) where the needle guide 650 is positioned over a top handle 606 of the subcutaneous implant delivery device 600, away from the area where the subcutaneous implant is being held. A U-lock or U-clamp 682 may be provided overlying the needle guide 650 or at least part of the needle guide 650. FIG. 6C shows schematic drawings (plan view, side view, and perspective view) illustrating the subcutaneous implant delivery device 600 of FIG. 6A and its components. For example, the subcutaneous implant delivery device 600 and the subcutaneous implant may include the same or like elements or components as those of the subcutaneous implant delivery apparatus 100 and the subcutaneous implantable device 104 of FIG. 1A, respectively, and as such, the same numerals are assigned and the like elements may be as described in the context of the subcutaneous implant delivery apparatus 100 and the subcutaneous implantable device 104 of FIG. 1A, and therefore the corresponding descriptions may be omitted here.

The delivery device 600 in FIG. 6A may be similar to the simplified version in FIGS. 2A to 2C, but with more features. The delivery device 600 may include the top handle member 606 that acts as a stabilizer, the bottom handle member 602 that holds the subcutaneous implant in place, the needle guide member 650 that guides a test needle (not

shown) to verify the correct orientation and position of the subcutaneous implant, and the handle 612. Each of these member (component) may be made from metal, such as though not limited to stainless steel S316, medical grade titanium etc; and/or from rigid plastics, such as though not limited to polyvinyl chloride (PVC), polycarbonate, acrylonitrile butadiene styrene (ABS), and so on.

The top handle 606 and the bottom handle 602 may function in the same way or in a similar way as the top stabilizer 206 and the bottom holder 202 respectively, as disclosed in FIG. 2A. For example, the bottom handle 602 and the top handle 606 may also include the same or like elements or components as those of the receiving portion 102 and the stabilizing portion 106 of the subcutaneous implant delivery apparatus 100 of FIG. 1A, respectively, and therefore the corresponding descriptions may be omitted here.

As seen in FIGS. 6A to 6C, the bottom handle 602 may hold an access device (e.g., the subcutaneous implant or the subcutaneous implantable device 104 of FIG. 1A). The bottom handle 602 may also be designed with a flat and fully covered hard base 651 (e.g., the protection base plate). The base 651 may be designed to shield the AV fistula or other vasculature/important anatomy that is below the delivery device 600 during the implantation procedure from injury such as misjudged needling or suturing that may puncture/perforate the AV fistula, causing undetected bleeding.

The distal end of the bottom handle 602 may also be configured to include a lowered step (not shown) for holding the subcutaneous implant in place, but yet may allow for easy removal of the delivery device 600 once subcutaneous implant is sutured onto the skin.

The needle guide 650 may be coupled movably to the top handle 606 and may have at least one test-needle through-hole channel(s) 652 which guide the piercing of a small needle size vertically (e.g., 25 G) to ensure the orientation of the access device to access the AV fistula. The device orientation may be confirmed upon seeing blood flash back in the test needle. A plurality of said test-needle channels 652 may be configured along the longitudinally axis of the needle guide 650, for example, the most distal channel leading a test needle to access the AV fistula in the distal front of the subcutaneous implant, the middle channel(s) leading a test needle to access the AV fistula through the subcutaneous implant, and the most proximal channel leading a test needle to access the AV fistula outside the proximal rear of the subcutaneous implant. The configuration of the test needle channels may be designed to verify whether the subcutaneous implant is anchored above a bending AV fistula; and if so, confirming that the subcutaneous implant may still guide any access needle/instruments to access the bending AV fistula.

The top handle 606 may include one or more suture guide groove-markings 654 that guides and confirms an operator has made sutures passing fully through the implant before being anchored onto the skin. For example, the top handle 606 may include at least three suture guide groove-markings. Suture guides 655 may be located on the sides of the bottom handle 602, aligned directly opposite each other to enable a suture needle entering from one side of the implant to exit from the direct opposite position of the other side of the implant horizontally. The top handle 606 may include a first through hole 656a of about 2 mm in diameter, about which the needle guide 650 may be pivoted when aligned with a through hole 656c, and a second through hole 656b of about 2 mm in diameter, about which the handle 612 may be pivoted.

Similar to the top stabilizer **206** of the embodiment in FIG. **2A**, the top handle **606** may include a gap at the distal end to ensure the device **600** holds down on the skin firmly but gently for different patients of different skin thickness.

The bottom handle **602** may be fixed to the handle **612** using screws through threaded holes **658a**, **658b**, **658c** of the bottom handle **602**.

The through hole **656d** at the bottom handle **602** may be the access hole for a test needle (e.g., **734** of FIG. **7C**) which allows the test needle to pass through the bottom handle **602** during the device orientation flashback testing.

The handle **612** may be configured to be attached to proximal ends of the top handle **606**, the bottom handle **602** and the needle guide **650** to allow the operator to hold on to the delivery device **600**.

FIG. **6D** shows a perspective view of a subcutaneous implant delivery device **670**, which is a similar variation of the subcutaneous implant delivery device **600** of FIG. **6A**, with added quick implant release mechanism. In other words, the device **670** of FIG. **6D** is somewhat similar to or based on that of FIG. **6A**, with some variations. For example, the subcutaneous implant delivery device **670** may have advance implant orientation guide, AVF safety protection base and implant quick release features. For convenience of referencing, the subcutaneous implant delivery device **600** of FIG. **6A** and the subcutaneous implant delivery device **670** of FIG. **6D** may have the same or like elements or components, and as such, the same numerals are assigned and the like elements may be as described in the context of subcutaneous implant delivery device **600** of FIG. **6A**, and therefore the corresponding descriptions may be omitted here. FIG. **6E** shows schematic drawings (plan view, side view, and perspective view) illustrating the subcutaneous implant delivery device **670** of FIG. **6D** and its components.

As seen in FIGS. **6D** and **6E**, one additional feature may be a quick release mechanism located at the bottom handle member **602** of the device **670**. Instead of a protection base plate (e.g., **651** of FIG. **6B**) and a side surrounding step to hold a subcutaneous implant in place, the bottom handle **602** may include a shaft **660** with a distal end of a male socket **662**. The male socket **662** may be designed with pings that slip fits a female (complementary) socket (not shown) on the subcutaneous implant to hold the implant in place. The male socket **662** may enable the delivery device **670** to quick release the subcutaneous implant when the implantation procedure is completed.

For the quick release version of the delivery device **670** of FIG. **6D**, the delivery device **670** may be removed by simply pulling the delivery device **670** out, with the male slip fit socket **662** releasing the subcutaneous implant or the access device (e.g., **104** of FIG. **1A**) that is anchored under the skin.

In other example, the bottom handle **602** may include a shaft **660** with a distal end of a female socket, which may slip fit to a male socket on the subcutaneous implant to hold the implant in place.

FIG. **6F** shows a perspective view of another subcutaneous implant delivery device **680**, which is a similar variation of the subcutaneous implant delivery device **600** of FIG. **6A**, with improved design and fastening mechanism. In other words, the device **680** of FIG. **6F** is somewhat similar to or based on that of FIG. **6A**, with some variations. For convenience of referencing, the subcutaneous implant delivery device **600** of FIG. **6A** and the subcutaneous implant delivery device **680** of FIG. **6F** may have the same or like elements or components, and as such, the same numerals are assigned and the like elements may be as described in the

context of subcutaneous implant delivery device **600** of FIG. **6A**, and therefore the corresponding descriptions may be omitted here. FIG. **6G** shows schematic drawings (plan view, side view, and perspective view) illustrating the subcutaneous implant delivery device **680** of FIG. **6F** and its components. For the variation of the subcutaneous implant delivery device **680** (FIG. **6F**), four features may be modified as improvements to the device **600** of FIG. **6A**. For example, the four improved features may be:—

a) Lateral swing activated needle guide—In the device **600** (FIG. **6A**), the needle guide **650** may be mounted on the top handle **606**, pivoted to the through hole **656a** and activated by rotation about the pivot. For the subcutaneous implant delivery device **680** (FIG. **6F**), the needle guide **650** may be mounted on the top handle **606**, pivoted to a lateral through hole **656a** and activated by swing rotation. This modification may provide an advantage of not needing the U-clamp **682** to be removed and reinserted when a test needle (e.g., **734** of FIG. **7C**) is deployed through the needle guide **650**, over the course of the procedure as outlined in FIGS. **7A** to **7H**. In other words, the use of the subcutaneous implant delivery device **680** (FIG. **6F**) may further simplify the procedure.

b) Skin-pinching prevention groove for U-clamp—As illustrated in FIG. **6G**, a groove **684** may be created on the bottom handle **602**. The purpose of the groove **684** may be to allow the U-clamp **682** to flush with the bottom surface of the bottom handle **602**, thereby preventing skin from being pinched when the U-clamp **682** is engaged to lock the top handle **606** and the bottom handle **602** together.

c) Shorter handle—The subcutaneous implant delivery device **680** may differ from the device **600** by having a shorter handle (e.g., **612**, FIG. **6F**). This may reduce the weight of the device **680**, provide better balance, improve user comfort and reduce manufacturing cost.

d) Screwless hinges—In the device **600** (FIG. **6A**), three screws for the screws through threaded holes **658a**, **658b**, and **658c** (FIG. **6C**) may be used to attach the handle **612** to the bottom handle **602**. In the subcutaneous implant delivery device **680** (FIG. **6F**), the three screws (FIG. **6C**) may be replaced by one threadless press fit rod hinge **686** (FIG. **6F**) passes through the through hole **688b** in FIG. **6G**. The purpose of replacing screws (as in the device **600** of FIG. **6A**) with a threadless press fit rod hinge (as in the subcutaneous implant delivery device **680** of FIG. **6F**) may be to reduce risk of residual sterilization ethylene oxide (EtO) entrapped in the screw threads. This improvement/modification may enable the sterilization process to be easier. In the device **600**, the top handle **606** may be attached to the handle **612** with a press fit rod hinge (e.g., through the through hole **656b** of FIG. **6C**), but in the subcutaneous implant delivery device **680** of FIG. **6F**, the top handle **606** may be attached to the bottom handle **602** with a press fit rod hinge **691** in FIG. **6F** that passes through the through hole **656b** (FIG. **6G**) and through hole **688a** (FIG. **6G**).

FIGS. **7A** to **7H** show diagrams illustrating a method of utilizing the delivery device **600** of FIG. **6A** and/or the variation thereof (i.e., the delivery device **680** of FIG. **6F**) to implant a subcutaneous implant, such as a vascular access device for AV fistula.

As seen in FIG. **7A** which illustrates creating an incision, a cut down incision between about 1 cm to about 3 cm long may be created on a skin **708**. The incision may be created using a surgical knife **730**. The incision may allow access to a space below the dermis and a thin layer of subcutaneous tissue. A tunnel along the subcutaneous tissue under the skin **708** may be created. The tunnel may be about 2-3 mm below the top surface of the skin **708** (or about 1 mm below the

bottom layer of the skin **708**), running parallel with the AV fistula in a longitudinal direction.

As seen in FIG. 7B (which illustrates insertion of an implant), an access device (e.g., the subcutaneous implantable device **104** of FIG. 1A) may be inserted using the delivery device **600, 680** into the incision created, and slipped along and into the subcutaneous tissue tunnel in the longitudinal direction parallel with the AVF. The depth of insertion may depend on the incision created or until the depth as indicated by the delivery device **600, 680**. A forcep or tweezer **732** may be used to hold the skin **708** and assist the insertion of the delivery device **600, 680**.

The orientation of the access device **104** (that is hidden underneath the skin **708**) may be confirmed by using a test needle **734**, which may be smaller in size than a typical dialysis needle (such as 21 G to 25 G), to access the AV fistula as seen in FIG. 7C (which illustrates confirmation of implant orientation). The device orientation may be confirmed upon seeing blood flash back in the test needle **734**. The test needle **734** may be inserted at an angle perpendicular to the implant **104** along needle guide test channels **752**. For example, the test needle **734** may be used on every of the two needle guide channels **752**, to access the AV fistula in front of, through and/or behind the access device **104**. This two test checks may verify whether the implanted access device **104** is positioned above an AV fistula at a bend, and if so, may be able to guide a needle (not shown in FIG. 7C) to access a curved AV fistula successfully.

Upon confirmation of the correct position and orientation of the access device **104**, the top handle **606** and the bottom handle **602** (not shown) of the delivery device **600, 680** may be locked in place with a U-lock **682**, sandwiching the skin **708** and the access device **104** together, as seen in FIG. 7D (which illustrates locking of the device **600, 680** in place using the U-lock **682**). The U-lock **682** may temporarily lock the access device **104** in a fixed position relative to the skin **708** and the AV fistula.

As seen in FIG. 7E (which illustrates suturing the distal end of the access device **104**), the distal end of the implanted access device **104** may be sutured onto the skin **708**. A suture needle **766** may be passed through suture guide groove-markings **754a** (found on both sides of the top handle **606**) that guide and confirm the operator has made sutures passing fully through the access device **104**. Upon this confirmation, the sutures may be tightened to pull the access device **104** upwards and tied to securely anchor the implant **104** against the skin **708**.

As seen in FIG. 7F (which illustrates suturing the proximal end of the access device **104**), the proximal end of the implanted access device **104** may be sutured onto the skin **708**. The suture needle **766** may be passed through suture guide groove-markings **754b** (found on both sides of the top handle **606**) that guide and confirm the operator has made sutures passing fully through the access device **104**. Upon this confirmation, the sutures may be tightened to pull the access device **104** upwards and tied to securely anchor the implant **104** against the skin **708**.

FIG. 7G illustrates removal of the delivery device **600, 680**. For the version of the delivery device **600, 680** of FIG. 6A and FIG. 6F, the skin **708** on top of the distal end of the access device **104** may be held by a tool **748** (e.g., a forcep or a tweezer) and the delivery device **600** may be removed by depressing slightly.

As seen in FIG. 7H (which illustrates closure of the incision), the incision site may be sutured closed after the procedure (method) for healing. Dialysis may be commenced after about 5-14 days, after the implant **104** is

encapsulated by its surrounding subcutaneous tissue. The skin sutures may be removed at this point if the operator wishes to. Once dialysis is completed, a needle for dialysis may be removed and pressure may be applied on the area to achieve hemostasis as per usual work protocol. As seen in FIGS. 7E, 7F and 7H, suturing may be performed manually.

While the invention has been particularly shown and described with reference to specific embodiments, it should be understood by those skilled in the art that various changes in form and detail may be made therein without departing from the spirit and scope of the invention as defined by the appended claims. The scope of the invention is thus indicated by the appended claims and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced.

The invention claimed is:

1. A subcutaneous implant delivery apparatus comprising:
 - a receiving portion configured to receive a subcutaneous implantable device; and
 - a stabilizing portion configured to cooperate with the receiving portion to hold the subcutaneous implantable device in a fixed position with a skin layer between the receiving portion and the stabilizing portion, wherein the receiving portion and the stabilizing portion are movable relative to each other between a released configuration and a closed configuration; wherein in the released configuration, the receiving portion and the stabilizing portion are configured to move apart from each other to allow the receiving portion to be inserted under the skin layer and the subcutaneous implantable device to be positioned subcutaneously maintaining the skin layer between the receiving portion and the stabilizing portion; and wherein in the closed configuration, the receiving portion and the stabilizing portion are configured to move toward each other maintaining the skin layer between them to allow the subcutaneous implantable device to be held adjacent to the skin layer, between the receiving portion and the stabilizing portion, in the fixed position.
2. The subcutaneous implant delivery apparatus of claim 1, further comprising at least one position indicator configured to facilitate a visual indication of at least one of a position or an angular orientation of the subcutaneous implantable device when received by the receiving portion and held adjacent to the skin layer.
3. The subcutaneous implant delivery apparatus of claim 2, wherein the position indicator comprises a needle guide configured to receive a needle upon alignment of the subcutaneous implantable device to at least one of a desired position or a desired angular orientation with respect to the receiving portion.
4. The subcutaneous implant delivery apparatus of claim 3, wherein the needle guide is configured to be coupled to the stabilizing portion and activated by a swing rotation to move laterally along the stabilizing portion.
5. The subcutaneous implant delivery apparatus of claim 1, further comprising at least one anchor guide configured to facilitate the subcutaneous implantable device to be anchored to the skin layer.
6. The subcutaneous implant delivery apparatus of claim 5, wherein the at least one anchor guide comprises a suture guide marking.
7. The subcutaneous implant delivery apparatus of claim 1, wherein the receiving portion comprises a blocking base plate on which the subcutaneous implantable device is to be

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placed, wherein the blocking base plate is configured to form a shield for an anatomy or a tissue underneath the subcutaneous implantable device.

8. The subcutaneous implant delivery apparatus of claim 1, wherein the receiving portion comprises a releasable attachment mechanism to which the subcutaneous implantable device is to be releasably attached.

9. The subcutaneous implant delivery apparatus of claim 1, wherein the receiving portion and the stabilizing portion are movable relative to each other about a pivoting point.

10. The subcutaneous implant delivery apparatus of claim 1, further comprising a handle extending from at least one of the receiving portion or the stabilizing portion.

11. The subcutaneous implant delivery apparatus of claim 10, wherein the handle is made of plastic.

12. The subcutaneous implant delivery apparatus of claim 1, further comprising a handle extending from each of the receiving portion and the stabilizing portion.

13. The subcutaneous implant delivery apparatus of claim 12, wherein the handles are configured to move toward each other upon exerting an external force thereon to correspondingly allow the receiving portion and the stabilizing portion to be moveable toward each other in the closed configuration.

14. The subcutaneous implant delivery apparatus of claim 1, further comprising at least one needle arranged to self suture through the subcutaneous implantable device when received by the receiving portion, to the skin layer upon moving the receiving portion and the stabilizing portion toward each other.

15. The subcutaneous implant delivery apparatus of claim 1, wherein the receiving portion and the stabilizing portion are made of a material selected from plastic, austenitic molybdenum-containing stainless steel, and medical grade titanium.

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16. The subcutaneous implant delivery apparatus of claim 1, further comprising a locking mechanism arranged to releasably lock the receiving portion and the stabilizing portion in the closed configuration.

17. The subcutaneous implant delivery apparatus of claim 16, wherein each of the receiving portion and the stabilizing portion comprises a screw hole, and wherein the locking mechanism comprises a screw arranged through the screw holes.

18. The subcutaneous implant delivery apparatus of claim 16, wherein the locking mechanism comprises a U-lock or a U-clamp.

19. A method of delivering a subcutaneous implantable device for accessing a vascular site, the method comprises: providing a subcutaneous implant delivery apparatus of claim 1; receiving a subcutaneous implantable device on the receiving portion of the subcutaneous implant delivery apparatus; inserting the receiving portion under a skin layer; positioning the subcutaneous implantable device subcutaneously; holding the subcutaneous implantable device adjacent to the skin layer between the receiving portion and the stabilizing portion in a fixed position; releasing the subcutaneous implantable device by allowing the receiving portion and the stabilizing portion to move apart from each other; and removing the receiving portion from under the skin layer.

20. The method of claim 19, further comprising providing a blocking base plate on which the subcutaneous implantable device is to be placed to form a shield for an anatomy or a tissue underneath the subcutaneous implantable device.

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