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SIDE-TO-END ANASTOMOTIC COUPLER

Abstract

An anastomotic coupler is provided. A ring is aligned with a cartridge in that at least a portion of the cartridge is disposed within a lumen of the first tubular structure and the ring is positioned external of the first tubular structure. The cartridge is operable to engage with the ring to secure the ring and the cartridge with the first tubular structure and allow a lumen of a second tubular structure to be in fluid communication with the lumen of the first tubular structure via a hole formed in a wall of the first tubular structure.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS [0001] This application is a continuation of U.S. application Ser. No. 17/365,484 filed July 1, 2021, which is a continuation-in-part application of U.S. application Ser. No. 17/181,440 filed Feb. 22, 2021, which is a continuation application of U.S. application Ser. No. 16/950,209 filed Nov. 17, 2020, now U.S. Pat. No. 10,939,913, which claims the benefit of U.S. Provisional Patent Application No. 62/936,868, filed in the U.S. Patent and Trademark Office on Nov. 18, 2019, and U.S. Provisional Patent Application No. 63/061,303, filed in the U.S. Patent and Trademark Office on Aug. 5, 2020, each of which is incorporated herein by reference in its entirety for all purposes.

FIELD
[0002] The present disclosure relates generally to an anastomotic coupler. In at least one example, the present disclosure relates to a surgical system and method to utilize an anastomotic coupler to connect two tubular structures such as vessels, esophagus, intestine, lymphatic structure, and/or graft material.
BACKGROUND
[0003] An anastomosis is a connection between two luminal structures. Commonly, these connections can occur with blood vessels (for example, vascular anastomosis), or tubular gastrointestinal structures (for example, intestines, stomach, esophagus). Conventional techniques allow the anastomosis to be completed between two ends (referred to as end-to-end anastomosis), or between the end of one structure and the side of another structure (referred to as end-to-side anastomosis). Procedures requiring these anastomoses are carried out thousands of times per day, globally. Likewise, multiple surgical specialties rely upon the creation of reliable, unobstructed anastomoses for successful treatment of their respective patients.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
[0004] Implementations of the present technology will now be described, by way of example only, with reference to the attached figures, wherein:
[0005] FIG. **1** illustrates a diagram of an anastomotic coupler;
[0006] FIG. **2** illustrates a fixation device;
[0007] FIG. **3** illustrates a tubular structure being received by a fixation device;
[0008] FIG. **4** illustrates a ring being aligned with a cartridge of the fixation device;
[0009] FIG. **5** illustrates a cross-sectional view of FIG. **4**;
[0010] FIG. **6** illustrates an exemplary fastener;
[0011] FIG. **7** illustrates another example of a fastener;
[0012] FIG. **8** illustrates another example of a fastener;
[0013] FIG. **9** illustrates a cross-sectional view of the cartridge aligned with the ring;
[0014] FIG. **10**A illustrates actuation of the fixation device;
[0015] FIG. **10**B illustrates a cross-sectional view of FIG. **10**A;

[0016] FIG. **11** illustrates an exemplary ring;
[0017] FIG. **12** illustrates an example of another ring;
[0018] FIG. **13** illustrates a cross-sectional view of two rings coupled with one another to join two tubular structures;
[0019] FIG. **14** illustrates a cap disposed over the two rings of FIG. **13**;
[0020] FIG. **15** illustrates an exemplary cap;
[0021] FIG. **16** is a flow chart of a method for utilizing an anastomotic coupler;
[0022] FIG. **17**A illustrates a fixation device engaging with a side hole of a tubular structure;
[0023] FIG. **17**B illustrates a ring being aligned on the tubular structure of FIG. **17**A;
[0024] FIG. **17**C illustrates actuation of the fixation device;
[0025] FIG. **17**D illustrates the ring being coupled with the side of the tubular structure;
[0026] FIG. **17**E illustrates a second tubular structure being coupled with the tubular structure; and
[0027] FIG. **18** is a flow chart of a method for coupling an end of a tubular structure with a side of a tubular structure.

DETAILED DESCRIPTION

[0028] It will be appreciated that for simplicity and clarity of illustration, where appropriate, reference numerals have been repeated among the different figures to indicate corresponding or analogous elements. In addition, numerous specific details are set forth in order to provide a thorough understanding of the examples described herein. However, it will be understood by those of ordinary skill in the art that the examples described herein can be practiced without these specific details. In other instances, methods, procedures and components have not been described in detail so as not to obscure the related relevant feature being described. Also, the description is not to be considered as limiting the scope of the examples described herein. The drawings are not necessarily to scale and the proportions of certain parts may be exaggerated to better illustrate details and features of the present disclosure.

[0029] The original technique for vascular suture anastomoses was created by Alexis Carrel between 1901-1910. This pioneering work resulted in Carrel receiving the Nobel Prize in 1912. Despite 100 years of surgical evolution and innovation since that discovery, the majority of vascular anastomoses to this day still employ suture techniques similar to Carrel's initial description in the early 1900s. In the 1970s, gastrointestinal stapling devices were introduced, which quickly replaced primary suture techniques for bowel anastomoses. However, most surgeons still employ circumferential suture techniques in the serosal layer overlying the stapled anastomosis for added support. Although generally successful, these techniques can take long periods of time, often require additional surgical expertise, and if not performed correctly, may result in leakage (blood, stool contents, gastric contents, lymphatic fluid), constriction, stenosis, and/or obstruction at the anastomotic site. In the case of vascular anastomoses, stenosis and/or obstruction can result in catastrophic complications such as heart attack, stroke, peripheral limb ischemia, amputation, death, and reconstructive failure and soft-tissue loss. For example, in the setting of gastrointestinal anastomoses, these complications can result in extra-luminal leak of gastrointestinal contents, infection, sepsis, obstruction, and death.

[0030] With the understood importance of reliable, open anastomoses, alternatives to sutures and staples have been used. An example of a vascular anastomotic coupler is described, for instance, in U.S. Patent Pub. No. 2015/0088172 A1 (the '172 Publication). This coupler has two circular ends with spikes or pins. The vessel is brought through the ring and the vessel wall is everted, or rolled over, the pins for securement as shown in FIGS. **2**A and **2**B of the '172 Publication. This is completed on each vessel end, and the two rings are then brought together with the spikes/pins being forced into the opposite ring to join the ends together as shown in FIG. **1**C of the '172 Publication. However, because of the potential for micro-motion of the vessels and size mismatch due to the anastomotic coupler of the '172 Publication, blood leakage may happen, and/or one of the pins may tear through the vessel wall creating a leak and/or site for platelet aggregation and

thrombosis (blood clot formation). Likewise, with the anastomotic coupler of the '172 Publication, for thicker walled, less elastic vessels, particularly arteries, everting vessel edges can be quite difficult and may result in trauma to the vessel wall (intima) and/or stenosis at the anastomosis, both of which can create platelet aggregation, turbid flow, and/or thrombosis with subsequent obstruction of flow. Additionally, the technique of the '172 Publication requires additional specialized equipment (surgical microscope, high-powered loupe magnification) to use. For gastrointestinal stapled anastomoses, many procedures are performed either side-to-side which is not a natural pathway for intestinal smooth muscle propulsion of stool contents (for example, non-longitudinal flow along the length of the intestine), or end-to-end, which requires a separate, remote full-thickness bowel access incision for deployment, thereby creating a secondary weak point for potential leak, or adhesion formation.

[0031] Referring now to FIG. **1**, an anastomotic coupler **10** is provided. The anastomotic coupler **10** is provided to create a connection between adjacent tubular structures **12**. The tubular structure **12** can include blood vessels, grafts, prostheses, gastrointestinal structures, esophagus, lymphatics, and/or any other suitable channels of the body or the operation for which the tubular structure **12** is created. The tubular structure **12** forms a lumen **14** through which matter can be passed, for example blood, food, fluids, and/or cells.

[0032] The anastomotic coupler **10** includes a ring **300** forming an aperture **302**. The ring **300** is operable to receive a tubular structure **12** through the aperture **302**. While the ring **300** as illustrated in FIG. **1** has a substantially circular shape, the ring **300** can have any suitable shape such as rectangular, triangular, octagonal, hexagonal, and/or oval. Additionally, the ring **300** as illustrated in FIG. **1** is a singular solid piece, in some examples, for ease of application or manufacturing purposes, the ring **300** can include two semi-circular or arc-type pieces that are joined together around the tubular structure **12**.

[0033] The size of the lumen **302** of the ring **300** can vary based on the application and the size of the tubular structure **12**. For example, the diameter of the lumen **302** can range from about 0.5 millimeters (mm) (for example for lymphatic connections) to about 60 millimeters (for example for gastrointestinal connections). Due to the range of diameters for the ring **300**, and the range of diameters for the tubular structure **12**, the appropriate ring **300** can be selected by measuring the internal diameter of the tubular structure **12**. This can be accomplished, for example, with an intraluminal measurement guide/device. If there is a significant size mismatch (1 mm or greater) between the tubular structure **12** and the ring **300**, then a short, cylindrical tube connector with a corresponding male and female end can be used to allow for gradual transition in size in any direction to accommodate the size difference. For example, a cylindric tube can be provided that tapers in size such that one end is 1 mm-2 mm larger/smaller than the other end, which would enable a connection of a 1 mm vessel to a 2.5 mm-3.5 mm vessel during microsurgical procedures without problem and vice versa.

[0034] Referring also to FIG. **2**, the anastomotic coupler **10** also includes a fixation device **100**. The fixation device **100** is operable to couple the tubular structure **12** with the ring **300**. The fixation device **100** can include a housing **102** and a cartridge **200**. The cartridge **200** includes a plurality of fasteners **206** (as shown in FIGS. **5-10**B). The fasteners **206** are operable to puncture the tubular structure **12** and be partially received in the ring **300** to couple the tubular structure **12** with the ring **300**. In at least one example, the cartridge **200** can be removably coupled with the housing **102**. Accordingly, the cartridge **200** may be replaceable to allow multiple uses of the fixation device **100**. In some examples, the cartridge **200** may not be removable such that the fixation device **100** is provided for a one-time use. The fixation device **100** can include a pusher rod **150** operable to actuate the fixation device **100** to drive the fasteners **206** from the cartridge **200**. Upon actuation of the fixation device **100**, the pusher rod **150** can translate along a longitudinal axis.

[0035] The fixation device **100** includes stop **104** to receive the tubular structure **12**. In at least one

example, the stop **104** can be formed as a portion of the cartridge **200** to ensure alignment with the cartridge **200**. In some examples, the stop **104** can be formed as a portion of the housing **102**. The stop **104** extends radially from the housing **104** such that a free end of the tubular structure abuts the stop **104**. As illustrated in FIG. **3**, the housing **102** receives the free end of the tubular structure **12** such that the cartridge **200** is inserted into the lumen **14** of the tubular structure. When correctly positioned, the free end of the tubular structure **12** abuts the stop **104**. The stop **104** ensures the placement and alignment of the ring **300**, the cartridge **200**, and the free end of the tubular structure **12**. The alignment of the ring **300**, the cartridge **200**, and the free end of the tubular structure **12** is critical to ensure adequate connection between the tubular structure **12** and another tubular structure **12**.

[0036] As illustrated in FIG. **4**, after the tubular structure **12** is received by the fixation device **100** and abuts the stop **104**, the ring **300** can be positioned to abut the stop such that the ring **300** is aligned with the free end of the tubular structure **12**.

[0037] The stop **104** can include a plurality of alignment components **106** which correspond with alignment components **304** of the ring **300**. Accordingly, when the ring **300** is aligned and/or correctly positioned, the alignment components **106** of the stop **104** are aligned with the alignment components **304** of the ring **300**. In some examples, the alignment components **106**, **304** can include one or more alignment markers **108**, **304**. The alignment markers **108**, **304** can be shaped, for example as triangles. Accordingly, to align the ring **300**, the tips of the triangles for the alignment markers **108**, **304** can point towards one another. In some examples, the alignment components **106**, **304** can include one or more alignment pins **110** and corresponding alignment receivers **308**. When the ring **300** is aligned, the alignment pins **100** can be received by the alignment receivers **308**. While the figures illustrate the alignment pins **100** being disposed on the fixation device **100** and the alignment receivers **308** being disposed on the ring **300**, in some examples, the alignment pins **100** may be disposed on the ring **300** and the alignment receivers can be disposed on the fixation device **100**.

[0038] FIG. **5** illustrates a cross-sectional view of the tubular structure **12**, the ring **300**, and the cartridge **200** aligned. In addition to ensuring the ring **300** aligns with the free end of the tubular structure **12**, the ring **300** is aligned with the cartridge **200**. When the ring **300** is properly aligned with the cartridge **200**, a plurality of receiving portions **310** of the ring **300** are aligned with the plurality of fasteners **206** of the cartridge **200**.

[0039] The fasteners **206** can be any suitable fastener **206** to couple the ring **300** with the tubular structure **12** and prevent movement between the ring **300** and the tubular structure **12**. For example, the fasteners **206** can include tacks **600**, **700** (as shown in FIGS. **6** and **7**), staples **800** (as shown in FIG. **8**), pins, adhesive, internal ring, internal mesh, wire, clamp, coil, stent, and/or suture.

[0040] As illustrated in FIG. **6**, the tack **600** can include a puncturing portion **602** which is operable to puncture the tubular structure **12**. An abutment surface **603** abuts against a surface of the corresponding receiving portion **310** of the ring **300**. A body **604** spans the thickness of the wall of the tubular structure **12**, and an end **606** includes an abutment surface **608** which abuts against the inner surface of the tubular structure **12**. The abutment surfaces **603**, **608** prevent the fastener **206** from being removed from the tubular structure **12** and the ring **300**.

[0041] As illustrated in FIG. **7**, the tack **700** can include a puncturing portion **702** which is operable to puncture the tubular structure **12**. The exemplary tack **700** does not include as long of a puncturing portion **702** as the puncturing portion **602** as illustrated in FIG. **6**. An abutment surface **703** abuts against a surface of the corresponding receiving portion **310** of the ring **300**. A body **704** spans the thickness of the wall of the tubular structure **12**, and an end **706** includes an abutment surface **708** which abuts against the inner surface of the tubular structure **12**. The abutment surfaces **703**, **708** prevent the fastener **206** from being removed from the tubular structure **12** and the ring **300**.

[0042] As illustrated in FIG. **8**, the staple **800** can include two puncturing portions **802** which are

operable to puncture through the tubular structure **12** and be received in the corresponding receiving portion **310** of the ring **300**. A body **804** spans between the puncturing portions **802** and is operable to abut the inner surface of the tubular structure **12** to prevent the fastener **206** from being removed from the tubular structure **12**. In at least one example, the puncturing portions **802** may be operable to bend or deform when received in the receiving portion **310** to prevent the puncturing portions **802** from being removed from the ring **300**, ensuring coupling of the tubular structure **12** with the ring **300**.

[0043] Referring to FIGS. **5** and **9**, the cartridge **200** can include a plurality of drivers **204** corresponding with the plurality of fasteners **206**. Upon actuation of the fixation device **100**, the drivers **204** activate to push the corresponding fasteners **206** radially outward from the cartridge **200**. The drivers **204** may include rods which abut the fasteners **206** and towards the center of the body **202** of the cartridge **200**. In some examples, the drivers **204** may be spring loaded.

[0044] The pusher rod **150**, as illustrated in FIG. **5**, is tapered from a front portion **154** with a smaller diameter D**1** to a rear portion **152** with a larger diameter D**2** which is greater than the smaller diameter D**1**. The drivers **204** may abut the fasteners **206** on one end while extending into the cartridge **200** so that the opposing end of the fasteners **206** abut the pusher rod **150**.

[0045] Referring to FIGS. **10**A and **10**B, the fixation device **100** is actuated. Actuation of the fixation device **100** can include translating the pusher rod **150** along the longitudinal axis through the cartridge **200** from the front portion **154** towards the rear portion **152**. The pusher rod **150**, increasing in thickness, then activates the drivers **204** to drive the fasteners **206** radially outward from the cartridge **200**, through the tubular structure **12**, and into the receiving portions **310** of the ring **300**. Once the ring **300** is coupled with the tubular structure **12**, the fixation device **100** can be removed from the tubular structure **12**. The ring **300** is then affixed or secured to the end of the tubular structure **12**, maintaining the structure of the lumen of the tubular structure **12**.

[0046] The fixation device **100**, the ring **300**, and/or the fasteners **206** can be made from mechanically suitable materials that are approved, and have sufficient strength, for use in the human or animal body. For example, the following materials, alone or in any combination, can be used: metals, in particular titanium or stainless steel, including the special alloys used for implants and medical instruments, nitinol, carbon materials, including carbon fiber meshes, soft plastic, for example silicone, hard plastic, for example Teflon, ceramic material, and/or bioresorbable material. The fixation device **100**, the ring **300**, and/or the fasteners **206** can be provided entirely or partially with a coating and/or structure that prevents or at least reduces the adherence of blood constituents. Such a coating can be composed of a material that smooths the surface. In at least one example, the coating can also contain anti-thrombotic medicaments (e.g. heparin).

[0047] The above process of coupling the ring **300** with the tubular structure **12** can be repeated for a second tubular structure **12** with a second ring **300**. For example, FIG. **11** illustrates an exemplary male ring **350**, and FIG. **12** illustrates an exemplary corresponding female ring **350**. Similar to the ring **300** discussed above, the male ring **350** and the female ring **360** each include an aperture **302** operable to receive a tubular structure **12**, receiving portions **310** operable to receive the fasteners **206**, and alignment portions **304**, **308**. The male ring **350** includes a mating portion **352**, and the female ring **360** includes a corresponding mating portion **362**. The mating portion **352** is operable to couple with the mating portion **362** to couple the male ring **350** and the female ring **360** with one another. As illustrated in FIGS. **11** and **12**, the mating portion **352** of the male ring **350** extends from the ring **350** and is operable to be received by the mating portion **362** of the female ring **360**. In some examples, the rings **300** can be coupled with one another by, for example, fastening, snapping, clamping, stenting, tacking, pinning, loop and hook, adhesive, and/or other connecting method so long as the rings **300** are securely coupled with one another.

[0048] As illustrated in FIG. **13**, when the rings **350**, **360** are coupled with one another, the lumens **14** of the two tubular structures **20**, **22** are aligned in fluid communication with one another. In at least one example, the rings **350**, **360** can create a seal to prevent fluid leakage. Accordingly, the

anastomotic coupler **10** provides a more reliable, faster, more secure anastomotic coupling device to create a sealed, leak-proof, open connection between the ends of the tubular structures **20**, **22** and allow for "stented" unobstructed flow of luminal contents through the connection/anastomosis (e.g. blood, lymph, fluid, stool contents, gastric contents, etc.). This connection can be strong enough to withstand tension, traction, and high flow pressure, which may occur with distal obstruction.

[0049] As illustrated in FIG. **14**, a cap **1400** can be provided over the two rings **350**, **360**. The cap **1400** can assist in ensuring the connection between the rings **350**, **360**, as well as protecting the rings **350**, **360** from external damage. As illustrated in FIG. **15**, the cap **1400** can include a recess **1402** which is operable to receive the two rings **350**, **360**. An opening **1404** can be formed such that the cap **1400** can be deformed to snap over the two rings **350**, **360**.

[0050] Referring to FIG. **16**, a flowchart is presented in accordance with an example embodiment. The method **1600** is provided by way of example, as there are a variety of ways to carry out the method. The method **1600** described below can be carried out using the configurations illustrated in FIG. **1-15**, for example, and various elements of these figures are referenced in explaining example method **1600**. Each block shown in FIG. **16** represents one or more processes, methods or subroutines, carried out in the example method **600**. Furthermore, the illustrated order of blocks is illustrative only and the order of the blocks can change according to the present disclosure. Additional blocks may be added or fewer blocks may be utilized, without departing from this disclosure. The example method **1600** can begin at block **1602**.

[0051] At block **1602**, a first tubular structure is received in an aperture of a first ring.

[0052] At block **1604**, a fixation device receives the first tubular structure such that a first cartridge is inserted into a lumen of the first tubular structure.

[0053] At block **1606**, the first ring is aligned with the first cartridge such that a plurality of receiving portions of the first ring are aligned with a plurality of fasteners of the first cartridge.

[0054] At block **1608**, the fixation device is actuated such that the plurality of fasteners puncture the first tubular structure radially outward from the lumen. The cartridge can include a plurality of drivers corresponding with the plurality of fasteners. Upon actuation of the fixation device, the drivers activate to push the corresponding fasteners radially outward from the cartridge. In at least one example, the fixation device can include a pusher rod. The pusher rod can be tapered from a front portion with a smaller diameter to rear portion with a larger diameter. Upon actuation of the fixation device, the pusher rod can translate along a longitudinal axis to activate the drivers. In at least one example, to activate the drivers, the pusher rod translates along the longitudinal axis and passes through the cartridge from the front portion to the rear portion such that the pusher rod abuts and pushes the drivers and the corresponding fasteners radially outward from the cartridge.

[0055] At block **1610**, the first tubular structure is coupled with the first ring by the receiving portions receiving the plurality of fasteners.

[0056] In at least one example, a second tubular structure can be received in an aperture of a second ring. A fixation device can receive the second tubular structure such that a second cartridge is inserted into a lumen of the second tubular structure. In at least one example, the fixation device may be the same fixation device that was utilized for the first ring. In some examples, the fixation device may be the same fixation device utilized for the first ring with a second cartridge that replaced the first cartridge. In some examples, the fixation device may be a second fixation device. The second ring can be aligned with the second cartridge such that a plurality of receiving portions of the second ring are aligned with a plurality of fasteners of the second cartridge. The fixation device can be actuated such that the plurality of fasteners puncture the second tubular structure radially outward from the lumen. The second tubular structure can be coupled with the second ring by the receiving portions receiving the plurality of fasteners.

[0057] The first ring can be aligned with the second ring such that the lumen of the first tubular structure and the lumen of the second tubular structure are aligned in fluid communication with one

another. The first ring can be coupled with the second ring to join the first tubular structure with the second tubular structure, providing a continuous passage between the first tubular structure and the second tubular structure. In at least one example, a cap can be positioned about the first and the second ring to ensure the connection between the first ring and the second ring.

[0058] FIGS. **17**A-**17**E illustrate examples of an anastomotic coupler **10** which is operable to couple an end of a tubular structure **12** with a side of a tubular structure **12**. Elements described in the system of FIGS. **17**A-**18** that have similar or the same name and/or the same reference numbers as elements in the disclosure for FIGS. **1-16** may have the same features as discussed above. While the discussion below for FIGS. **17**A-**17**E may highlight some differences in features, the disclosure for the system of FIGS. **17**A-**18** are not limited to those and may also include any and/or all of the features as discussed above.

[0059] FIG. **17**A illustrates alignment and positioning of a fixation device **100** and a ring **300** on a tubular structure **12**. The fixation device **100** and the ring **300** are positioned such that the ring **300** can be coupled to the tubular structure **12** where an aperture **302** of the ring **300** can be aligned with a hole **1300** formed in a wall **13** of the tubular structure **12**. In other words, the tubular structure **12** has a hole **1300** formed in a side wall **13**. In at least one example, a cutting mechanism (not shown) can be operable to cut the hole **1300** in the wall **13** of the tubular structure **12**. In some examples, the cutting mechanism can be a separate component operable to cut a precise hole **1300** in the wall **13** of the tubular structure **12**. In some examples, the cutting mechanism can be part of the fixation device **1700** such that only one component is needed in the fixation device **1700** to cut a hole **1300** and couple the ring **300** to the tubular structure **12**. The cutting mechanism can create a symmetrical, controllable-sized opening in the side wall **13** of the tubular structure **12**.

[0060] In at least one example, the fixation device **1700** can be similar to fixation device **100** as discussed herein. In some examples, fixation device **1700** may be modified to couple the ring **1702** to the wall **13** of the tubular structure **12** to align with the hole **1300** in the wall **13** instead of coupling the ring **1702** to the tubular structure **12** in line with the lumen **14** of the tubular structure. In at least one example, the fixation device **1700** can include a stop which extends radially from the housing **102** such that the wall **13** of the tubular structure **12** abuts the stop. Accordingly, the fixation device **1700** provides guidance to the user for when the fixation device **1700** is in a desired position. In some examples, the stop can include a plurality of alignment components corresponding with alignment components of the ring **1702**. As such, when the ring **1702** is aligned, the alignment components of the stop are aligned with the alignment components of the ring **1702**.

[0061] As illustrated in FIGS. **17**A and **17**B, a cartridge **1710** can be disposed within the lumen **14** of the tubular structure **12**. The cartridge **1710**, similar to cartridge **300**, includes a plurality of fasteners **260** (for example shown in **17**C-**17**E) operable to be received in corresponding plurality of receiving portions **310** in the ring **300**. The ring **1702**, as illustrated in FIGS. **17**A-**17**E has a cylindrical shape. However, in other examples, the ring **1702** can have any suitable shape such that the ring **1702** can be aligned with the hole **1300** and prevent leakage between the tubular structure **12** and the ring **1702**. The ring **1702**, in some examples, may include a sealing component operable to abut against the wall **13** of the tubular structure **12** to prevent leakage of fluid.

[0062] In some examples, the position of the receiving portions **310** in the ring **1702** may be adjusted to better receive the plurality of fasteners **260** and provide a stronger coupling between the ring **1702** and the tubular structure **12**. For example, as illustrated in FIGS. **17**A-**17**E, the receiving portions **310** may be disposed towards the bottom of the ring **1702** so that the receiving portions **310** are adjacent to the tubular structure **12**.

[0063] Similarly, in some examples, the position of the fasteners **260** in the cartridge **1710** may be adjusted towards the top to be adjacent to the wall **13** of the tubular structure **12**. Accordingly, the distance between the fasteners **260** in the cartridge **1710** and the receiving portions **310** can be smaller to minimize the chance of error in coupling the ring **1702** with the tubular structure **12**.

[0064] As illustrated in FIG. **17**A-**17**C, the ring **1702** can be positioned opposite the cartridge **1710** in relation to the wall **13** of the tubular structure **12**. The ring **1702** can be positioned external of the tubular structure **12** so that the ring **1702** does not cause any obstruction in the lumen **14** of the tubular structure **12**. The cartridge **1710**, as illustrated in FIGS. **17**A-**17**C, can be positioned inside the lumen **14** of the tubular structure **12** to push the fasteners **260** across the wall **13** of the tubular structure **12** into the receiving portions **310** of the ring **1702**. In some examples, the cartridge **1710** may also be positioned external of the tubular structure **12**, so long as the fasteners **260** can couple the ring **1702** with the tubular structure **12**.

[0065] As illustrated in FIGS. **17**C, the fixation device **1700** can be actuated so that the plurality of fasteners **260** puncture the tubular structure **12** and are received by the receiving portions **310**. Accordingly, the tubular structure **12** can be coupled with the ring **1702**. In at least one example, as illustrated in FIG. **17**C, the fixation device **1700** can include a pusher rod **150**. Upon actuation of the fixation device **1700**, the pusher rod **150** can translate along a longitudinal axis to activate drivers to push the corresponding fasteners **260** from the cartridge **1710**. In some examples, the fixation device **1700** can have any suitable mechanism to activate the drivers to push the fasteners **260** from the cartridge **1710**.

[0066] As illustrated in FIG. **17**D, after the ring **1702** is coupled with the tubular structure **12**, the fixation device **1700**, along with the cartridge **1710**, can be removed. The ring **1702** remains coupled with the tubular structure **12** such that the aperture **302** of the ring **1702** is aligned with the hole **1300** in the wall **13** of the tubular structure **12**.

[0067] As illustrated in FIG. **17**E, the ring **1702** is operable to be coupled with a second tubular structure **22** such that a lumen **14** of the second tubular structure **22** is in fluid communication with the lumen **14** of the tubular structure **20** via the hole **1300** formed in the wall **13** of the tubular structure **20**. The side ring **1702** is operable to be coupled with the first tubular structure **20** such that the aperture **302** of the side ring **1702** is aligned with the hole **1300** formed in the wall **13** of the first tubular structure **12**. The end ring **1704**, similar to the rings **350**, **360** as illustrated in FIGS. **1-14**, is operable to be coupled with a second tubular structure **22** such that the aperture **302** of the end ring **1704** is in line with the lumen **14** of the second tubular structure **22**. The side ring **1702** is operable to be coupled with the end ring **1704** such that the lumen **14** of the second tubular structure **22** is in fluid communication with the lumen **14** of the first tubular structure **20** via the hole **1300** formed in the wall **13** of the first tubular structure **20**. Accordingly, an end-to-side anastomosis is achieved. In some examples, the side ring **1702** and the end ring **1704** create a seal to prevent fluid leakage. The seal can be achieved by any suitable mechanism.

[0068] As illustrated in FIG. **17**E, fluid may flow through the lumen **14** of the first tubular structure **20** while some fluid may flow into and through the lumen **14** of the second tubular structure **22**. In some examples, fluid from the second tubular structure **22** may flow into the first tubular structure **20**.

[0069] The aforementioned side-to-end anastomotic coupler **50** and system provides users with a better, more reliable alternative to the conventional techniques. The only technique conventionally practiced for side-to-end anastomosis is through hand-sewn suture techniques. Hand-sewn suture techniques are labor intensive and prone to failure. Similarly, the process of creating the side opening in the tubular structure is conventionally completed in an uncontrolled fashion using a scalpel or scissors to haphazardly cut the side of the structure, which can result in an asymmetric opening of variable size.

[0070] Referring to FIG. **18**, a flowchart is presented in accordance with an example embodiment. The method **1800** is provided by way of example, as there are a variety of ways to carry out the method. The method **1800** described below can be carried out using the configurations illustrated in FIG. **1-17**E, for example, and various elements of these figures are referenced in explaining example method **1800**. Each block shown in FIG. **18** represents one or more processes, methods or subroutines, carried out in the example method **1800**. Furthermore, the illustrated order of blocks is

illustrative only and the order of the blocks can change according to the present disclosure. Additional blocks may be added or fewer blocks may be utilized, without departing from this disclosure. The example method **1800** can begin at block **1802**.

[0071] At block **1802**, a side ring is coupled with a first tubular structure such that an aperture of the side ring is aligned with a hole formed in a wall of the first tubular structure.

[0072] At block **1804**, the side ring is coupled with a second tubular structure such that a lumen of the second tubular structure is in fluid communication with a lumen of the first tubular structure via the hole formed in the wall of the first tubular structure. In at least one example, the second tubular structure can be coupled with an end ring such that an aperture of the end ring is in line with the lumen of the second tubular structure. The side ring can be coupled with the end ring to join the first tubular structure with the second tubular structure. In at least one example, the side ring and the end ring can create a seal to prevent fluid leakage.

[0073] The disclosures shown and described above are only examples. Even though numerous properties and advantages of the present technology have been set forth in the foregoing description, together with details of the structure and function of the present disclosure, the disclosure is illustrative only, and changes may be made in the detail, especially in matters of shape, size and arrangement of the parts within the principles of the present disclosure to the full extent indicated by the broad general meaning of the terms used in the attached claims. It will therefore be appreciated that the examples described above may be modified within the scope of the appended claims.

Claims

1. An anastomotic coupler comprising: a ring; a cartridge, wherein the ring is aligned with the cartridge in that at least a portion of the cartridge is disposed within a lumen of the first tubular structure and the ring is positioned external of the first tubular structure, wherein the cartridge is operable to engage with the ring to secure the ring and the cartridge with the first tubular structure and allow a lumen of a second tubular structure to be in fluid communication with the lumen of the first tubular structure via a hole formed in a wall of the first tubular structure.

2. The anastomotic coupler of claim 1, wherein the ring forms an aperture that aligns with the hole formed in the wall of the first tubular structure.

3. The anastomotic coupler of claim 1, wherein the fixation device includes a stop, the stop extending radially from the housing such that the wall of the first tubular structure abuts the stop.

4. The anastomotic coupler of claim 3, wherein the stop includes a plurality of alignment components corresponding with alignment components of the ring, wherein when the ring is aligned, the alignment components of the stop are aligned with the alignment components of the ring.

5. The anastomotic coupler of claim 1, wherein the ring includes a sealing component operable to abut against the wall of the first tubular structure to prevent leakage of fluid.

6. The anastomotic coupler of claim 1, wherein the wall of the first tubular structure is disposed between the ring and the cartridge.

7. The anastomotic coupler of claim 1, wherein the cartridge includes a surface that is operable to abut against the wall of the first tubular structure opposite the ring.

8. A system comprising: a fixation device; a ring; a cartridge, wherein the fixation device is operable to be at least partially received in a first tubular structure such that at least a portion of the cartridge is disposed within a lumen of the first tubular structure, wherein the fixation device is operable to deploy the cartridge to engage with a wall of the first tubular structure, wherein the ring is aligned with the cartridge in that the at least a portion of the cartridge is disposed within the lumen of the first tubular structure and the ring is positioned external of the first tubular structure, wherein the cartridge is operable to engage with the ring to secure the ring and the cartridge with

the first tubular structure and allow a lumen of a second tubular structure to be in fluid communication with the lumen of the first tubular structure via a hole formed in a wall of the first tubular structure.

9. The system of claim 8, wherein the ring forms an aperture that aligns with the hole formed in the wall of the first tubular structure.

10. The system of claim 8, wherein the fixation device includes a stop, the stop extending radially from the housing such that the wall of the first tubular structure abuts the stop.

11. The system of claim 10, wherein the stop includes a plurality of alignment components corresponding with alignment components of the ring, wherein when the ring is aligned, the alignment components of the stop are aligned with the alignment components of the ring.

12. The system of claim 8, wherein the ring includes a sealing component operable to abut against the wall of the first tubular structure to prevent leakage of fluid.

13. The system of claim 8, wherein the wall of the first tubular structure is disposed between the ring and the cartridge.

14. The system of claim 8, wherein the cartridge includes a surface that is operable to abut against the wall of the first tubular structure opposite the ring.

15. A method comprising: deploying, by a fixation device, a cartridge so that at least a portion of the cartridge is disposed within a lumen of a first tubular structure; and engaging, by the cartridge, with the ring to secure the ring and the cartridge with the first tubular structure and allow a lumen of a second tubular structure to be in fluid communication with the lumen of the first tubular structure via a hole formed in a wall of the first tubular structure, wherein the ring is aligned with the cartridge in that the at least a portion of the cartridge is disposed within the lumen of the first tubular structure and the ring is positioned external of the first tubular structure.

16. The method of claim 15, wherein when the fixation device deploys the cartridge, the cartridge engages with the wall of the first tubular structure.

17. The method of claim 16, wherein the cartridge includes a surface that is operable to abut against the wall of the first tubular structure opposite the ring.

18. The method of claim 15, wherein the ring includes a sealing component operable to abut against the wall of the first tubular structure to prevent leakage of fluid.

19. The method of claim 15, wherein the wall of the first tubular structure is disposed between the ring and the cartridge.

20. The method of claim 15, wherein the ring forms an aperture that aligns with the hole formed in the wall of the first tubular structure.