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(54) **Title**: TUBULAR SURGICAL CONSTRUCTS INCLUDING ADJUNCT MATERIAL

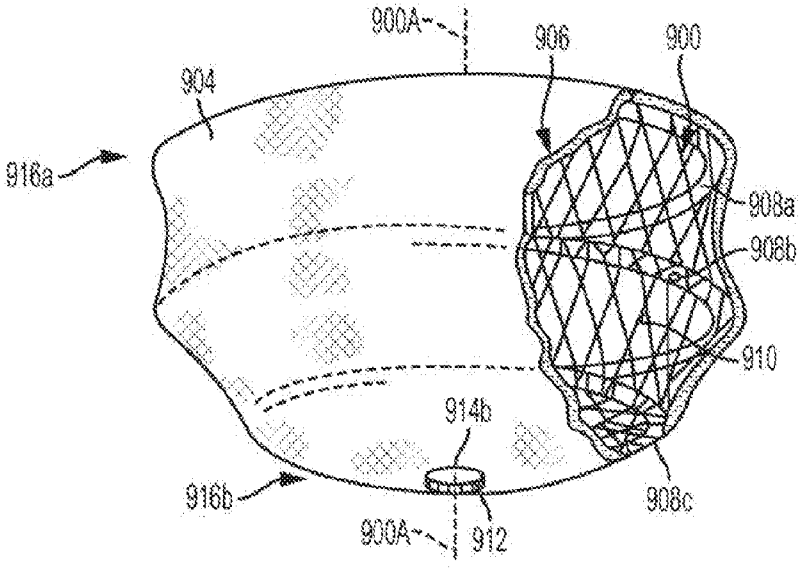


FIG. 45

(57) **Abstract**: Tubular surgical constructs including adjunct material are provided. In general, a tubular construct can be configured to be applied to tissue of a patient. The tubular construct can be configured to be implantable and to be implanted within a tissue lumen. The tubular construct can be configured to radially expand and radially constrict. The tubular construct can have an adjunct material disposed thereon. The adjunct can have one or more medicants releasably retained therein. Each of the one or more medicants can be effective to provide a desired effect on tissue in a predetermined manner.

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TUBULAR SURGICAL CONSTRUCTS INCLUDING ADJUNCT MATERIAL

FIELD

[0001] The present disclosure relates generally to tubular surgical constructs including adjunct material.

BACKGROUND

[0002] Surgical staplers are used in surgical procedures to close openings in tissue, blood vessels, ducts, shunts, or other objects or body parts involved in the particular procedure. The openings can be naturally occurring, such as passageways in blood vessels or an internal organ like the stomach, or they can be formed by the surgeon during a surgical procedure, such as by puncturing tissue or blood vessels to form a bypass or an anastomosis, or by cutting tissue during a stapling procedure.

[0003] Most staplers have a handle with an elongate shaft having a pair of movable opposed jaws formed on an end thereof for holding and forming staples therebetween. The staples are typically contained in a staple cartridge, which can house multiple rows of staples and is often disposed in one of the two jaws for ejection of the staples to the surgical site. In use, the jaws are positioned so that the object to be stapled is disposed between the jaws, and staples are ejected and formed when the jaws are closed and the device is actuated. Some staplers include a knife configured to travel between rows of staples in the staple cartridge to longitudinally cut and/or open the stapled tissue between the stapled rows.

[0004] While surgical staplers have improved over the years, a number of problems still present themselves. One common problem is that leaks can occur due to the staple forming holes when penetrating the tissue or other object in which it is disposed. Blood, air, gastrointestinal fluids, and other fluids can seep through the openings formed by the staples, even after the staple is fully formed. The tissue being treated can also become inflamed due to the trauma that results from stapling. Still further, staples, as well as other objects and materials that can be implanted in conjunction with procedures like stapling, generally lack some characteristics of the tissue in which they are implanted. For example, staples and other objects and materials can lack the natural flexibility of the tissue in which they are implanted. A person skilled in the art will

recognize that it is often desirable for tissue to maintain as much of its natural characteristics as possible after staples are disposed therein.

[0005] In some instances, biologic materials have been used in conjunction with tissue stapling. However, the use of biologic materials presents a number of additional problems. For example, it can be difficult to maintain a location of the biologic material with respect to jaws of the stapler prior to and during staple ejection. It can also be difficult to keep the biologic material at a desired location at the surgical site after stapling is completed. Further, it can be difficult to manufacture the biologic material to a desired shape and thickness. Common plastic and molding manufacturing techniques are not generally conducive to the manufacture of thin biologic layers for use in conjunction with surgical staplers. The fragile nature of many biologic materials also makes them difficult to use with surgical staplers because they lack structural support.

[0006] Accordingly, there remains a need for improved devices and methods for stapling tissue, blood vessels, ducts, shunts, or other objects or body parts such that leaking and inflammation is minimized while substantially maintaining the natural characteristics of the treatment region. There further remains a need for improved implantable materials that include biologics.

SUMMARY

[0007] In general, tubular surgical constructs including adjunct material are provided.

[0008] In one aspect, a surgical device is provided that in one implementation includes a tubular construct having an inner lumen extending therethrough, a biocompatible adjunct material disposed on the tubular construct, and an effective amount of at least one medicant disposed within and releasable from the adjunct material. The tubular construct is configured to be delivered to a tissue lumen and be positioned therein so as to provide structural support to the tissue lumen. The tubular construct is radially collapsible. The adjunct material is configured to be delivered to the tissue lumen with the tubular construct. Each of the at least one medicants is effective to provide a desired effect on tissue in a predetermined manner.

[0009] The surgical device can vary in any number of ways. For example, the adjunct material can be in the form of a fiber lattice. The fiber lattice can have at least two distinct heterogeneous

fiber lattice sections. Each of the fiber lattice sections of the adjunct material can be arranged in a pattern configured to promote organized tissue remodeling in a desired manner. The at least two distinct heterogeneous fiber lattice sections can include a first fiber lattice section having fibers extending along a longitudinal axis of the tubular construct and a second fiber lattice section having fibers extending annularly around the longitudinal axis of the tubular construct.

[0010] For another example, the adjunct material can be in the form of a fiber lattice and/or a film. For yet another example, the tubular construct can include a scaffold having a plurality of pores configured to facilitate tissue ingrowth. For still another example, the tubular construct can include a funnel shape with a smaller diameter at a first end of the shape than at a second, opposite end of the shape. For another example, the tubular construct can include at least two rings extending circumferentially therearound, the tubular construct can include at least one support structure extending between the at least two rings, and the adjunct material can be disposed as a covering over the at least two rings and the at least one support structure. For still another example, the tubular construct can include first and second independent tubular members.

[0011] In another aspect, a method of using the surgical device is provided that in one implementation includes positioning a circular surgical stapler at a target location within a patient within a lumen of a tissue of the patient. The stapler has releasably coupled to a distal end thereof the tubular construct having the adjunct material disposed thereon. The method also includes, with the stapler positioned at the target location, actuating the stapler to deploy staples from the stapler and into the tissue. The deployed staples secure the tubular construct within the lumen of the tissue. The method also includes removing the stapler from the patient, the tubular construct remaining within the lumen.

[0012] The method can have any number of variations. For example, the tissue can include one of an intestine and an esophagus. For another example, the adjunct material can be in the form of a fiber lattice having at least two distinct heterogeneous fiber lattice sections. The at least two distinct heterogeneous fiber lattice sections can include a first fiber lattice section having fibers extending along a longitudinal axis of the tubular construct and a second fiber lattice section having fibers extending annularly around the longitudinal axis of the tubular construct. The

longitudinal axis of the tubular construct can be substantially parallel to a longitudinal axis of the lumen having the tubular construct secured therein.

[0013] For still another example, the tubular construct can include first and second independent tubular members. Prior to the actuation of the stapler, the first tubular member can be releasably retained on an anvil of the stapler and the second tubular member can be releasably retained on a cartridge assembly at the distal end of the stapler. The actuation can release the first tubular member from the anvil and can release the second tubular member from the cartridge assembly. The first tubular member can be releasably retained on the anvil such that an inner passageway of the first tubular member is aligned with the lumen of the tissue following the securing of the tubular construct within the lumen, and the second tubular member can be releasably retained on the cartridge assembly such that an inner passageway of the second tubular member is aligned with the lumen of the tissue following the securing of the tubular construct within the lumen.

[0014] In another aspect, an end effector for a circular surgical stapler is provided that in one implementation includes a cartridge assembly, an anvil, a tubular construct releasably retained on each of the cartridge assembly and the anvil, a biocompatible adjunct material disposed on the tubular construct, and an effective amount of at least one medicant disposed within and releasable from the adjunct material. The cartridge assembly has a cartridge body removably attached thereto. The cartridge body has on a tissue-facing surface thereof a plurality of annularly-arranged staple cavities configured to seat staples therein. The anvil has a plurality of annularly-arranged staple forming cavities formed on a tissue-facing surface thereof. At least one of the cartridge assembly and the anvil is movable relative to the other. The tubular construct has an inner lumen extending therethrough. The tubular construct is configured to be delivered to a tissue lumen by deployment of the staples in the cartridge body. The tubular construct is radially collapsible. The adjunct material is configured to be delivered to the tissue lumen with the tubular construct. Each of the at least one medicants is effective to provide a desired effect on tissue in a predetermined manner.

[0015] The end effector can vary in any number of ways. For example, the adjunct material can be in the form of a fiber lattice. The fiber lattice can have at least two distinct heterogeneous fiber lattice sections. Each of the fiber lattice sections of the adjunct material can be arranged in

a pattern configured to promote organized tissue remodeling in a desired manner. The at least two distinct heterogeneous fiber lattice sections can include a first fiber lattice section having fibers extending along a longitudinal axis of the tubular construct and a second fiber lattice section can have fibers extending annularly around the longitudinal axis of the tubular construct.

[0016] For another example, the adjunct material can be in the form of a fiber lattice and/or a film. For yet another example, the tubular construct can include a scaffold having a plurality of pores configured to facilitate tissue ingrowth. For still another example, the tubular construct can include a funnel shape with a smaller diameter at a first end of the shape than at a second, opposite end of the shape. For another example, the tubular construct can include at least two rings extending circumferentially therearound, the tubular construct can include at least one support structure extending between the at least two rings, and the adjunct material can be disposed as a covering over the at least two rings and the at least one support structure. For still another example, the tubular construct can include first and second independent tubular members. The first tubular member can be releasably retained on the anvil, and the second tubular member can be releasably retained on the cartridge assembly. Each of the first and second tubular members can have a continuous tubular wall.

[0017] In another aspect, a method of using the end effector is provided that in one implementation includes positioning a circular surgical stapler at a target location within a patient within a lumen of a tissue of the patient. The stapler has the end effector at a distal end thereof. The method also includes, with the stapler positioned at the target location, actuating the stapler to deploy the staples from the cartridge body and into the tissue. The deployed staples secure the tubular construct within the lumen of the tissue. The method also includes removing the stapler from the patient, the tubular construct remaining within the lumen.

[0018] The method can have any number of variations. For example, the tissue can include one of an intestine and an esophagus. For another example, the adjunct material can be in the form of a fiber lattice having at least two distinct heterogeneous fiber lattice sections. The at least two distinct heterogeneous fiber lattice sections can include a first fiber lattice section having fibers extending along a longitudinal axis of the tubular construct and a second fiber lattice section having fibers extending annularly around the longitudinal axis of the tubular construct. The

longitudinal axis of the tubular construct can be substantially parallel to a longitudinal axis of the lumen having the tubular construct secured therein.

[0019] For still another example, the tubular construct can include first and second independent tubular members. Prior to the actuation of the stapler, the first tubular member can be releasably retained on the anvil and the second tubular member can be releasably retained on the cartridge assembly. The actuation can release the first tubular member from the anvil and can release the second tubular member from the cartridge assembly. The first tubular member can be releasably retained on the anvil such that an inner passageway of the first tubular member is aligned with the lumen of the tissue following the securing of the tubular construct within the lumen, and the second tubular member can be releasably retained on the cartridge assembly such that an inner passageway of the second tubular member is aligned with the lumen of the tissue following the securing of the tubular construct within the lumen.

BRIEF DESCRIPTION OF DRAWINGS

[0020] This invention will be more fully understood from the following detailed description taken in conjunction with the accompanying drawings, in which:

[0021] Figure 1 is a perspective view of one embodiment of a surgical stapler;

[0022] Figure 2 is an exploded view of a distal portion of the surgical stapler of Figure 1;

[0023] Figure 3 is a perspective view of a firing bar of the surgical stapler of Figure 1, the firing bar having an E-beam at a distal end thereof;

[0024] Figure 4 is a perspective view of another embodiment of a surgical stapler;

[0025] Figure 5 is a perspective view of yet another embodiment of a surgical stapler;

[0026] Figure 6 is a graphical representation of an embodiment of an adjunct material with different types of medicants encapsulated using different release mechanisms before medicant release;

[0027] Figure 7 is a graphical representation of the adjunct material of Figure 6, showing release of a first medicant;

[0028] Figure 8 is a graphical representation of the adjunct material of Figure 6, showing release of a second medicant;

[0029] Figure 9 is another graphical representation of an embodiment of an adjunct material with different types of medicants encapsulated using different release mechanisms before medicant release;

[0030] Figure 10 is a graphical representation of the adjunct material of Figure 9, showing release of the medicants as a result of absorption of a first coating;

[0031] Figure 11 is a graphical representation of the adjunct material of Figure 9, showing release of the medicants as a result of absorption of a second coating;

[0032] Figure 12 is a graphical representation of an adjunct material including top and bottom layers of an absorbable polymer having different degradation rates;

[0033] Figure 13 is a graphical representation of the adjunct material of Figure 12, showing a top layer partially degraded;

[0034] Figure 14 is a graphical representation of the adjunct material of Figure 12, showing a bottom layer partially degraded after the top layer has been degraded;

[0035] Figure 15 is a graphical representation of an adjunct material configured to release at least one medicant in response to at least one environmental condition;

[0036] Figure 16 is a graphical representation of the adjunct material of Figure 15, showing the at least one medicant partially released from the adjunct material in response to at least one environmental condition;

[0037] Figure 17 is another graphical representation of the adjunct material of Figure 15, showing the at least one medicant substantially entirely released from the adjunct material in response to at least one environmental condition;

[0038] Figure 18 is a graphical representation of an adjunct material configured to release at least one medicant by changing its conformation;

[0039] Figure 19 is a graphical representation of the adjunct material of Figure 18, showing the adjunct material with its conformation changes and the at least one medicant partially released;

[0040] Figure 20 is a graphical representation of an adjunct material including multiple fibers associated with vessels having at least one medicant disposed therein;

[0041] Figure 21 is a graphical representation of the adjunct material of Figure 20, showing the at least one medicant released from the adjunct material under the effect of strain;

[0042] Figure 22 is a graphical representation of an adjunct material configured to release at least one medicant in response to strain applied to the adjunct material;

[0043] Figure 23 is a graphical representation of the adjunct material of Figure 22, showing the at least one medicant being released in response to strain applied to the adjunct material;

[0044] Figure 24 is a graphical representation of a vessel having at least one medicant encapsulated therein;

[0045] Figure 25 is a graphical representation of the vessel of Figure 24, showing the at least one medicant being released in response to strain applied to the vessel;

[0046] Figure 26 is a graphical representation of an adjunct material configured to release at least one medicant when the adjunct material changes its conformation;

[0047] Figure 27 is a graphical representation of the adjunct material of Figure 26, showing the at least one medicant being released in response a change in the conformation of the adjunct material;

[0048] Figure 28 is another graphical representation of an adjunct material configured to release at least one medicant when the adjunct material changes its conformation;

[0049] Figure 29 is a graphical representation of the adjunct material of Figure 28, showing the at least one medicant being released in response a change in the conformation of the adjunct material;

[0050] Figure 30 is a graphical representation of an adjunct material having vessels configured to release at least one medicant encapsulated therein in a non-homogeneous manner;

[0051] Figure 31 is a graphical representation of a vessel configured to release multiple medicants encapsulated at different layers thereof in a non-homogeneous manner;

[0052] Figure 32 is a graphical representation of an adjunct material having different portions configured to release at least one medicant in a non-homogeneous manner;

[0053] Figure 33 is another graphical representation of an adjunct material having different portions configured to release at least one medicant in a non-homogeneous manner;

[0054] Figure 34 is a graphical representation of a side view of the adjunct material of Figure 33;

[0055] Figure 35 is a graphical representation of a side view of an adjunct material having different portions configured to release at least one medicant in a non-homogeneous manner;

[0056] Figure 36 is another graphical representation of a side view of an adjunct material having different portions configured to release at least one medicant in a non-homogeneous manner;

[0057] Figure 37 is a graphical representation of an adjunct material having different concentric regions configured to release at least one medicant at different rates;

[0058] Figure 38 is a graphical representation of an adjunct material having different radial regions configured to release at least one medicant at different rates;

[0059] Figure 39 is another graphical representation of an adjunct material having different concentric regions configured to release at least one medicant at different rates;

[0060] Figure 40 is a graphical representation of an embodiment of wound healing over time with doses of medicants;

[0061] Figure 41 is a graphical representation of a hemostatic stage in the wound healing of Figure 40;

[0062] Figure 42 is a graphical representation of a portion of an inflammation stage in the wound healing of Figure 40;

[0063] Figure 43 is a graphical representation of another portion of the inflammation stage in the wound healing of Figure 40;

[0064] Figure 44 is a graphical representation of a proliferation stage in the wound healing of Figure 40;

[0065] Figure 45 is a partial cutaway perspective view of an implementation of a tubular surgical construct including adjunct material;

[0066] Figure 46 is a partial cutaway perspective view of another implementation of a tubular surgical construct including adjunct material;

[0067] Figure 47 is a side cross-sectional view of a distal portion of an implementation of a circular surgical stapler having the tubular surgical constructs of Figure 45 and Figure 46 releasably coupled thereto;

[0068] Figure 48 is a partial cutaway perspective view of yet another implementation of a tubular surgical construct including adjunct material; and

[0069] Figure 49 is a side cross-sectional view of an implementation of a tissue lumen having the tubular surgical constructs of Figure 45 and Figure 46 stapled thereto.

DETAILED DESCRIPTION

[0070] Certain exemplary embodiments will now be described to provide an overall understanding of the principles of the structure, function, manufacture, and use of the devices and methods disclosed herein. One or more examples of these embodiments are illustrated in the

accompanying drawings. Those skilled in the art will understand that the devices and methods specifically described herein and illustrated in the accompanying drawings are non-limiting exemplary embodiments and that the scope of the present invention is defined solely by the claims. The features illustrated or described in connection with one exemplary embodiment may be combined with the features of other embodiments. Such modifications and variations are intended to be included within the scope of the present invention.

[0071] Further, in the present disclosure, like-named components of the embodiments generally have similar features, and thus within a particular embodiment each feature of each like-named component is not necessarily fully elaborated upon. Additionally, to the extent that linear or circular dimensions are used in the description of the disclosed systems, devices, and methods, such dimensions are not intended to limit the types of shapes that can be used in conjunction with such systems, devices, and methods. A person skilled in the art will recognize that an equivalent to such linear and circular dimensions can easily be determined for any geometric shape. Sizes and shapes of the systems and devices, and the components thereof, can depend at least on the anatomy of the subject in which the systems and devices will be used, the size and shape of components with which the systems and devices will be used, and the methods and procedures in which the systems and devices will be used.

[0072] It will be appreciated that the terms "proximal" and "distal" are used herein with reference to a user, such as a clinician, gripping a handle of an instrument. Other spatial terms such as "front" and "back" similarly correspond respectively to distal and proximal. It will be further appreciated that for convenience and clarity, spatial terms such as "vertical" and "horizontal" are used herein with respect to the drawings. However, surgical instruments are used in many orientations and positions, and these spatial terms are not intended to be limiting and absolute.

[0073] Various exemplary devices and methods are provided for performing surgical procedures. In some embodiments, the devices and methods are provided for open surgical procedures, and in other embodiments, the devices and methods are provided for laparoscopic, endoscopic, and other minimally invasive surgical procedures. The devices may be fired directly by a human user or remotely under the direct control of a robot or similar manipulation tool.

However, a person skilled in the art will appreciate that the various methods and devices disclosed herein can be used in numerous surgical procedures and applications. Those skilled in the art will further appreciate that the various instruments disclosed herein can be inserted into a body in any way, such as through a natural orifice, through an incision or puncture hole formed in tissue, or through an access device, such as a trocar cannula. For example, the working portions or end effector portions of the instruments can be inserted directly into a patient's body or can be inserted through an access device that has a working channel through which the end effector and elongated shaft of a surgical instrument can be advanced.

[0074] It can be desirable to use one or more biologic materials and/or synthetic materials, collectively referred to herein as "adjuncts," in conjunction with surgical instruments to help improve surgical procedures. While a variety of different surgical end effectors can benefit from the use of adjuncts, in some exemplary embodiments the end effector can be a surgical stapler. When used in conjunction with a surgical stapler, the adjunct(s) can be disposed between and/or on jaws of the stapler, incorporated into a staple cartridge disposed in the jaws, or otherwise placed in proximity to the staples. When staples are deployed, the adjunct(s) can remain at the treatment site with the staples, in turn providing a number of benefits. For example, the adjunct(s) may reinforce tissue at the treatment site, preventing tearing or ripping by the staples at the treatment site. Tissue reinforcement may be needed to keep the staples from tearing through the tissue if the tissue is diseased, is healing from another treatment such as irradiation, medications such as chemotherapy, or other tissue property altering situation. In some instances, the adjunct(s) may minimize tissue movement in and around the staple puncture sites that can occur from tissue deformation that occurs after stapling (e.g., lung inflation, gastrointestinal tract distension, etc.). It will be recognized by one skilled in the art that a staple puncture site may serve as a stress concentration and that the size of the hole created by the staple will grow when the tissue around it is placed under tension. Restricting the tissues movement around these puncture sites can minimize the size the holes may grow to under tension. In some instances, the adjunct(s) can be configured to wick or absorb beneficial fluids, e.g., sealants, blood, glues, that further promote healing, and in some instances, the adjunct(s) can be configured to degrade to form a gel, e.g., a sealant, that further promotes healing. In some instances, the adjunct(s) can be used to help seal holes formed by staples as they are implanted into tissue, blood vessels, and

various other objects or body parts. The adjunct(s) may also affect tissue growth through the spacing, positioning and/or orientation of any fibers or strands associated with the adjunct(s).

[0075] The adjunct(s) can also have medicant(s) thereon and/or therein. The medicant(s) can vary depending on the desired effect of the medicant(s) on the surrounding tissue. As a non-limiting example, medicant(s) can be provided to influence hemostasis, inflammation, macrophages, and/or fibroblasts. Medicant(s) can be mixed or combined in any combination or a medicant can be provided alone, again depending on the desired effect on the tissue. The medicant(s) can be eluted from the adjunct(s) in a variety of different ways. As non-limiting examples, coatings on the adjunct(s) can be varied to be absorbed at different times, thereby releasing the medicant(s) at different times; the adjunct(s) can be varied to allow diffusion of the medicant(s) across the adjunct(s) at varying rates; the adjunct(s) can vary in molecular weight and/or physical characteristics to cause release of the medicant(s) at different times; etc.

[0076] SURGICAL STAPLING INSTRUMENTS

[0077] A variety of surgical instruments can be used in conjunction with the adjunct(s) and/or medicant(s) disclosed herein. "Adjuncts" are also referred to herein as "adjunct materials." The surgical instruments can include surgical staplers. A variety of surgical staplers can be used, for example linear surgical staplers and circular staplers. In general, a linear stapler can be configured to create longitudinal staple lines and can include elongate jaws with a cartridge coupled thereto containing longitudinal staple rows. The elongate jaws can include a knife or other cutting element capable of creating a cut between the staple rows along tissue held within the jaws. In general, a circular stapler can be configured to create annular staple lines and can include circular jaws with a cartridge containing annular staple rows. The circular jaws can include a knife or other cutting element capable of creating a cut inside of the rows of staples to define an opening through tissue held within the jaws. The staplers can be used in a variety of different surgical procedures on a variety of tissues in a variety of different surgical procedures, for example in thoracic surgery or in gastric surgery.

[0078] Figure 1 illustrates one example of a linear surgical stapler 10 suitable for use with one or more adjunct(s) and/or medicant(s). The stapler 10 generally includes a handle assembly 12, a shaft 14 extending distally from a distal end 12d of the handle assembly 12, and an end effector

30 at a distal end 14d of the shaft 14. The end effector 30 has opposed lower and upper jaws 32, 34, although other types of end effectors can be used with the shaft 14, handle assembly 12, and components associated with the same. The lower jaw 32 has a staple channel 56 configured to support a staple cartridge 40, and the upper jaw 34 has an anvil surface 33 that faces the lower jaw 32 and that is configured to operate as an anvil to help deploy staples of the staple cartridge 40 (the staples are obscured in Figure 1 and Figure 2). At least one of the opposed lower and upper jaws 32, 34 is moveable relative to the other lower and upper jaws 32, 34 to clamp tissue and/or other objects disposed therebetween. In some implementations, one of the opposed lower and upper jaws 32, 34 may be fixed or otherwise immovable. In some implementations, both of the opposed lower and upper jaws 32, 34 may be movable. Components of a firing system can be configured to pass through at least a portion of the end effector 30 to eject the staples into the clamped tissue. In various implementations a knife blade 36 or other cutting element can be associated with the firing system to cut tissue during the stapling procedure.

[0079] Operation of the end effector 30 can begin with input from a user, e.g., a clinician, a surgeon, etc., at the handle assembly 12. The handle assembly 12 can have many different configurations designed to manipulate and operate the end effector 30 associated therewith. In the illustrated example, the handle assembly 12 has a pistol-grip type housing 18 with a variety of mechanical and/or electrical components disposed therein to operate various features of the instrument 10. For example, the handle assembly 12 can include a rotation knob 26 mounted adjacent a distal end 12d thereof which can facilitate rotation of the shaft 14 and/or the end effector 30 with respect to the handle assembly 12 about a longitudinal axis L of the shaft 14. The handle assembly 12 can further include clamping components as part of a clamping system actuated by a clamping trigger 22 and firing components as part of the firing system that are actuated by a firing trigger 24. The clamping and firing triggers 22, 24 can be biased to an open position with respect to a stationary handle 20, for instance by a torsion spring. Movement of the clamping trigger 22 toward the stationary handle 20 can actuate the clamping system, described below, which can cause the jaws 32, 34 to collapse towards each other and to thereby clamp tissue therebetween. Movement of the firing trigger 24 can actuate the firing system, described below, which can cause the ejection of staples from the staple cartridge 40 disposed therein and/or the advancement the knife blade 36 to sever tissue captured between the jaws 32, 34. A person skilled in the art will recognize that various configurations of components for a firing

system, mechanical, hydraulic, pneumatic, electromechanical, robotic, or otherwise, can be used to eject staples and/or cut tissue.

[0080] As shown in Figure 2, the end effector 30 of the illustrated implementation has the lower jaw 32 that serves as a cartridge assembly or carrier and the opposed upper jaw 34 that serves as an anvil. The staple cartridge 40, having a plurality of staples therein, is supported in a staple tray 37, which in turn is supported within a cartridge channel of the lower jaw 32. The upper jaw 34 has a plurality of staple forming pockets (not shown), each of which is positioned above a corresponding staple from the plurality of staples contained within the staple cartridge 40. The upper jaw 34 can be connected to the lower jaw 32 in a variety of ways, although in the illustrated implementation the upper jaw 34 has a proximal pivoting end 34p that is pivotally received within a proximal end 56p of the staple channel 56, just distal to its engagement to the shaft 14. When the upper jaw 34 is pivoted downwardly, the upper jaw 34 moves the anvil surface 33 and the staple forming pockets formed thereon move toward the opposing staple cartridge 40.

[0081] Various clamping components can be used to effect opening and closing of the jaws 32, 34 to selectively clamp tissue therebetween. As illustrated, the pivoting end 34p of the upper jaw 34 includes a closure feature 34c distal to its pivotal attachment with the staple channel 56. Thus, a closure tube 46, whose distal end includes a horseshoe aperture 46a that engages the closure feature 34c, selectively imparts an opening motion to the upper jaw 34 during proximal longitudinal motion and a closing motion to the upper jaw 34 during distal longitudinal motion of the closure tube 46 in response to the clamping trigger 22. As mentioned above, in various implementations, the opening and closure of the end effector 30 may be effected by relative motion of the lower jaw 32 with respect to the upper jaw 34, relative motion of the upper jaw 34 with respect to the lower jaw 32, or by motion of both jaws 32, 34 with respect to one another.

[0082] The firing components of the illustrated implementation includes a firing bar 35, as shown in Figure 3, having an E-beam 38 on a distal end thereof. The firing bar 35 is encompassed within the shaft 14, for example in a longitudinal firing bar slot 14s of the shaft 14, and guided by a firing motion from the handle 12. Actuation of the firing trigger 24 can affect distal motion of the E-beam 38 through at least a portion of the end effector 30 to thereby cause

the firing of staples contained within the staple cartridge 40. As illustrated, guides 39 projecting from a distal end of the E-Beam 38 can engage a wedge sled 47 shown in Figure 2, which in turn can push staple drivers 48 upwardly through staple cavities 41 formed in the staple cartridge 40. Upward movement of the staple drivers 48 applies an upward force on each of the plurality of staples within the cartridge 40 to thereby push the staples upwardly against the anvil surface 33 of the upper jaw 34 and create formed staples.

[0083] In addition to causing the firing of staples, the E-beam 38 can be configured to facilitate closure of the jaws 32, 34, spacing of the upper jaw 34 from the staple cartridge 40, and/or severing of tissue captured between the jaws 32, 34. In particular, a pair of top pins and a pair of bottom pins can engage one or both of the upper and lower jaws 32, 34 to compress the jaws 32, 34 toward one another as the firing bar 35 advances through the end effector 30. Simultaneously, the knife 36 extending between the top and bottom pins can be configured to sever tissue captured between the jaws 32, 34.

[0084] In use, the surgical stapler 10 can be disposed in a cannula or port and disposed at a surgical site. A tissue to be cut and stapled can be placed between the jaws 32, 34 of the surgical stapler 10. Features of the stapler 10 can be maneuvered as desired by the user to achieve a desired location of the jaws 32,34 at the surgical site and the tissue with respect to the jaws 32, 34. After appropriate positioning has been achieved, the clamping trigger 22 can be pulled toward the stationary handle 20 to actuate the clamping system. The trigger 22 can cause components of the clamping system to operate such that the closure tube 46 advances distally through at least a portion of the shaft 14 to cause at least one of the jaws 32, 34 to collapse towards the other to clamp the tissue disposed therebetween. Thereafter, the trigger 24 can be pulled toward the stationary handle 20 to cause components of the firing system to operate such that the firing bar 35 and/or the E-beam 38 are advanced distally through at least a portion of the end effector 30 to effect the firing of staples and optionally to sever the tissue captured between the jaws 32, 34.

[0085] Another example of a surgical instrument in the form of a linear surgical stapler 50 is illustrated in Figure 4. The stapler 50 can generally be configured and used similar to the stapler 10 of Figure 1. Similar to the surgical instrument 10 of Figure 1, the surgical instrument 50

includes a handle assembly 52 with a shaft 54 extending distally therefrom and having an end effector 60 on a distal end thereof for treating tissue. Upper and lower jaws 64, 62 of the end effector 60 can be configured to capture tissue therebetween, staple the tissue by firing of staples from a cartridge 66 disposed in the lower jaw 62, and/or to create an incision in the tissue. In this implementation, an attachment portion 67 on a proximal end of the shaft 54 can be configured to allow for removable attachment of the shaft 54 and the end effector 60 to the handle assembly 52. In particular, mating features 68 of the attachment portion 67 can mate to complementary mating features 71 of the handle assembly 52. The mating features 68, 71 can be configured to couple together via, e.g., a snap fit coupling, a bayonet type coupling, etc., although any number of complementary mating features and any type of coupling can be used to removably couple the shaft 54 to the handle assembly 52. Although the entire shaft 54 of the illustrated implementation is configured to be detachable from the handle assembly 52, in some implementations, the attachment portion 67 can be configured to allow for detachment of only a distal portion of the shaft 54. Detachable coupling of the shaft 54 and/or the end effector 60 can allow for selective attachment of a desired end effector 60 for a particular procedure, and/or for reuse of the handle assembly 52 for multiple different procedures.

[0086] The handle assembly 52 can have one or more features thereon to manipulate and operate the end effector 60. By way of non-limiting example, a rotation knob 72 mounted on a distal end of the handle assembly 52 can facilitate rotation of the shaft 54 and/or the end effector 60 with respect to the handle assembly 52. The handle assembly 52 can include clamping components as part of a clamping system actuated by a movable trigger 74 and firing components as part of a firing system that can also be actuated by the trigger 74. Thus, in some implementations, movement of the trigger 74 toward a stationary handle 70 through a first range of motion can actuate clamping components to cause the opposed jaws 62, 64 to approximate toward one another to a closed position. In some implementations, only one of the opposed jaws 62, 24 can move to the jaws 62, 64 to the closed position. Further movement of the trigger 74 toward the stationary handle 70 through a second range of motion can actuate firing components to cause the ejection of the staples from the staple cartridge 66 and/or the advancement of a knife or other cutting element (not shown) to sever tissue captured between the jaws 62, 64.

[0087] One example of a surgical instrument in the form of a circular surgical stapler 80 is illustrated in Figure 5. The stapler 80 can generally be configured and used similar to the linear staplers 10, 50 of Figure 1 and Figure 4, but with some features accommodating its functionality as a circular stapler. Similar to the surgical instruments 10, 50, the surgical instrument 80 includes a handle assembly 82 with a shaft 84 extending distally therefrom and having an end effector 90 on a distal end thereof for treating tissue. The end effector 90 can include a cartridge assembly 92 and an anvil 94, each having a tissue-contacting surface that is substantially circular in shape. The cartridge assembly 92 and the anvil 94 can be coupled together via a shaft 98 extending from the anvil 94 to the handle assembly 82 of the stapler 80, and manipulating an actuator 85 on the handle assembly 82 can retract and advance the shaft 98 to move the anvil 94 relative to the cartridge assembly 92. The anvil 94 and cartridge assembly 92 can perform various functions and can be configured to capture tissue therebetween, staple the tissue by firing of staples from a cartridge 96 of the cartridge assembly 92 and/or can create an incision in the tissue. In general, the cartridge assembly 92 can house a cartridge containing the staples and can deploy staples against the anvil 94 to form a circular pattern of staples, e.g., staple around a circumference of a tubular body organ.

[0088] In one implementation, the shaft 98 can be formed of first and second portions (not shown) configured to releasably couple together to allow the anvil 94 to be detached from the cartridge assembly 92, which may allow greater flexibility in positioning the anvil 94 and the cartridge assembly 92 in a body of a patient. For example, the first portion of the shaft can be disposed within the cartridge assembly 92 and extend distally outside of the cartridge assembly 92, terminating in a distal mating feature. The second portion of the shaft 84 can be disposed within the anvil 94 and extend proximally outside of the cartridge assembly 92, terminating in a proximal mating feature. In use, the proximal and distal mating features can be coupled together to allow the anvil 94 and cartridge assembly 92 to move relative to one another.

[0089] The handle assembly 82 of the stapler 80 can have various actuators disposed thereon that can control movement of the stapler. For example, the handle assembly 82 can have a rotation knob 86 disposed thereon to facilitate positioning of the end effector 90 via rotation, and/or the trigger 85 for actuation of the end effector 90. Movement of the trigger 85 toward a stationary handle 87 through a first range of motion can actuate components of a clamping

system to approximate the jaws, i.e. move the anvil 94 toward the cartridge assembly 92. Movement of the trigger 85 toward the stationary handle 87 through a second range of motion can actuate components of a firing system to cause the staples to deploy from the staple cartridge assembly 92 and/or cause advancement of a knife to sever tissue captured between the cartridge assembly 92 and the anvil 94.

[0090] The illustrated examples of surgical stapling instruments 10, 50, and 80 provide only a few examples of many different configurations, and associated methods of use, that can be used in conjunction with the disclosures provided herein. Although the illustrated examples are all configured for use in minimally invasive procedures, it will be appreciated that instruments configured for use in open surgical procedures, e.g., open linear staplers as described in U.S. Pat. No. 8,317,070 entitled "Surgical Stapling Devices That Produce Formed Staples Having Different Lengths" and filed February 28, 2007, can be used in conjunction with the disclosures provided herein. Greater detail on the illustrated examples, as well as additional examples of surgical staplers, components thereof, and their related methods of use, are provided in U.S. Pat. Pub. No. 2013/0256377 entitled "Layer Comprising Deployable Attachment Members" and filed February 8, 2013, U.S. Pat. No. 8,393,514 entitled "Selectively Orientable Implantable Fastener Cartridge" and filed September 30, 2010, U.S. Pat. No. 8,317,070 entitled "Surgical Stapling Devices That Produce Formed Staples Having Different Lengths" and filed February 28, 2007, U.S. Pat. No. 7,143,925 entitled "Surgical Instrument Incorporating EAP Blocking Lockout Mechanism" and filed June 21, 2005, U.S. Pat. Pub. No. 2015/0134077 entitled "Sealing Materials For Use In Surgical Stapling" and filed November 8, 2013, entitled "Sealing Materials for Use in Surgical Procedures, and filed on November 8, 2013, U.S. Pat. Pub. No. 2015/0134076, entitled "Hybrid Adjunct Materials for Use in Surgical Stapling," and filed on November 8, 2013, U.S. Pat. Pub. No. 2015/0133996, entitled "Positively Charged Implantable Materials and Method of Forming the Same," and filed on November 8, 2013, U.S. Pat. Pub. No. 2015/0129634, entitled "Tissue Ingrowth Materials and Method of Using the Same," and filed on November 8, 2013, U.S. Pat. Pub. No. 2015/0133995, entitled "Hybrid Adjunct Materials for Use in Surgical Stapling," and filed on November 8, 2013, U.S. Pat. App. No. 14/226,142, entitled "Surgical Instrument Comprising a Sensor System," and filed on March 26, 2014, and U.S. Pat. App. No. 14/300,954, entitled "Adjunct Materials and Methods of Using Same in

Surgical Methods for Tissue Sealing," and filed on June 10, 2014, which are hereby incorporated by reference herein in their entireties.

[0091] IMPLANTABLE ADJUNCTS

[0092] As indicated above, various implantable adjuncts are provided for use in conjunction with surgical stapling instruments. The adjuncts can have a variety of configurations, and can be formed from various materials. In general, an adjunct can be formed from one or more of a film, a foam, an injection molded thermoplastic, a vacuum thermoformed material, a fibrous structure, and hybrids thereof. The adjunct can also include one or more biologically-derived materials and one or more drugs. Each of these materials is discussed in more detail below.

[0093] An adjunct can be formed from a foam, such as a closed-cell foam, an open-cell foam, or a sponge. An example of how such an adjunct can be fabricated is from animal derived collagen, such as porcine tendon, that can then be processed and lyophilized into a foam structure. Examples of various foam adjuncts are further described in previously mentioned U.S. Pat. No. 8,393,514 entitled "Selectively Orientable Implantable Fastener Cartridge" and filed September 30, 2010.

[0094] An adjunct can also be formed from a film formed from any suitable material or combination thereof discussed below. The film can include one or more layers, each of which can have different degradation rates. Furthermore, the film can have various regions formed therein, for example, reservoirs that can releasably retain therein one or more medicants in a number of different forms. The reservoirs having at least one medicant disposed therein can be sealed using one or more different coating layers which can include absorbable or non-absorbable polymers. The film can be formed in various ways, for example, it can be an extruded or a compression molded film.

[0095] An adjunct can also be formed from injection molded thermoplastic or a vacuum thermoformed material. Examples of various molded adjuncts are further described in U.S. Pat. Pub. No. 2013/0221065 entitled "Fastener Cartridge Comprising A Releasably Attached Tissue Thickness Compensator" and filed February 8, 2013, which is hereby incorporated by reference in its entirety. The adjunct can also be a fiber-based lattice which can be a woven fabric, knitted

fabric or non-woven fabric such as a melt-blown, needle-punched or thermal-constructed loose woven fabric. An adjunct can have multiple regions that can be formed from the same type of lattice or from different types of lattices that can together form the adjunct in a number of different ways. For example, the fibers can be woven, braided, knitted, or otherwise interconnected so as to form a regular or irregular structure. The fibers can be interconnected such that the resulting adjunct is relatively loose. Alternatively, the adjunct can include tightly interconnected fibers. The adjunct can be in a form of a sheet, tube, spiral, or any other structure that can include compliant portions and/or more rigid, reinforcement portions. The adjunct can be configured such that certain regions thereof can have more dense fibers while others have less dense fibers. The fiber density can vary in different directions along one or more dimensions of the adjunct, based on an intended application of the adjunct.

[0096] The adjunct can also be a hybrid construct, such as a laminate composite or melt-locked interconnected fiber. Examples of various hybrid construct adjuncts are further described in U.S. Pat. Pub. No. 2013/0146643 entitled "Adhesive Film Laminate" and filed February 8, 2013, and in U.S. Pat. No. 7,601,118 entitled "Minimally Invasive Medical Implant And Insertion Device And Method For Using The Same" and filed September 12, 2007, which are hereby incorporated by reference in their entireties.

[0097] MATERIALS

[0098] The adjuncts in accordance with the described techniques can be formed from various materials. The materials can be used in various embodiments for different purposes. The materials can be selected in accordance with a desired therapy to be delivered to tissue so as to facilitate tissue in-growth. The materials described below can be used to form an adjunct in any desired combination.

[0099] The materials can include bioabsorbable and biocompatible polymers, including homopolymers and copolymers. Non-limiting examples of homopolymers and copolymers include p-dioxanone (PDO or PDS), polyglycolic acid (PGA), poly(lactic-co-glycolic acid) (PLGA), polycaprolactone (PCL), trimethylene carbonate (TMC), and polylactic acid (PLA), poly(glycolic acid-co-lactic acid) (PLA/PGA) (e.g., PLA/PGA materials used in Vicryl, Vicryl Rapide, PolySorb, and Biofix), polyurethanes (such as Elastane, Biospan, Tecoflex, Bionate, and

Pellethane fibers), polyorthoesters, polyanhydrides (e.g., Gliadel and Biodel polymers), polyoxaesters, polyesteramides, and tyrosine-based polyesteramides. The copolymers can also include poly(lactic acid-co- polycaprolactone) (PLA/PCL), poly(L-lactic acid-co-polycaprolactone) (PLLA/PCL), poly(glycolic acid-co-trimethylene carbonate) (PGA/TMC) (e.g., Maxon), Poly(glycolic acid-co-caprolactone) (PCL/PGA) (e.g., Monocryl and Capgly), PDS/PGA/TMC (e.g., Biosyn), PDS/PLA, PGA/PCL/TMC/PLA (e.g., Caprosyn), and LPLA/DLPLA (e.g., Optima).

[00100] An adjunct can also include active agents, such as active cell culture (e.g., diced autologous tissue, agents used for stem cell therapy (e.g., Biosutures and Cellerix S.L.), hemostatic agents, and tissue healing agents. Non-limiting examples of hemostatic agents can include cellulose such as oxidized Regenerated Cellulose (ORC) (e.g., Surgicel and Interceed), fibrin/thrombin (e.g., Thrombin-JMI, TachoSil, Tiseel, Floseal, Evicel, TachoComb, Vivostat, and Everest), autologous platelet plasma, gelatin (e.g., Gelfilm and Gelfoam), hyaluronic acid such as microfibers (e.g., yarns and textiles) or other structures based on hyaluronic acid, or hyaluronic acid-based hydrogels. The hemostatic agents can also include polymeric sealants such as, for example, bovine serum albumin and glutarldehyde, human serum albumin and polyethylene cross-linker, and ethylene glycol and trimethylene carbonate. The polymeric sealants can include FocalSeal surgical sealant developed by Focal Inc.

[00101] The adjuncts described herein can releasably retain therein at least one medicant that can be selected from a large number of different medicants. Medicants include, but are not limited to, drugs or other agents included within, or associated with, the adjunct that have a desired functionality. The medicants include, but are not limited to, for example, antimicrobial agents such as antibacterial and antibiotic agents, antifungal agents, antiviral agents, anti-inflammatory agents, growth factors, analgesics, anesthetics, tissue matrix degeneration inhibitors, anti-cancer agents, hemostatic agents, and other agents that elicit a biological response.

[00102] Non-limiting examples of antimicrobial agents include Ionic Silver, Aminoglycosides, Streptomycin, Polypeptides, Bacitracin, Triclosan, Tetracyclines, Doxycycline, Minocycline, Demeclocycline, Tetracycline, Oxytetracycline, Chloramphenicol, Nitrofurans, Furazolidone, Nitrofurantoin, Beta-lactams, Penicillins, Amoxicillin, Amoxicillin +, Clavulanic Acid,

Azlocillin, Flucloxacillin, Ticarcillin, Piperacillin + tazobactam, Tazocin, Biopiper TZ, Zosyn, Carbapenems, Imipenem, Meropenem, Ertapenem, Doripenem, Biapenem, Panipenem/betamipron, Quinolones, Ciprofloxacin, Enoxacin, Gatifloxacin, Gemifloxacin, Levofloxacin, Lomefloxacin, Moxifloxacin, Nalidixic Acid, Norfloxacin, Sulfonamides, Mafenide, Sulfacetamide, Sulfadiazine, Silver Sulfadiazine, Sulfadimethoxine, Sulfamethizole, Sulfamethoxazole, Sulfasalazine, Sulfisoxazole, Bactrim, Prontosil, Ansamycins, Geldanamycin, Herbimycin, Fidaxomicin, Glycopeptides, Teicoplanin, Vancomycin, Telavancin, Dalbavancin, Oritavancin, Lincosamides, Clindamycin, Lincomycin, Lipopeptide, Daptomycin, Macrolides, Azithromycin, Clarithromycin, Erythromycin, Roxithromycin, Telithromycin, Spiramycin, Oxazolidinones, Linezolid, Aminoglycosides, Amikacin, Gentamicin, Kanamycin, Neomycin, Netilmicin, Tobramycin, Paromycin, Paromomycin, Cephalosporins, Ceftobiprole, Ceftolozane, Cefclidine, Flomoxef, Monobactams, Aztreonam, Colistin, and Polymyxin B.

[00103] Non-limiting examples of antifungal agents include Triclosan, Polyenes, Amphotericin B, Candicidin, Filipin, Hamycin, Natamycin, Nystatin, Rimocidin, Azoles, Imidazole, Triazole, Thiazole, Allylamines, Amorolfin, Butenafine, Naftifine, Terbinafine, Echinocandins, Anidulafungin, Caspofungin, Micafungin, Ciclopirox, and Benzoic Acid.

[00104] Non-limiting examples of antiviral agents include uncoating inhibitors such as, for example, Amantadine, Rimantadine, Pleconaril; reverse transcriptase inhibitors such as, for example, Acyclovir, Lamivudine, Antisenses, Fomivirsen, Morpholinos, Ribozymes, Rifampicin; and virucidals such as, for example, Cyanovirin-N, Griffithsin, Scytovirin, α-Lauroyl-L-arginine ethyl ester (LAE), and Ionic Silver.

[00105] Non-limiting examples of anti-inflammatory agents include non-steroidal anti-inflammatory agents (e.g., Salicylates, Aspirin, Diflunisal, Propionic Acid Derivatives, Ibuprofen, Naproxen, Fenoprofen, and Loxoprofen), acetic acid derivatives (e.g., Tolmetin, Sulindac, and Diclofenac), enolic acid derivatives (e.g., Piroxicam, Meloxicam, Droxicam, and Lornoxicam), anthranilic acid derivatives (e.g., Mefenamic Acid, Meclofenamic Acid, and Flufenamic Acid), selective COX-2 inhibitors (e.g., Celecoxib (Celebrex), Parecoxib, Rofecoxib (Vioxx), Sulfonanilides, Nimesulide, and Clonixin), immune selective anti-inflammatory derivatives, corticosteroids (e.g., Dexamethasone), and iNOS inhibitors.

[00106] Non-limiting examples of growth factors include those that are cell signaling molecules that stimulate cell growth, healing, remodeling, proliferation, and differentiation. Exemplary growth factors can be short-ranged (paracrine), long ranged (endocrine), or self-stimulating (autocrine). Further examples of the growth factors include growth hormones (e.g., a recombinant growth factor, Nutropin, Humatrope, Genotropin, Norditropin, Saizen, Omnitrope, and a biosynthetic growth factor), Epidermal Growth Factor (EGF) (e.g., inhibitors, Gefitinib, Erlotinib, Afatinib, and Cetuximab), heparin-binding EGF like growth factors (e.g., Epiregulin, Betacellulin, Amphiregulin, and Epigen), Transforming Growth Factor alpha (TGF-a), Neuroregulin 1-4, Fibroblast Growth Factors (FGFs) (e.g., FGF1-2, FGF2, FGF11-14, FGF18, FGF15/19, FGF21, FGF23, FGF7 or Keratinocyte Growth Factor (KGF), FGF10 or KGF2, and Phenytoin), Insuline-like Growth Factors (IGFs) (e.g., IGF-1, IGF-2, and Platelet Derived Growth Factor (PDGF)), Vascular Endothelial Growth Factors (VEGFs) (e.g., inhibitors, Bevacizumab, Ranibizumab, VEGF-A, VEGF-B, VEGF-C, VEGF-D and Becaplermin).

[00107] Additional non-limiting examples of the growth factors include cytokines, such as Granulocyte Macrophage Colony Stimulating Factors (GM-CSFs) (e.g., inhibitors that inhibit inflammatory responses, and GM-CSF that has been manufactured using recombinant DNA technology and via recombinant yeast-derived sources), Granulocyte Colony Stimulating Factors (G-CSFs) (e.g., Filgrastim, Lenograstim, and Neupogen), Tissue Growth Factor Beta (TGF-B), Leptin, and interleukins (ILs) (e.g., IL-1a, IL-1b, Canakinumab, IL-2, Aldesleukin, Interking, Denileukin Diftitox, IL-3, IL-6, IL-8, IL-10, IL-11, and Oprelvekin). The non-limiting examples of the growth factors further include erythropoietin (e.g., Darbepoetin, Epocept, Dynepo, Epomax, NeoRecormon, Silapo, and Retacrit).

[00108] Non-limiting examples of analgesics include Narcotics, Opioids, Morphine, Codeine, Oxycodone, Hydrocodone, Buprenorphine, Tramadol, Non-Narcotics, Paracetamol, acetaminophen, NSAIDS, and Flupirtine.

[00109] Non-limiting examples of anesthetics include local anesthetics (e.g., Lidocaine, Benzocaine, and Ropivacaine) and general anesthetic.

[00110] Non-limiting examples of tissue matrix degradation inhibitors that inhibit the action of metalloproteinases (MMPs) and other proteases include MMP inhibitors (e.g., exogenous MMP

inhibitors, hydroxamate-based MMP inhibitors, Batimastat (BB-94), Ilomastat (GM6001), Marimastat (BB2516), Thiols, Periostat (Doxycycline), Squaric Acid, BB-1101, Hydroxyureas, Hydrazines, Endogenous, Carbamoylphosphates, Beta Lactams, and tissue Inhibitors of MMPs (TIMPs)).

[00111] Non-limiting examples of anti-cancer agents include monoclonial antibodies, bevacizumab (Avastin), cellular/chemoattractants, alkylating agents (e.g., Bifunctional, Cyclophosphamide, Mechlorethamine, Chlorambucil, Melphalan, Monofunctional, Nitrosoureas and Temozolomide), anthracyclines (e.g., Daunorubicin, Doxorubicin, Epirubicin, Idarubicin, Mitoxantrone, and Valrubicin), cytoskeletal disrupters (e.g., Paclitaxel and Docetaxel), epothilone agents that limit cell division by inhibiting microtubule function, inhibitor agents that block various enzymes needed for cell division or certain cell functions, histone deacetylase inhibitors (e.g., Vorinostat and Romidepsin), topoisomerase I inhibitors (e.g., Irinotecan and Topotecan), topoisomerase II inhibitors (e.g., Etoposide, Teniposide, and Tafluposide), kinase inhibitors (e.g., Bortezomib, Erlotinib, Gefitinib, Imatinib, Vemurafenib, and Vismodegib), nucleotide analogs (e.g., Azacitidine, Azathioprine, Capecitabine, Cytarabine, Doxifluridine, Fluorouracil, 5-FU, Adrucil, Carac, Efudix, Efudex, Fluoroplex, Gemcitabine, Hydroxyurea, Mercaptopurine, and Tioguanine), peptide antibiotic agents that cleave DNA and disrupt DNA unwinding/winding (e.g., Bleomycin and Actinomycin), platinum-based anti-neoplastic agents that cross link DNA which inhibits DNA repair and/or synthesis (e.g., Carboplatin, Cisplatin, Oxaliplatin, and Eloxatin), retinoids (e.g., Tretinoin, Alitretinoin, and Bexarotene), vinca alkaloids gents that inhibit mitosis and microtubule formation (e.g., Vinblastine, Vincristine, Vindesine, Vinorelbine), anti-ileus agents, pro-motility agents, immunosuppresants (e.g., Tacrolimus), blood aspect modifier agents (e.g., Vasodilator, Viagra, and Nifedipine), 3-hydroxy-3-methyl-glutaryl-CoA (HMG CoA) reductase inhibitors (e.g., Atorvastatin), and anti-angiogenesis agents.

[00112] Exemplary medicants also include agents that passively contribute to wound healing such as, for example, nutrients, oxygen expelling agents, amino acids, collageno synthetic agents, Glutamine, Insulin, Butyrate, and Dextran. Exemplary medicants also include anti-adhesion agents, non-limiting examples of which include Hyaluronic acid/ Carboxymethyl

cellulose (seprafilm), Oxidized Regenerated Cellulose (Interceed), and Icodextrin 4% (Extraneal, Adept).

[00113] DRUG RELEASE

[00114] An adjunct in accordance with the described techniques can be associated with at least one medicant in a number of different ways, so as to provide a desired effect, such as on tissue in-growth, in a desired manner. The at least one medicant can be configured to be released from the adjunct in multiple spatial and temporal patterns to trigger a desired healing process at a treatment site. The medicant can be disposed within, bonded to, incorporated within, dispersed within, or otherwise associated with the adjunct. For example, the adjunct can have one or more regions releasably retaining therein one or more different medicants. The regions can be distinct reservoirs of various sizes and shapes and retaining medicants therein in various ways, or other distinct or continuous regions within the adjuncts. In some aspects, a specific configuration of the adjunct allows it to releasably retain therein a medicant or more than one different medicant.

[00115] Regardless of the way in which the medicant is disposed within the adjunct, an effective amount of the at least one medicant can be encapsulated within a vessel, such as a pellet which can be in the form of microcapsules, microbeads, or any other vessel. The vessels can be formed from a bioabsorbable polymer.

[00116] Targeted delivery and release of at least one medicant from an adjunct can be accomplished in a number of ways which depend on various factors. In general, the at least one medicant can be released from the adjunct material as a bolus dose such that the medicant is released substantially immediately upon delivery of the adjunct material to tissue. Alternatively, the at least one medicant can be released from the adjunct over a certain duration of time, which can be minutes, hours, days, or more. A rate of the timed release and an amount of the medicant being released can depend on various factors, such as a degradation rate of a region from which the medicant is being released, a degradation rate of one or more coatings or other structures used to retains the medicant within the adjuncts, environmental conditions at a treatment site, and various other factors. In some aspects, when the adjunct has more than one medicant disposed therein, a bolus dose release of a first medicant can regulate a release of a second medicant that commences release after the first medicant is released. The adjunct can include multiple

medicants, each of which can affect the release of one or more other medicants in any suitable way.

[00117] Release of at least one medicant as a bolus dose or as a timed release can occur or begin either substantially immediately upon delivery of the adjunct material to tissue, or it can be delayed until a predetermined time. The delay can depend on a structure and properties of the adjunct or one or more of its regions.

[00118] An adjunct material can be configured to have a structure that facilitates distribution of effective amounts of one or more medicants carried within the adjunct to provide a desired effect. For example, the targeted delivery of the medicants can be accomplished by incorporating the medicants into regions (e.g., reservoirs such as pores or other structures) within the adjunct formed in a pattern that allows a certain spatial distribution of the medicants upon their delivery. The medicants disposed within the reservoir can be incorporated into distinct vessels. A reservoir can include more than one type of different medicants. The one or more medicants can be eluted from the adjunct in a homogeneous manner or in heterogeneous spatial and/or temporal manner to deliver a desired therapy. The structure of the adjunct and the way in which the medicants are released therefrom can be used to influence or control tissue re-growth. Moreover, the tissue regrowth can be encouraged in certain locations at the treatment site and discouraged at other locations at the treatment site.

[00119] Figure 6 through Figure 8 illustrate a biocompatible adjunct 100 having multiple pores carrying different medicants that are encapsulated within the pores disposed at different locations and using different absorbable coatings. The coatings can absorb, dissolve or otherwise disintegrate at different times after delivery of the adjunct 100 to a treatment site and staple deployment so as to allow the medicants to also release at different times and in different directions. Thus, the medicants can be released from the adjunct 100 in a non-homogeneous manner. For example, one of the medicants can be released immediately after delivery and/or staple deployment whereas one or more of other medicants can be released at a later time, such as over a predetermined release profile. The release of these subsequently released medicants can be controlled by or depend upon the release of the first medicant. The opposite sides of the adjunct 100 can be covered by coatings (or be formed of materials) having different absorption

rates such that certain medicant(s) are released on one side of the adjunct while other medicant(s) are released on another side of the adjunct. This provides a more controlled and targeted way of delivering therapies to tissue.

[00120] In this example, the adjunct 100 is in the form of a layer having multiple porous regions, two of which are shown by way of example as pores 101, 103. As shown in Figure 6, the porous regions 101, 103 carry respective first and second medicants 102, 104 which can be different medicants. It should be appreciated that the adjunct 100 has multiple porous regions which can carry the medicants 102, 104 in an alternating manner or in any other patterns.

[00121] As shown in Figure 6, a first side 100a of the adjunct 100 has coatings A, C such that the coating A seals the porous region 101 with the first medicant 102 and the coating C seals the porous region 103 with the second medicant 104. A second, opposite side 100b of the adjunct 100 is covered by a coating B. In the illustrated example, the coatings A, B, C that create a barrier that affects release of a medicant can be selected such that the coating A absorbs first after the staple deployment, the coating B absorbs after the coating A has been at least partially absorbed, and the coating C is not absorbable.

[00122] As shown in Figure 7, after the delivery and/or staple deployment, the coating A is first absorbed so as to allow the first medicant 102 to be released from the porous region 101 at the first side 100a of the adjunct 100. For example, if the first side 100a is a tissue-contacting surface, the first medicant 102 can be a medicant that promotes healing at the treatment site. Subsequently, after a certain time period, the coating B can be absorbed so as to allow the second medicant 104 to be released from the porous region 103 at the second side 100b of the adjunct 100, as shown in Figure 8. For example, if the second side 100b is a non-tissue-contacting surface, the second medicant 104 can be a medicant that prevents adhesion. As also shown in Figure 8, the coating C seals the porous region 103 at the first side 100a and thus prevents the second medicant 104 from being released at the first side 100a of the adjunct 100. Although in this example the coating C is not absorbable, it can alternatively be absorbable after the coating B has been absorbed and the second medicant 104 can been released at the second side 100b. It should be appreciated that, to allow a porous region to be exposed and a medicant to release, a coating can be absorbed in its entirety or at least partially. A rate of absorption of a coating can

control a rate of release of a medicant.

[00123] A person skilled in the art will appreciate that more than two different medicants can be releasably incorporated into different porous regions or other structures within an adjunct. The medicants can be retained within the adjunct using various coatings that can be selected so as to control rate and direction of release of the medicants.

[00124] An adjunct can include regions (e.g., pores or other reservoirs) releasably retaining a plurality of vessels, such as micro beads or other vessels, that have one or more medicants encapsulated therein. Figure 9 through Figure **11** illustrate an adjunct 108 including at least one medicant encapsulated in a plurality of vessels that are releasably retained by respective regions that regulate the dispersion of the vessels from the adjunct. The vessels can be micro capsules, micro beads, or any other types of vessels of a suitable size and shape. Each vessel can have an absorbable outer layer that can degrade and thus release a medicant retained within that vessel once the vessels are released from an adjunct. The adjunct can be used to deliver medicants in a non-homogeneous manner with respect to at least time of release and location of release.

[00125] As shown in Figure 9, the adjunct 108 has multiple reservoirs or regions, five of which are shown as regions 109a, 111a, 113a, 109b, 111b that carry respective vessels 110, 112, 114, 110, 112. Thus, as shown schematically in Figure 9, the regions 109a, 109b carry the same first type of vessels 110, the regions 111a, 111b carry the same second type of vessels 112, and the region 113a carries a third type of vessels 114.

[00126] As shown in Figure 9, on a first side 108a of the adjunct 108, a layer of coating B1 seals the regions 111a, 113a and the region 111b. A layer of a coating A1 is disposed over the entire first side 108a and covers the layers of the coating B1. On a second, opposite side 108b of the adjunct 108, a layer of the coating B1 seals the region 109a and another layer of the coating B1 seals the region 109b. A layer of a coating C1 seals the region 113a on the second side 108b. Similar to the first side 108a, the entire second side 108b is covered by the coating A1.

[00127] In this example, the coatings A1, B1, C1 have different degradation or absorption rates such that the coating A1 begins to absorb first, upon a delivery of the adjunct to tissue, the coating B1 absorbs after the coating A1 is at least partially absorbed, and the coating C1 is not

absorbable. The coating A1 can be selected such that it absorbs substantially immediately after the delivery of the adjunct to tissue or at some later time. The coating A1 can be absorbed before the coating B1 because the coating A1 is disposed on the surface of the adjunct and is therefore more accessible to water and/or other agents at a treatment side. Other properties of the coating A1 can contribute to its absorption rate additionally or alternatively.

[00128] Because of the different absorption characteristics of the coating used, the coating A1 absorbs so as to release the first medicant 110 from the regions 109a, 109b at the first side 108a and to release the second medicant 112 from the regions 111a, 111b at the second side 108b, as shown in Figure 10. As also shown in Figure 10, the layers of the coating B1 remain associated with the adjunct 108. As shown in Figure 11, after the first medicant 110 is released at the first side 108a and the second medicant 112 is released at the second side 108b, the coating B1 absorbs so as to release the third medicant 114 from the region 113a at the first side 108a. In this way, different medicants can be delivered at appropriate times to desired locations in tissue being treated. It should be appreciated that an adjunct can have any suitable pattern of regions releasably retaining various medicants to create a desired healing process/profile.

[00129] In some aspects, alternatively or in addition to using various coatings, an adjunct can be in a form of a fiber lattice having regions with different absorption characteristics. For example, each of the regions can be in the form of fiber lattices having different absorption rates. A medicant associated with a fiber lattice can be released as the fiber lattice disintegrates. Because of the heterogeneous degradation of absorbable polymers forming the adjunct, the adjunct can be configured such that one or more medicants associated therewith can release in various spatial and temporal patterns. The medicant can be incorporated into pellets having a dissolvable coating (e.g., like a gobstopper) such that, as the coating is disintegrated, the medicant can be distributed as a bolus dose or as a time release dosage.

[00130] Figure 12 through Figure 14 illustrate an adjunct 116 having first (top) and second (bottom) layers 118, 120 formed from absorbable polymers having different degradation rates. For example, the first layer 118 can be a low molecular weight absorbable polymer that absorbs during a first time period after the adjunct 116 is delivered to tissue and the second layer 120 can be a high molecular weight absorbable polymer that absorbs during a second time period after

the first time period is completed. The first and second layers 118, 120 can be formed from different polymers or from the same type of polymer that is treated so as to form layers or other structures having different degradation properties.

[00131] In the example of Figure 12 through Figure 14, the first layer 118 has a first medicant 119 present therein, and the second layer 120 has second medicant 121 present therein. It should be appreciated, however, that each of the first and second layers 118, 120 can include more than one type of different medicant. The medicants can be retained in association with the first and second layers 118, 120 in a number of suitable ways. The first medicant 119 can be released first due to absorption of the first layer 118, as shown in Figure 13 where the first layer 118 is shown partially disintegrated such that the pellets containing the first medicant 119 are being released. As shown, the first layer 118 begins to absorb from its surface that is more accessible to water and other agents than portions of the first layer 118 removed farther from the surface. After the first layer 118 has been entirely or partially absorbed, the second layer 120 can commence to disintegrate from its surface so as to release pellets harboring the second medicant 121, as shown in Figure 14 where the second layer 120 is shown partially disintegrated and the pellets containing the second medicant 121 are being released from the adjunct 116.

[00132] In some aspects, an adjunct releasably retaining one or more medicants can be configured such that one or more regions of the adjunct disintegrate due to effects of temperature, pH, light, or other environmental factors so as to release the medicant(s). Alternatively, the adjunct can break under the strain exerted upon one or more of its portions. Figure 15 through Figure 17 illustrate an adjunct 122 having a body 123 retaining a medicant 124, a porous layer 125 disposed over the body 123, and an absorbable outer film layer 126 disposed over the porous layer 125. The medicant 124 can be in the form of pellets (e.g., solid micro-capsules or micro-beads or other vessels) releasably carrying one or more medicants.

[00133] In the example illustrated, in its original configuration, the adjunct 122 has a first width X1, as shown in Figure 15. In such configuration, the outer film layer 126 restrains the porous layer 125 and pores in the porous layer 125 have a size that does not allow the medicant 124 to escape the adjunct 122. However, when the adjunct 122 is delivered to tissue and the outer film layer 126 thus becomes exposed to pH, temperature, various agents, and/or other environmental

conditions at the treatment site, the absorbable outer film layer 126 can begin to disintegrate, as shown by a tear or opening 127 in the film layer 126 in Figure 16. Additionally or alternatively, the outer film layer 126 can break upon strain due to deployment of staples or other mechanical strain on the adjunct 122.

[00134] Regardless of the specific factors that result in disintegration or breaking of the outer film layer 126, the adjunct 122 can swell or otherwise alter its conformation such that its width increases from the original width X1 to a larger width X2. As also shown in Figure 15, the size of the pores of porous layer 125 increases, allowing the pores' content, the pellets carrying the medicant 124, to pass through the enlarged pores and to be thus released from the adjunct 122.

[00135] A period of time during which the adjunct body 123 expands and the pellets with the medicant 124 are released can vary based on an absorption rate of the outer film 126, properties of the adjunct body 123, characteristics of the environment to which the adjunct 122 is delivered, and other factors. After a certain time period, the outer film layer 126 can disintegrate and the adjunct 122 can expand further to have a width X3 such that the entirety or substantially the entirety of the medicant 124 becomes released from the body 123 to deliver appropriate therapy or achieve the desired effect, as shown in Figure 17. The adjunct 122 can be formed from at least one absorbable polymer (e.g., gelatin, cellulose, etc.) that regulates dispersion of the vessels. Thus, the adjunct 122 can act as a space filler that creates a temporary seal at a treatment site and is then dissolved to be subsequently replaced with tissue.

[00136] Figure 18 and Figure 19 illustrate another example of an adjunct 128 releasably retaining different medicants and configured to release the medicants in a non-homogeneous manner. The adjunct 128 can be configured to release the medicants due the effects of temperature, pH, various agents, and/or other environmental factors upon the adjunct 128. The adjunct 128 can change a conformation of one or more of its portions in response to the environmental factors. As shown in Figure 18, the adjunct 128 can have multiple regions or reservoirs two of which, first and second reservoirs 130, 132 carrying first and second medicants 131, 133, respectively, are shown. The reservoirs 130, 132 can be in the form of tubes, cavities, holes, or any other structures. The first reservoir 130 is sealed by a first coating A2 at a first side 128a of the adjunct 128 and by a second coating B2 at a second side 128b of the adjunct 128.

The second reservoir 131 is sealed by the second coating B2 at the first side 128a and by the first coating A2 at the second side 128. In this example, the first and second coatings A2, B2 are selected such that the first coating A2 and its properties and/or configuration can be altered by the effects of temperature, pH, active agents, and/or other factors and thus open a reservoir that it seals. For example, the first coating A2 can swell, soften, or otherwise become altered.

[00137] Accordingly, as shown in Figure 19, upon the delivery of the adjunct 128 to a treatment site, the first coating A2 can change its configuration such that it no longer seals the reservoir 130 at the first side 128a of the adjunct 128 and it no longer seals the reservoir 132 at the second side 128b of the adjunct 128. As a result, the first and second medicants 131, 133 are released at the first and second sides 128a, 128b of the adjunct, respectively, as also shown in Figure 19. The second coating B2 remains in place at least until the entirety of the medicants are released into desired tissue locations, such preventing the release of the medicants.

[00138] In some aspects, the adjunct can be in the form of fibers or other structural components associated with one or more viscous fluid components (e.g., vessels) retaining the medicant. The viscous component can be in a dry form (e.g., in a freeze-dried powder form) and it can re-hydrate upon deployment of the adjunct. As the viscous component rehydrates, it can open and thus release a medicant. Additionally or alternatively, the vessel retaining the medicant can be disrupted by strain such as, for example, mechanical breaking imposed thereon by the staples or other means.

[00139] Figure 20 and Figure 21 illustrate an adjunct 140 in the form of multiple fibers, three of which are denoted by way of example as fibers 142, 144, 146. As shown, each of the fibers 142, 144, 146 is associated with a respective one of vessels 143, 145, 147 retaining a medicant. The vessels 143, 145, 147 can retain the same or different medicants. In the illustrated example, the vessels 143, 145, 147 are in the form of irregularly shaped rounded beads having different sizes, however they can be shaped in any other manner and can have various sizes. The vessels can be applied to the fibers as a powder or they can be bonded, anchored to, or otherwise associated with the fiber strands. The vessels can remain associated with the fibers or they can be released from the fibers to thus deliver a desired treatment using the adjunct.

[00140] As shown in Figure 21, when strain is applied to the adjunct 140, which is schematically

shown by arrows 141, the fibers can deform and vessels can break and release the medicant incorporated therein. The magnitude of the strain can control rates of release of the medicants. For example, as shown in Figure 21, the vessel 143 is broken and a medicant 148 is being released. In some aspects, the vessels can be broken at different times, depending on their size and/or other properties. In this example, the vessel 143 can be broken first to release the medicant 148 retained therein, as shown in Figure 21, after which the smaller vessel 145 and then even smaller vessel 147 can break thus releasing respective medicants at different times (not shown). However, depending on the applied pressure and other factors, one or more vessels can break simultaneously. Furthermore, as mentioned above, the vessels 143, 145, 147 can absorb at different times so as to release the respective medicants at different times.

[00141] In some aspects, an adjunct can have various surface textures of its fibers and it can release one or more medicants in various ways to influence or control re-growth of tissue. The adjunct can be delivered by staples carrying the adjunct thereon such that the medicants release when the staple is deformed upon staple deployment. For example, Figure 22 illustrates an adjunct 150 having an outer layer or coating 152 encapsulating an inner layer 154 disposed over a staple 151 of a surgical device used to deliver the adjunct 150. However, in some aspects, rather than being disposed over a staple, the adjunct 150 can be disposed over a fiber lattice which can be folded into a tubular or other shape.

[00142] A first medicant can be retained between the outer coating 152 and the inner layer 154, and a second medicant can be incorporated into the inner layer 154. The inner layer 154 can be in the form of a flexible mesh wound over the fiber 156. When strain is applied to the adjunct 150 (e.g., when the staple 151 is deformed), as schematically shown by an arrow 153 in Figure 23, the outer coating 152 can be caused to also deform and rupture. Upon the rupture of the outer coating 152, the first medicant retained between the outer coating 152 and the inner layer 154 can release (155) the first medicant as a bolus dose. The second medicant incorporated into the inner layer 154 can commence its release as a timed release after the first medicant is released or during the time when the first medicant is released. The release of the second medicant to tissue can be regulated by the release of the first medicant. The second medicant can alternatively be released at a bolus dose. It should be appreciated that the adjunct 150 can include one medicant disposed within the inner layer 154 that can release as a bolus dose.

[00143] As mentioned above, an effective amount of at least one medicant disposed within or associated with an adjunct can be retained within distinct vessels carried by the adjunct. The vessels can be disposed within one or more regions of the adjunct or otherwise associated therewith. **Figure 24** and **Figure 25** illustrate an example of a vessel 158 in the form of a pellet or capsule having an outer coating 159 encapsulating therewithin at least one medicant 160. In this example, the vessel 158 has a spherical shape and resembles a gobstopper. However, it should be appreciated that the vessel can have any other shape. Furthermore, in some exemplary implementations, the outer coating 159 can encapsulate an inner region including at least one bioabsorbable polymer having at least one medicant incorporated therein. The vessels 158 can include multiple layers having different degradation rates and releasably retaining therein one or more medicants. Each of the layers can retain a different medicant, or two or more of the layers can carry the same medicant.

[00144] When a strain is applied to the vessel 158 as schematically shown by an arrow 161 in **Figure 25**, the outer coating 159 can break or rupture such that its contents in the form of the at least one medicant 160 are released. Additionally or alternatively, the outer coating 159 can absorb, dissolve or otherwise disintegrate upon exposure of the vessel 158 to one or more environmental conditions such that the at least one medicant 160 is released from the vessel 158.

[00145] Figure 26 and Figure 27 illustrate an example of an adjunct 162 in the form of a fiber lattice having a certain conformation that is changeable, such as by the action of water and/or other agents that the adjunct is subjected to at the treatment site. As shown in Figure 26, the adjunct 162 having a shape of a tightly wound spiral can retain therein one or more vessels carrying a medicant 164. The medicant 164 can be retained in association with the adjunct 162 by being held tightly by fibers of the adjunct. For example, the medicant can include a multilayered medicant/absorbable polymer structure where an outermost one of the layers includes an absorbable polymer that can be bound to the fibers of the adjunct, e.g., bonding of one absorbable polymer to another absorbable polymer, as will be appreciated by a person skilled in the art.

[00146] When the adjunct 162 is delivered at the treatment site, the wound fibers thereof can swell and increase in length, or elongate, such that the distances between the fibers increase and

the adjunct 162 "unwinds" and releases the medicant 164 "trapped" within the adjunct 162, as shown in Figure 27. The fibers of the adjunct 162 can unwind such that the entire adjunct 162 adopts a different conformation, like in the example of Figure 26 and Figure 27. However, in some aspects, the fibers of the adjunct can begin to unwind or fray from an end or other surface of the adjunct.

[00147] Figure 28 and Figure 29 illustrate another example of an adjunct 166 having a medicant 168 releasably retained therein. In this example, the adjunct 166 is in the form of a sheet-like fiber woven mesh. As shown in Figure 28, the tight fibers of the adjunct 166 in its original configuration allow the medicant 168 to be retained therein. When the adjunct 166 is delivered at the treatment site, water and/or other agents, shown schematically as drops 167a, 167b in Figure 28, can cause the fibers to swell and elongate such that the distances between the fibers increase, as shown in Figure 29. In this way, the medicant 168 is released, as also shown in Figure 29. A person skilled in the art will appreciate that the adjunct 166 can be formed from different types of fibers. The fibers can have different absorption rates, density, direction, patterns, size, and other properties that are selected so as to provide desired tissue re-growth. While some regions of the adjunct can be configured to release at least one medicant so as to encourage tissue re-growth, one or more regions of the adjunct can be configured to release at least one medicant so as to discourage tissue re-growth.

[00148] In aspects in which at least one medicant is disposed within a vessel formed from a bioabsorbable polymer coating encapsulating the medicant, the medicant can be configured to be released from the vessel at certain time based on various factors. The factors can include, for example, a degradation rate of the bioabsorbable polymer, a volume of the vessel, a surface area of the vessel, environmental conditions in a physiological environment surrounding the vessel and responsiveness of the bioabsorbable polymer to such conditions, a number of layers of the bioabsorbable polymer, a concentration of the medicant, and a type of association between the medicant and the bioabsorbable polymer.

[00149] Figure 30 illustrates an example of first and second vessels 170, 172 that can be associated with a schematically shown adjunct 171. In this example, the first and second vessels 170, 172 are in the form of spherical beads. However, other types of vessels can be used

additionally or alternatively such that the adjunct 171 can include one or more different types of vessels carrying different types of medicants. The first and second vessels 170, 172 have absorbable polymer outer coatings A3, B3 that have different degradation rates which therefore control release of first and second medicants D1, D2 encapsulated within the coatings A3, B3 in different manners. A degradation rate of the outer coating A3 can be higher than a degradation rate of the outer coating B3. Thus, the first medicant D1 is released from the first vessel 170 before the second medicant D2 is released from the second vessel 172. For example, the first medicant D1 can be an inflammatory agent that is released within 1-2 days after the adjunct 171 is delivered to a treatment site. The second medicant D2 can be an anti-inflammatory agent that is released within 3-5 days after the delivery of the adjunct 171. In this way, the release of the medicants D1, D2 from the first and second vessels 170, 172 can provide a desired effect on tissue in-growth.

[00150] A vessel having at least one medicant encapsulated therein can have multiple medicants associated therewith in a number of different ways. Figure 31 illustrates an example of a vessel 174 in a form of a sphere having multiple concentric layers each carrying a respective at least one medicant. In this example, as shown in Figure 31, the vessel 174 has, from the outside to the inside, four distinct layers E1, E2, E3, E4 having first, second, third, and fourth medicants F1, F2, F3, F4, respectively. Each of the layers E1, E2, E3, E4 can have different degradation rate, thickness, density, responsiveness to environmental conditions, and other properties that control release of the medicants disposed therein. For example, the outermost first layer E1 can be configured to degrade first such the medicant is released first, and the other layers E2, E3, E4 can be configured to degrade such that an outer layer degrades before an inner layer does.

[00151] As each layer degrades, a respective medicant incorporated therein is released. It should be appreciated that the layers can be selected such that at least one inner layer can start to degrade after only a portion of at least one outer layer has been degraded. The medicants F1, F2, F3, F4 disposed within the multi-layer vessel 174 can be different or at least some of the medicants can be the same. The medicants can be released as a bolus dose or in other manners. For example, the first medicant F1 disposed within the first layer E1 can be released as a bolus dose substantially immediately upon delivery of an adjunct retaining the vessel 174 to tissue. Release of the second medicant F2 disposed within the second layer E2 can be regulated by the

release of the first medicant F1.

[00152] A spatial distribution of medicants in an adjunct can vary depending on a type of the medicants and a desired effect on tissue in-growth. Targeted delivery of the medicants can be accomplished in a number of ways. For example, an adjunct can be configured to release one or more medicants in a heterogeneous manner such that various medicants can be delivered to tissue at different times, to facilitate desired healing. Different portions of the adjunct can be formed from different materials or form the same material treated so as to have different absorption rates.

[00153] Figure 32 illustrates an adjunct 176 in the form of a laminate including heterogeneous portions or layers having different degradation rates and incorporating different medicants. As shown, the adjunct 176 has a top layer or portion 178 and a bottom layer or portion 180 that have different degradation rates. Furthermore, each of the top and bottom portions 178, 180 can have various portions having degradation rates that vary in a distinct or continuous manner. The degradation rates can vary across the adjunct in a number of suitable ways that depend on a desired treatment effect to be provided by the adjunct.

[00154] In the example of Figure 32, the top portion 178 of the adjunct 176 has two portions 178a, 178b having different degradation rates. The bottom portion 180 has two portions 180a, 180b having different degradation rates. Each of the portions can include a different medicant such that, as a portion degrades, a respective medicant is eluted or released. The degradation rates and distribution of the medicants within one or more of the portions 178a, 178b, 180a, 180b can further vary in a distinct or continuous manner such that the adjunct 176 can provide an elution profile shown in a graph 177 in Figure 32. As shown, a central area 182 of the adjunct 176 centered around a mid-portion 179 thereof has an increased elution rate of one or more medicants that peaks at the mid-portion 179, whereas smaller amount of the medicant(s) is eluted from opposite sides of the adjunct 176 along its length L. The increased elution rate can be due to properties of the adjunct 176 at the central area 182 and the concentration of the medicants.

[00155] As further shown in Figure 32, the adjunct 176 is configured to release medicants in different elution profiles along the length L thereof and along a width W thereof. For example, the medicants can be released along the width W as a bolus dose and along the length as a time-

release dose. Release of one or more of the medicants can regulate release of at least one other of the medicants. However, the medicants can be released in any other manner, depending on a desired treatment to be delivered.

[00156] Figure 33 illustrates another example of an adjunct 184 having top and bottom layers or portions 186, 188. Similar to the adjunct 176 in Figure 32, each of the top and bottom portions 186, 188 of the adjunct 184 can have different medicants disposed therein. Thus, as shown in Figure 33, the top portion 186 can have first and second medicants G1 and G2, at respective portions thereof. The bottom portion 188 can have third and fourth medicants G3 and G4 at respective portions thereof disposed such that the third medicant G3 is in a portion disposed over a portion carrying the fourth medicant G4, as also shown in Figure 34.

[00157] Figure 35 illustrates an example of a portion of an adjunct 185 that can be similar to adjunct 176 (Figure 32) or adjunct 184 (Figure 33). As shown in Figure 35, the adjunct 185 can have side-to-side portions 185a, 185b having different medicants G5, G6 disposed therein. Figure 36 illustrates another example of a portion of an adjunct 187 having an inner portion 187a and an outer portion 187b having different medicants G7, G8 disposed therein.

[00158] In some aspects, elution rates of at least one medicant from an adjunct having one or more distinct portions formed from at least one bioabsorbable polymer can depend on a position of the portions within the adjunct, a degradation rate of the at least one bioabsorbable polymer, responsiveness of the at least one bioabsorbable polymer to environmental conditions, and an overall configuration of the adjunct.

[00159] Figure 37 illustrates an example of an adjunct 190 in a form of a cylinder that has outer and inner concentric layers 191, 192 which can be formed from different types of absorbable polymer and can have different thickness and other properties. The outer and inner layers 191, 192 can have different medicants B4, A4 disposed therein and that can be released from the respective layers 191, 192 at different times and at different rates. In this example, an innermost cavity 193 lined by the inner layer 192 can be empty. The medicant A4 can be configured to commence to release before the medicant B4 is released. It should be appreciated that, in some aspects, the outer and inner layers 191, 192 can be disposed over a fiber.

[00160] Figure 38 illustrates an example of a tubular adjunct 194 that has multiple radial portions formed from different types of absorbable polymer. As shown, the adjunct 194 has an inner cavity 194a having the radial portions disposed concentrically therearound. In the example illustrated, the portions can be formed from first and second types of polymer in an alternating manner, as shown by portions 195, 196 in Figure 38 formed from the first and second polymers, respectively. The portion 195 formed from the first polymer has a medicant A5 disposed therein, the portion 197 formed from the second polymer has a medicant B5 disposed therein, and other portions formed from the first and second polymers have the medicants A5, B5 disposed therein in the same alternating manner, as shown in Figure 38. Similar to the examples before, the medicants A5, B5 can be released from the respective layers at different times and at different rates. For example, the medicant A5 can be configured to commence to release before the medicant B5 is released.

[00161] Figure 39 illustrates an example of a tubular adjunct 197 similar to adjunct 190 (Figure 37). As shown in Figure 39, the adjunct 197 has outer and inner concentric layers 198, 199 which can be formed from different types of absorbable polymer and can have different thickness and other properties. The outer and inner layers 198, 199 can have different medicants B6, A6 disposed therein and that can be released from the respective layers 198, 199 at different times and at different rates. For example, as shown in a graph 197a in Figure 39, the medicant A6 can release before the medicant B6 is released. Furthermore, the medicant A6 can release at a higher dosage than the medicant B6, as also shown in the graph 197a.

[00162] In at least some implementations, a staple cartridge can include a lubricant (e.g., sodium stearate or other lubricant) applied thereto that includes at least one medicant (e.g., LAE, Doxycycline, and/or other antimicrobial agent) releasable therefrom. The lubricant can be applied to the staple cartridge as a spray and can coat the cartridge and the staples releasably disposed therein. The lubricant including one or more medicants may allow the medicant(s) to be applied to the staples. In this way, the medicant(s) may be delivered to a targeted area (e.g., along a staple line defined by the staples) where the medicant(s) may be best able to facilitate wound healing, as discussed herein. The lubricant including one or more medicants can be used with an adjunct including one or more medicants, which may facilitate targeted wound healing.

[00163] WOUND HEALING

[00164] During performance of a surgical procedure, tissue of a patient can be wounded (e.g., cut, torn, punctured, etc.) in any of a variety of ways. The wounding may be an intended aspect of the surgical procedure, such as in an anastomosis procedure and/or when tissue is cut and fastened using a surgical device such as a surgical stapler. The wounded tissue typically heals over time in generally the same way for all patients.

[00165] Wound healing is traditionally considered to include four stages: hemostasis, inflammation, proliferation, and remodeling. The hemostasis stage generally involves blood clotting, e.g., stopping bleeding. In general, damaged blood vessels constrict to slow blood flow, platelets aggregate to help seal the wound site, the platelets activate fibrin to further facilitate wound sealing, and a blood clot forms at the wound site. The inflammation stage generally involves cleaning of the wound site. In general, the immune system provides a response to the threat of possible infection at the wound site via signaling to defensive immune cells such as neutrophils and macrophages. The proliferation stage generally involves rebuilding tissue with tissue growth and angiogenesis (blood vessel growth). In general, fibroblasts arrive at the wound site, the fibroblasts lay down collagen, the fibroblasts release growth factors that attract epithelial cells, and the epithelial cells attract endothelial cells. The remodeling stage, also referred to as a maturation stage, generally involves strengthening scar tissue at the wound site. In general, collagen fibers align and crosslink, and the scar matures to eventually fade away. Each of these four stages is discussed further below.

[00166] While each of wound healing's four stages involves a different aspect of the healing process, stages typically overlap with one another. Namely, each of the last three stages typically overlaps with its preceding stage, e.g., inflammation overlaps with hemostasis, proliferation overlaps with inflammation, and remodeling overlaps with proliferation. The speed at which the transition between stages occurs generally affects the speed of overall wound healing and thus generally affects patient recovery time, chances of complications arising, and/or patient comfort. Similarly, the length of each of the four individual stages generally affects the speed of overall wound healing and the patient's general recovery. In general, the slower the wound healing process, and in particular the longer it takes to begin the remodeling stage, the

more likely that the wound will become infected, cause the patient discomfort, become a chronic wound, cause an ulcer, and/or develop pathological scarring.

[00167] The hemostasis stage generally begins within minutes of the initial injury, unless there are underlying clotting disorders, in which case hemostasis may be delayed. The hemostasis stage typically lasts for 30 to 60 minutes before the inflammation stage begins (e.g., before neutrophils arrive, as discussed below) and typically ends hours after the injury, e.g., 2 to 6 hours post-injury. Poor hemostatic control that results in a longer hemostasis stage can lead to increased bleeding and tissue damage. Additionally, a prolonged hemostasis stage can result in additional scar formation that delays the proliferation and remodeling stages.

[00168] In the hemostasis stage, injured blood vessels at the wound site are sealed. The blood vessels constrict in response to injury, e.g., in response to being cut, but this spasm ultimately relaxes. Blood platelets secrete vasoconstrictive substances to aid in this process. The platelets also form a stable clot sealing the damaged vessels. Under the influence of adenosine diphosphate (ADP) leaking from the damaged tissue at the wound site, the blood platelets aggregate and adhere to exposed collagen. The blood platelets secrete factors, which interact with and stimulate an intrinsic clotting cascade through the production of thrombin, which in turn initiates the formation of fibrin from fibrinogen. The clotting cascade occurs to achieve hemostasis, or stop blood loss by way of a fibrin clot. More particularly, the fibrin forms a mesh that strengthens the platelet aggregate into a stable hemostatic plug or clot, thereby reducing and/or preventing bleeding. The mesh serves as a scaffold for invading cells, such as neutrophils, macrophages, fibroblasts, and endothelial cells, during the inflammation and proliferation stages. Additionally, the platelets secrete various soluble factors, such as chemokines, cytokines, and platelet-derived growth factor (PDGF). This secretion generally initiates the inflammation stage of wound healing, as the soluble factors attract cells that phagocytize material (e.g., debris, microorganisms such as bacteria, and damaged tissue).

[00169] The clotting cascade occurs in the hemostasis stage just before the inflammatory stage begins. The inflammation stage typically begins within an hour of the injury and typically lasts for 2 to 6 days but can last even longer, e.g., up to 10 days. The longer the inflammation stage, the more likely that additional scarring will occur, thereby delaying the proliferation and

remodeling stages. During the inflammation stage, the wounded tissue can show various signs of inflammation, such as erythema, heat, edema, pain, and functional disturbance. These signs can last for most or all of the inflammation stage. Accordingly, the longer the inflammation stage, the longer the tissue experiences these adverse effects of inflammation, which in turn can prolong patient discomfort and/or prolong the period of time in which the patient is particularly susceptible to infection. The adverse effects of inflammation can be severe enough in some patients to cause death. Inflammation must occur during proper wound healing, however, and its adverse effects tolerated in order for the final stages of wound healing to commence.

[00170] In the inflammation stage, the cells attracted by the soluble factors secreted in the hemostasis stage phagocytize material. Namely, immune cells including phagocytic cells, neutrophils, and macrophages destroy material in an effort to help prevent infection. The arrival of neutrophils generally signals the start of the inflammation stage. Neutrophils typically arrive at the wound site within an hour of wounding. The neutrophils are able to phagocytize debris and microorganisms and provide a first line of defense against infection. They are aided by local mast cells. Fibrin is broken down, and the degradation products attract macrophages. Macrophages typically appear 1 to 2 days post-injury. The macrophages are able to phagocytize bacteria and provide a second line of defense against infection. The macrophages secrete a variety of chemotactic factors and growth factors such as fibroblast growth factor (FGF), epidermal growth factor (EGF), transforming growth factor beta (TGF-β), and interleukin-1 (IL-1), which are traditionally recognized as directing the subsequent proliferation and remodeling stages. In other words, the macrophages release angiogenic substances to help begin the proliferation stage to stimulate capillary growth and granulation, thereby setting the stage for the remodeling stage. Lymphocytes (e.g., T lymphocytes) attracted to the wound site typically appear at the wound site after the macrophages appear.

[00171] The proliferation stage typically begins 2 to 5 days post-injury and typically lasts for 2 to 21 days. In the proliferation stage, the macrophages' secretion induces the proliferation of fibroblasts. The fibroblasts enter the wound site and form an extracellular matrix (ECM) by excreting collagen and fibronectin. The wound is thus "rebuilt" with new granulation tissue that includes the collagen and the ECM into which a new network of blood vessels develop, a process traditionally known as angiogenesis. The collagen increases the strength of the wound.

Accordingly, the sooner collagen can be produced, e.g., the sooner that fibroblasts enter the wound area, the sooner the wound can gain strength and thereby be less likely to cause any number of problems such as infection and patient discomfort.

[00172] Concurrent with the ECM formation, epithelial cells (e.g., keratinocytes) migrate from the wound's edge to cover the wound and form a barrier between the wound and its environment. In other words, the epithelial cells resurface the wound, in a process traditionally known as epithelialization. The epithelial cells migrate over the granulation tissue but underneath the scab on the wound (if a scar was earlier formed). The epithelial cells must dissolve the clot, debris, and parts of the ECM in order to properly migrate over the wound. To facilitate their migration, the epithelial cells secrete a plasminogen activator, which activates plasminogen, turning it into plasmin to dissolve the clot, debris, and parts of the ECM. Additionally, since cells can only migrate over living tissue, the epithelial cells excrete collagenases and proteases such as matrix metalloproteinases (MMPs) to dissolve damaged parts of the ECM in their migrational path. In the final phase of epithelialization, contraction of the wound occurs as the fibroblasts differentiate into myofibroblasts to form the protective outer layer, or stratum corneum. Contraction can last for days or several weeks and continues even after the wound is completely reepithelialized. Contraction is the main cause of scarring associated with wound healing.

[00173] The remodeling stage generally begins when the levels of collagen production and degradation equalize. In other words, remodeling generally begins once a scar has formed and the tensile strength of the wound has begun to increase. The remodeling stage typically begins 7 to 21 days post-injury and typically lasts for at least 3 weeks and can last for months or years depending on factors such as wound size and re-injury.

[00174] In the remodeling stage, the wound matures to become stronger, e.g., to have increased tensile strength. In general, weaker type III collagen, which is common at the wound site in the proliferation stage, is replaced by stronger type I collagen. This replacement generally involves reorganizing, crosslinking, and aligning the temporary collagen fibers. As remodeling progresses, the scar disappears.

[00175] Figure 40 illustrates a depiction of wound healing over time. An upper portion of Figure 40 shows a first wound healing graph 200 of tissue strength (tensile force F) versus time (t). A

lower portion of Figure 40 shows a second wound healing graph 202 of medicant dose amount versus time (t). The first and second graphs 200, 202 are plotted with a shared horizontal axis to facilitate comparison of data shown in the first and second graphs 200, 202. Time zero (t=0) in the first and second graphs 200, 202 represents a time of injury, e.g., when a wound occurs. A first tissue strength F1 in the first graph 200 thus represents the tissue's strength at the wound at the time of injury.

[00176] The first graph 200 includes a first curve 204 of tissue strength over time during typical wound healing, and includes a second curve 206 of tissue strength over time during accelerated wound healing in accordance with at least some methods, systems, and devices provided herein. The second curve 206 of accelerated wound healing can be achieved using one or more doses of medicants provided in the second graph 202, as discussed further below. Stages of wound healing (a hemostasis stage 208, an inflammation stage 210, and a proliferation stage 212) are shown in Figure 40 with reference to the second graph 202, and hence also to the second curve 206 of the first graph 200. The first curve 204 in the first graph 200 has a different timing of hemostasis, inflammation, and proliferation stages, as discussed below.

[00177] The time scale in Figure 40 is an example only. As discussed above, the timing of wound healing can vary, e.g., the stages of wound healing can begin at different times for different wounds and/or for different patients. Figure 40 demonstrates that for the same wound in the same patient, the wound's typical healing, as illustrated by the first curve 204, is improved when one or more medicants are dosed to the patient in accordance with the second graph 202, as illustrated by the second curve 206. In other words, regardless of the time scale of the horizontal axis of the first and second graphs 200, 202, the dosing of one or more medicants may provide for faster wound healing than typical wound healing and may provide a shorter period of minimum tissue tensile strength than typical wound healing.

[00178] As demonstrated by the first curve 204, typical wound healing involves the tissue having the first tissue strength F1 at time zero and decreasing in strength over time to a minimum tissue strength F4 that begins during day four ($5 > t > 4$) during an inflammation stage and persists until sometime during day six ($7 > t > 6$) before tissue strength begins to gradually improve back toward the first tissue strength F1. The first tissue strength F1 can be re-achieved during typical

wound healing, as shown by the first curve 204, at some point during or after a proliferation stage. The tissue's strength begins to decrease from the first tissue strength F1 in response to inflammation, e.g., in response to entry into the inflammation stage, during day one ($2 > t > 1$) and continues decreasing toward and/or remains at its lowest level F4 until inflammation of the tissue begins to subside, e.g., until the proliferation stage begins, during day six. The tissue is thus decreasing in strength and is at its most vulnerable to succumb to any number of inflammation's adverse effects for a relatively long period of time that starts during day one and lasts into day six.

[00179] As demonstrated by the second curve 206, accelerated wound healing in accordance with at least some embodiments of the methods, systems, and devices provided herein involves the tissue having the first tissue strength F1 at time zero and decreasing in strength over time to a minimum tissue strength F3 that begins during day three ($4 > t > 3$) during the inflammation stage 210 and persists until sometime during day four ($5 > t > 4$) before tissue strength begins to gradually improve back toward the first tissue strength F1. The minimum tissue strength F3 in the accelerated wound healing is greater than the minimum tissue strength F4 in the typical wound healing. The tissue experiencing the accelerated wound healing thus never has strength as low as that during typical wound healing. In other words, the accelerated wound healing allows for less tissue weakening than typical wound healing. The tissue's strength begins to decrease from the first tissue strength F1 in response to inflammation, e.g., in response to entry into the inflammation stage 210, during day one ($2 > t > 1$) and continues decreasing toward and/or remains at its lowest level F3 until inflammation begins to improve, e.g., until the proliferation stage 212 begins, during day four. The tissue is thus decreasing in strength and is at its most vulnerable to succumb to any number of inflammation's adverse effects sooner and for a shorter period of time than typical wound healing, i.e., starting during day one and lasting into day four instead of starting during day one and lasting into day six. In other words, the accelerated wound healing can provide for a shorter inflammation stage than typical wound healing. The tissue's strength may not increase back to its pre-wound tissue strength F1 after the inflammation stage 210 in the accelerated healing but can increase to a level close thereto, as shown by the second curve 206 reaching a new maximum tissue strength F2 during the proliferation stage 212.

[00180] The second graph 202 illustrates an example of doses of medicants that can be administered to the patient to achieve the accelerated wound healing indicated by the second curve 206. The doses of medicants can include a dose of medicant A configured to facilitate hemostasis in the hemostasis stage 208 as also shown in Figure 41; doses of medicant B, medicant B_1, medicant C, and medicant C_1 configured to facilitate inflammation in the inflammation stage 210 as also shown in Figure 42; doses of medicant D and medicant D_1 configured to inhibit MMPs during a macrophages phase 214 of the inflammation stage 210 (e.g., during a time when macrophages are present and active at the wound site in the inflammation stage 210) as also shown in Figure 43; a dose of medicant E configured to prevent inflammation in the proliferation stage 212 during a fibroblasts phase 216 of the proliferation stage 212 (e.g., during a time when fibroblasts are present and active at the wound site in the proliferation stage 212) as also shown in Figure 44; and a dose of medicant F configured to facilitate tissue growth in the proliferation stage 212 during a fibroblasts phase 216 of the proliferation stage 212 (e.g., during a time when fibroblasts are present and active at the wound site in the proliferation stage 212) as also shown in Figure 44. Each of the medicants A, B, B_1, C, C_1, D, D_1, E, F is discussed further below.

[00181] In one example, at least one medicant can be administered to tissue during each of the hemostasis, inflammation, and proliferation stages 208, 210, 212 of the wound healing to overall improve the wound healing process with all of the medicants shown in the second graph 202 being administered, e.g., the medicant A in the hemostasis stage 208, the medicants B, B_1, C, C_1, D, D_1 in the inflammation stage 210, and the medicants E, F in the proliferation stage 212. In another example, at least one medicant can be administered to tissue during each of the hemostasis, inflammation, and proliferation stages 208, 210, 212 of the wound healing to overall improve the wound healing process without all of the medicants shown in the second graph 202 being administered, e.g., the medicant A in the hemostasis stage 208, at least one of the medicants B, B_1, C, C_1, D, D_1 in the inflammation stage 210 (and in a further example, at least two of the medicants B, B_1, C, C_1, D, D_1), and one or both of the medicants E, F in the proliferation stage 212. The subset of the medicants A, B, B_1, C, C_1, D, D_1, E, F administered can be determined on a case-by-case basis based on any one or more factors such as wound type, wound size, surgeon preference, available medicants at a time of surgery, patient medical history, etc. In yet another example, at least one medicant can be administered to tissue during

only one or two of the hemostasis, inflammation, and proliferation stages 208, 210, 212 to improve select stages of the wound healing process (with an improvement in one stage being able to improve subsequent stage(s) of the wound healing process, as discussed above) without all of the medicants shown in the second graph 202 being administered. Further, the medicants can be administered in the selected one or two stages as shown in the second graph 202 (e.g., the medicant A in the hemostasis stage, the medicants B, B_1, C, C_1, D, D_1 in the inflammation stage 210, the medicants E, F in the proliferation stage 212) or can be selectively administered in the selected one or two stages (e.g., the medicant A in the hemostasis stage 208, at least one of the medicants B, B_1, C, C_1, D, D_1 in the inflammation stage 210 (and in a further example, at least two of the medicants B, B_1, C, C_1, D, D_1), one or both of the medicants E, F in the proliferation stage 212). The one or two of the stages 208, 210, 212 in which medicant doses are administered can be determined on a case-by-case basis based on any one or more factors such as wound type, wound size, surgeon preference, available medicants at a time of surgery, patient medical history, etc.

[00182] As discussed herein, an adjunct material including one or more medicants releasable therefrom can be delivered to tissue, e.g., using a surgical stapler. The adjunct material's one or more medicants can include each of the medicants A, B, B_1, C, C_1, D, D_1, E, F being administered, whether it be all of the medicants A, B, B_1, C, C_1, D, D_1, E, F or a subset thereof. The administered ones of the medicants A, B, B_1, C, C_1, D, D_1, E, F can thus be delivered to the patient concurrent with a time of the injury (t=0). As discussed herein, the adjunct material's medicants can be releasable therefrom in a variety of ways. The timing of the release can allow the medicants to be administered to tissue at the appropriate time in the wound healing process, as also discussed herein. The medicants A, B, B_1, C, C_1, D, D_1, E, F (or the selected subset thereof) can thus be simultaneously delivered to the patient but can be released to the patient's tissue at different times and over time to achieve the desired effects.

[00183] The medicant A configured to facilitate hemostasis can have a variety of configurations. In general, the medicant A can include a hemostatic agent configured to promote hemostasis. The administration of the medicant A may thus help stop bleeding and help shorten a length of the hemostasis stage 208 and, accordingly, help the inflammation stage 210 begin sooner than in typical wound healing. Examples of the medicant A include fibrin and thrombin. Also,

examples of hemostatic agents configured to promote hemostasis and delivery thereof are described in U.S. Pat. Pub. No. 2013/0149343 entitled "Hemostatic Bioabsorbable Device with Polyethylene Glycol Binder" filed December 13, 2011, U.S. Pat. No. 8,383,147 entitled "Reinforced Absorbable Synthetic Matrix For Hemostatic Applications" filed August 22, 2012, and U.S. Pat. No. 8,329,211 entitled "Reinforced Absorbable Multi-Layered Fabric For Hemostatic Applications" filed May 17, 2010, which are hereby incorporated by reference in their entireties.

[00184] The medicant A can be administered in a variety of ways. In one example, the medicant A can be administered from a vessel. The vessel can include a bioabsorbable or dissolvable coating, e.g., a saccharide coating, etc., surrounding the medicant A. The coating can be configured to bioabsorb/dissolve relatively quickly so as to be administered to the wounded tissue within minutes of the injury, e.g., within minutes of t=0. The medicant A's hemostatic effects can thus begin prior to the start of the inflammation stage 210. As shown in Figure 40 and Figure 41, the dose of the medicant A can decrease over time as the agent dissipates in the tissue/the patient's body.

[00185] The medicants B, B_1, C, C_1 configured to facilitate inflammation can each have a variety of configurations. In general, the medicants B, B_1, C, C_1 can each include an inflammatory agent configured to promote inflammation. The medicants B, B_1, C, C_1 may thus help speed up the inflammatory process and, accordingly, help shorten the inflammation stage 210 as compared to typical wound healing, help the proliferation stage 212 begin sooner than in typical wound healing, help the tissue reach its minimum strength F3 sooner than when the minimum strength F4 is reached in typical wound healing, and help shorten a period of time at which the tissue is at its minimum strength F3 as compared to typical wound healing. Examples of the medicants B, B_1, C, C_1 include pro-inflammatory medicants. In some aspects, the medicants B, B_1, C, C_1 can each include the same agent. In other aspects, the medicants B, B_1 can each include the same agent, and the medicants C, C_1 can each include the same agent as each other that is a different agent than the medicants B, B_1. In still other aspects, the medicants B, B_1, C, C_1 can each include a different agent from one another.

[00186] The medicants B, B_1, C, C_1 can each be administered in a variety of ways. In one example, the medicant B can be administered as a vessel with the medicant B_1 being a coating of the medicant B vessel, and the medicant C can be administered as another vessel with the medicant C_1 being a coating of the medicant C vessel. The dosages of the vessel medicants B, C can be greater than the dosages of the coating medicants B_1, C_1, as shown in Figure 40 and Figure 42, as vessel coatings typically include less substance than the vessel that they surround.

[00187] In one example, the medicant B_1 can be configured to begin release prior to the medicant B, which can be configured to begin release prior to the medicant C_1, which can be configured to begin release prior to the medicant C. The inflammatory medicants B, B_1, C, C_1 can thus be configured to be stagger-released with each medicants' dose peaking at a different time (e.g., at a different point along the time t axis of the second graph 202). The different peak dosages of the inflammatory medicants B, B_1, C, C_1 can allow the medicants B, B_1, C, C_1 to have a cumulative inflammatory dose, shown as "BC" in Figure 40 and Figure 42, greater than any of their individual doses. In other words, the peak dosages of the individual medicants B, B_1, C, C_1 can be timed to contribute to an overall inflammatory dose "BC" greater than can be achieved individually with their doses. The inflammatory dose "BC" can generally have the shape of a square wave, as also shown in Figure 40 and Figure 42.

[00188] The inflammatory medicants B, B_1, C, C_1 can be configured to each begin release prior to the release of the other medicants effective in the inflammation stage 210, the medicants D, D_1 configured to inhibit MMPs. In this way, the tissue at the wound site can be allowed to be inflamed and approach its minimum tensile strength F3 a short time before day three (t=3), at which time the macrophage phase 214 of the inflammation stage 210 generally begins and during which the medicants D, D_1 can be administered.

[00189] The medicants D, D_1 configured to inhibit MMPs can each have a variety of configurations. In general, the medicants D, D_1 can each include an agent configured to inhibit MMP, e.g., an MMP inhibitor. The medicants D, D_1 can thus help less MMP be released in the inflammation stage 210, thereby allowing less of the ECM to be destroyed in the inflammation stage 210. The tissue at the wound site may thus be less torn down while still allowing the inflammatory process and, accordingly, allow the tissue to have more strength than in the typical

wound healing process, e.g., F3 > F4. Examples of the medicants D, D_1 include tissue matrix degradation inhibitors that inhibit the action of MMPs and other proteases. In one example, the medicants D, D_1 each include the same agent, but the medicants D, D_1 can differ from one another in at least some examples.

[00190] The medicants D, D_1 can each be administered in a variety of ways. In one example, each of the medicants D, D_1 can be administered via vessel. Each of the two vessels can include a coating configured to facilitate release of the medicants D, D_1 at the appropriate time in the wound healing process, e.g., at a time after release of the inflammatory medicants B, B_1, C, C_1, such as sometime 4 to 7 days after the injury ($4 < t < 7$). Examples of the coating include a copolymer having 90% polyglycolide (also referred to as polyglycolic acid (PGA)) and 10% polylactide (also referred to as polyactic acid (PCA)), such as Vicryl™ Rapide.

[00191] In one example, the medicant D can be configured to begin release prior to the medicant D_1. The MMP-inhibiting medicants D, D_1 can thus be configured to be stagger-released with each medicants' dose peaking at a different time (e.g., at a different point along the time t axis of the second graph 202). The different peak dosages of the MMP-inhibiting medicants D, D_1 can allow the medicants D, D_1 to have a cumulative MMP-inhibiting dose, shown as "DD_1" in Figure 40 and Figure 43, greater than their individual doses. In other words, the peak dosages of the individual medicants D, D_1 can be timed to contribute to an overall MMP-inhibiting dose "DD_1" greater than can be achieved individually with their doses.

[00192] The MMP-inhibiting medicants D, D_1 can be configured to each begin release prior to the release of the medicants E, F. In this way, the tissue at the wound site can be allowed to be inflamed and endure its minimum tensile strength F3 before the proliferation stage 212 begins sometime during day four.

[00193] The medicant E configured to prevent inflammation can have a variety of configurations. In general, the medicant E can include an agent configured to inhibit inflammation, e.g., an anti-inflammatory agent. The medicant E can thus be configured to help reduce inflammation at the wound site and, accordingly, help end the inflammation stage 210. Examples of the medicant E include diclofenac.

[00194] The medicant E can be administered in a variety of ways. In one example, the medicant E can be administered as a vessel. The vessel can include a coating configured to facilitate release of the medicant E at the appropriate time in the wound healing process, e.g., at a time after release of the MMP-inhibiting medicants D, D_1, such as at least 4 days after the injury ($4 < t$), e.g., sometime 7 to 10 days after the injury ($7 < t < 10$). Examples of the coating include a copolymer having 90% PGA and 10% PCA and having a high molecular weight, e.g., a higher molecular weight than the coating used for the MMP-inhibiting medicants D, D_1 so as to be released thereafter.

[00195] The medicant F configured to facilitate tissue growth can have a variety of configurations. In general, the medicant F can include an agent configured to promote tissue growth, e.g., a growth factor. The medicant F can thus be configured to help the tissue rebuild in the proliferation stage 212. Examples of the medicant F include TGF-β.

[00196] The medicant F can be administered in a variety of ways. In one example, the medicant F can be administered as a vessel. The vessel can include a coating configured to facilitate release of the medicant F at the appropriate time in the wound healing process, e.g., at a time after release of the anti-inflammatory medicant E, such as at least 5 days after the injury ($5 < t$), e.g., sometime 5 to 10 days after the injury ($5 < t < 10$). Examples of the coating include a copolymer having 65% PGA and 35% PCA.

[00197] IMPLEMENTATIONS

[00198] Various exemplary tubular surgical constructs including adjunct material are described herein. In general, a tubular construct can be configured to be applied to tissue of a patient. The tubular construct can be configured to be implantable and to be implanted within a tissue lumen, such as within a lumen of an esophagus or within a gastrointestinal (GI) lumen (e.g., within an intestine, such as a colon). The tubular nature of the construct may allow the construct to be implanted within a tissue lumen without obstructing passage of fluid and/or other matter that passes through the tissue lumen. In other words, the tubular construct can have a lumen extending therethrough, and the construct's lumen can be in communication with the tissue's lumen when the construct is implanted therein such that fluid and/or other matter that would typically flow through the tissue lumen can flow through the implanted tubular construct so as to

not obstruct the typical flow of fluid/matter through the tissue lumen. The tubular construct being implanted within a tissue lumen may allow the tissue lumen to be reinforced by the tubular construct. In other words, the construct may provide structural stability to the tissue lumen. The construct may thus help stabilize the lumen when it is weaker than normal, such as when the tissue lumen is wounded and experiencing the process of wound healing.

[00199] The tubular construct can be configured to radially expand and radially constrict. In other words, the tubular construct can have a changeable diameter. An outer diameter of the construct can be configured to change due to the radial expansion/constriction, and, similarly, a diameter of an inner passageway extending through the construct can be configured to change due to the radial expansion/constriction. The radial movement of the construct may allow dynamic movement of the construct with a tissue to which the construct is applied. The construct may thus be able to mimic the natural movement of the tissue (e.g., the natural radial expansion/constriction of a tissue lumen) and thereby limit the construct's interference with natural function of the tissue.

[00200] The tubular construct can have an adjunct (also referred to herein as an "adjunct material") disposed thereon. The adjunct can thus be configured to be implanted with the construct. The adjunct can be disposed on the construct so as to be a covering thereon. The adjunct may help thus protect the structural elements forming the construct from an outside environment. The structural elements may thus be less likely to reduce in strength after being implanted, which may in turn help maximize an amount of reinforcement the construct provides to the tissue lumen. The adjunct can have any of a variety of configurations, as described herein, such as by including a fiber-based lattice, a foam, and/or a film. Adjuncts in the form of a fiber-based lattice are further described in U.S. Pat. App. No. [ ] entitled "Adjunct Material To Promote Tissue Growth" filed on even date herewith [Attorney Docket No. 47364-162F01US (END7625USNP)], which is hereby incorporated by reference in its entirety. The fiber-based lattice can be configured to encourage tissue growth to be in a certain direction and/or discourage tissue growth in a certain area and/or on a certain structure, as also further described in U.S. Pat. App. No. [ ] entitled "Adjunct Material To Promote Tissue Growth" filed on even date herewith [Attorney Docket No. 47364-162F01US (END7625USNP)].

[00201] Similar to the construct being configured to radially expand and radially constrict, the adjunct disposed thereon the construct can be configured to radially expand and radially constrict therewith, such as by including a fiber-based lattice, a foam, and/or a film

[00202] The adjunct can have one or more medicants releasably retained therein, as discussed herein. The at least one medicant can be configured to be release according to any of a variety of temporal patterns, as discussed above, such as by being a bolus dose or a time release dose, and to any of a variety of spatial patterns, as also discussed above. Each of the one or more medicants can be effective to provide a desired effect on tissue in a predetermined manner, which may facilitate wound healing, as also discussed herein, and/or may affect other aspects of healing as discussed herein. The tubular construct can thus be configured as a drug delivery mechanism. In other words, the construct can be a mechanical structure configured to deliver at least one medicant to wounded tissue, which as discussed herein can facilitate wound healing. The one or more medicants can be releasably retained by the adjunct in a variety of ways, as discussed above, such as by being coated thereon, included in one or more vessels coupled thereto, etc.

[00203] In at least some implementations, the at least one medicant releasably retained in the adjunct and coupled to the tubular construct can be configured to facilitate tissue growth and remodeling, such as by including at least one of a growth factor (e.g., TGF-B, IGF-1, etc.), an agent that passively contributes to wound healing such as Dextran, and an active agent (e.g., diced autologous tissue, agents used for stem cell therapy, etc.). In the case of a tubular construct being applied to a tissue lumen, such as by being stapled thereto in an anastomosis procedure, the at least one medicant being configured to facilitate tissue growth and remodeling may help the tissue lumen regain structural integrity as quickly as possible. Such strength may be particularly important in such procedures because failure of the tissue lumen due to a leak at the staple line, due to tissue weakness limiting passage of material through the lumen, and/or due to another factor can slow healing, if not prevent healing entirely without further surgical intervention.

[00204] In at least some implementations, the at least one medicant releasably retained in the adjunct and coupled to the tubular construct can be configured to perform a function of any one

or more of slowing down macrophage function and/or production, increasing fibroblast activity and attraction, and reducing inflammation. The at least one medicant can thus be configured to improve healing during the inflammation stage and/or the proliferation stage of wound healing, which as discussed herein, can allow the remodeling stage to begin sooner and thereby facilitate the tissue regaining strength as quickly as possible. In the case of a tubular construct being applied to a tissue lumen, such as by being stapled thereto in an anastomosis procedure, the at least one medicant being configured to slow down macrophage function and/or production, increase fibroblast activity and attraction, and/or reduce inflammation may facilitate the tissue lumen regaining structural integrity as quickly as possible, which as mentioned above may be particularly important in such procedures.

[00205] The at least one medicant releasably retained in the adjunct and coupled to the tubular construct can be targeted to treat a specific tissue and/or targeted to treat a specific disease. The at least one medicant can thus be selected for a particular use to maximize its positive impact on healing.

[00206] For example, colectomies are a common treatment for certain types of cancer such as colon cancer and colorectal cancer. In resecting the colon in the colectomy using surgical staples, a tubular construct, having an adjunct and medicant(s) coupled thereto, can be applied to the colon in conjunction with the staples. The at least one medicant can include an anti-cancer agent (e.g., a monoclonal antibody, a chemotherapy agent such as an alkylating agent, etc.) so as to be targeted to treat a specific disease, in this case cancer. The adjunct can releasably retain the one or more medicants targeted to treat cancer in any of a variety of ways, as discussed herein. For example, the adjunct can be formed from one or more bioabsorbable and biocompatible polymers having known degradation rates, as discussed above for example regarding the adjunct 116 of Figure 12, and having the one or more medicants releasably trapped therein. For another example, the adjunct can be formed from one or more bioabsorbable and biocompatible polymers configured to disintegrate due to effects of temperature, pH, light, or other environmental factors so as to release the medicant(s) retained therein, as discussed above for example regarding the adjunct 122 of Figure 15.

[00207] For another example, a tubular construct, having an adjunct and medicant(s) coupled thereto, can be applied to a tissue in conjunction with staples in an anastomosis being performed as part of a cancer treatment of a tissue lumen such as the colon or the esophagus. Irradiation of the tissue following the performance of the anastomosis may also be part of the cancer treatment. The adjunct releasably retaining the at least one medicant can be formed from one or more polymers configured to degrade in the presence of radiation. In this way, the post-anastomosis radiation can cause the degradation of the polymer and thereby allow release of the one or more medicants from the adjunct. The at least one medicant can include an agent configured to address adverse effect(s) of radiation, such as an agent configured to improve renal function (e.g., bardoxolone, etc.), since radiation nephropathy is an injury that may occur due to radiation therapy. The at least one medicant may thus help maintain and/or improve kidney function. In addition to or instead of the at least one medicant being including an agent configured to address adverse effect(s) of radiation, the at least one medicant can include an anti-cancer agent such as cytosine arabinoside, Cyclophosphamide, methotrexate, or other agent configured to protect healthy tissue during the radiation therapy.

[00208] In at least some implementations, when irradiation of the tissue following performance of the anastomosis in which the tubular construct is applied is also part of the cancer treatment, the at least one medicant can be configured to deliver at least some of the radiation. The at least one medicant can in the form of one or more radiation seeds configured to deliver radiation within a patient's body, as will be appreciated by a person skilled in the art. For example, the adjunct coupled to the tubular construct can have a plurality of vessels disposed therein, such as by being a fiber-based lattice defining one or more cavities therein. Each of the plurality of vessels can include one or more radiation seeds, and the vessels can be contained within the cavities.

[00209] For yet another example, a tubular construct, having an adjunct and medicant(s) coupled thereto, can be applied to a colon as part of a treatment for irritable bowel syndrome or Crohn's disease. The at least one medicant can include an anti-inflammatory agent, e.g., a monoclonal antibody, tumor necrosis factor alpha (TNF-A), an interleukin-2 (IL-2) inhibitor, etc. The at least one medicant can thus be configured to help reduce inflammation at the wound site and, accordingly, help treat the underlying disease and/or help end the inflammation stage of wound

healing when the colon would typically be at its weakest during the wound healing. For example, the adjunct can be formed from one or more bioabsorbable and biocompatible polymers having known degradation rates and/or one or more bioabsorbable and biocompatible polymers configured to disintegrate due to effects of temperature, pH, light, or other environmental factors.

[00210] The tubular construct can include a single tubular member or multiple independent tubular members that together define the construct. In general, a tubular member generally has the structure of a tube with an inner passageway extending between opposed openings of the tube. The tube's diameter can be constant along its longitudinal length or can vary therealong. The openings can each have a same diameter or a different diameter. Additionally, as mentioned above, a tubular construct can be radially expandable/constrictable such that the tube's diameter can dynamically vary and the size of the openings can dynamically vary.

[00211] In an exemplary implementation of the tubular construct including multiple independent tubular members, the tubular construct can include two tubular members (i.e., first and second tubular members). The first and second tubular members can thus together define a tubular construct configured to be secured to tissue. The first and second tubular members can each have a variety of sizes, shapes, and configurations.

[00212] In at least some implementations, the first and second tubular members that collectively define the tubular construct can be the same as one another. The first and second tubular members being the same as one another may facilitate assembly (whether the first and second tubular members are releasably coupled to a surgical stapler during manufacturing or during preparation for a surgical procedure when a surgeon or other user releasably couples the first and second tubular members to a surgical stapler) since it does not matter which of the first and second tubular members is attached to an anvil of the stapler and which is attached to a cartridge assembly of the stapler. The first and second tubular members being the same as one another may facilitate performance of a surgical procedure in which the first and second tubular members are secured to tissue using a surgical stapler because the stapler can be positioned relative to the tissue according to surgeon preference without regard to which side of the tissue the first and

second tubular members will be respectively deployed because the sides of tissue will each have a same tubular member applied thereto.

[00213] Regardless of whether the first and second tubular members releasably coupled to a surgical stapler are identical to one another or not, each of the first and second tubular members can have an adjunct coupled thereto, e.g., the first tubular member having a first adjunct coupled thereto and the second tubular member having a second adjunct coupled thereto. The first and second adjuncts can be the same as one another or can be different from one another. The first and second adjuncts being the same as one another may facilitate assembly, similar to that discussed above regarding same tubular members. The one or more medicants releasably retained by each of the first and second adjuncts can be the same for each of the first and second adjuncts or can be different from one another. The medicants of the first and second adjuncts being the same as one another may facilitate assembly, similar to that discussed above regarding same tubular members. The medicants of the first and second adjuncts being different from one another may allow the tubular construct to provide more varied treatments, e.g., include at least one medicant directed to wound healing and at least one medicant directed to cancer treatment.

[00214] Figure 45 illustrates one implementation of a tubular member 900. The tubular member 900 can alone define a tubular construct deliverable to tissue or can define a tubular construct together with at least one other tubular member, such as with a second tubular member 902 illustrated in Figure 46. The tubular member 900 can have a variety of sizes, shapes, and configurations. The tubular member 900 can have an inner passageway 912 extending longitudinally therethrough between opposed openings 914a, 914b of the tubular member 900 (see also Figure 47). The opposed openings 914a, 914b can be at opposite vertical ends 916a, 916b, e.g., proximal and distal ends, of the tubular member 900, with the vertical direction being defined for the tubular member 900 by a longitudinal axis 900A of the tubular member 900.

[00215] The tubular member 900 can have a tapered funnel shape with one of the vertical ends 916a, 916b having a diameter that is less than a diameter at the other of the vertical ends 916a, 916b at least when the tubular member 900 is in its default, natural shape. Here, the bottom or distal end 916b of the tubular member 900 has a diameter that is less than a diameter of the top or proximal end 916a of the tubular member 900 at least when the tubular member 900 is in its

default, natural shape. The tubular member 900 is shown in its default, natural shape in Figure 45. As mentioned above, the tubular member 900 can be configured to radially expand and radially constrict. The diameters at the vertical ends 916a, 916b can thus change while the tubular member 900 is deployed within a tissue lumen and/or during the process of deploying the tubular member 900 within the tissue lumen such that the diameters at the vertical ends 916a, 916b are equal to one another or so that the diameter of the top end 916b becomes greater than the diameter of the bottom end 916a. The tubular member 900 can be deployed within a tissue lumen such that a direction of fluid flow within the tissue lumen is from the larger vertical end 916a to the smaller vertical end 916b. The tapered funnel shape of the tubular member 900 may thus facilitate the passage of fluid and/or other matter through a tissue lumen within which the tubular member 900 is deployed.

[00216] The tubular member 900 can include a scaffold configured to support an adjunct material 904 thereon, and hence also support one or more medicants 906 releasably retained by the adjunct material 904. The tubular member 900 can thus function as a buttress by supporting the adjunct material 904 and the medicant(s) 906 and, when applied to tissue, by providing structural support to the tissue. The adjunct material 904 is shown partially cutaway from the scaffold in Figure 45 for clarity of illustration. The adjunct material 904 fully covers an exterior surface of the illustrated scaffold (see also Figure 47 and Figure 49). The adjunct 904 fully covering the scaffold's exterior surface may help the medicant(s) 906 release over more area of tissue against which the adjunct 904 abuts, may help the tubular member 900 grip tissue to which it is delivered and thereby help the tubular member 900 stay in place relative to the tissue, and/or may help more evenly distribute pressure exerted outwardly by the tubular member 900 on tissue so as to help irritate the tissue less as foreign matter implanted within the body.

[00217] The scaffold can have a variety of sizes, shapes, and configurations. As illustrated, the scaffold can include a plurality of circumferential rings 908a, 908b, 908c and a support member 910 that couples the rings 908a, 908b, 908c together. The tubular member 900 in this illustrated implementation includes three rings 908a, 908b, 908c, but a tubular member can have another plural number of rings, e.g., two, four, five, etc. In general, the more rings that a tubular member has, the more structural stability that the tubular member can provide to the adjunct material thereon and to the tissue to which the tubular member is delivered, the more pressure can be

distributed along the longitudinal length of the tubular member so as to help reduce an amount of pressure that the tubular member exerts at any one axial position along a tissue lumen within which the tubular member is deployed, and/or the less pressure may be exerted along a staple line near which the tubular member is deployed. In general, the less pressure exerted on a wounded tissue, the better the tissue can heal.

[00218] The rings 908a, 908b, 908c can extend horizontally, with reference to the vertically-extending longitudinal axis 900A of the tubular member 900. The horizontal positioning of the rings 908a, 908b, 908c may facilitate a more even distribution of pressure along the longitudinal length of the tubular member 900 and hence may facilitate tissue healing and/or may help relieve pressure along a staple line near which the tubular member 900 is deployed.

[00219] In an exemplary implementation, each of the rings 908a, 908b, 908c has a same shape as one another. As shown, the rings 908a, 908b, 908c each have a circular shape. Tissue lumens typically have a circular inner diameter. Thus, the rings' circular shape may allow the rings 908a, 908b, 908c to mimic the shape of a tissue lumen's inner diameter within which the tubular member 900 may be deployed. The rings 908a, 908b, 908c may thus help the tubular member 900 conform to the shape of the tissue lumen and, hence and/or may help allow the tubular member 900 to be less obstructive to the tissue lumen's natural passageway. In other words, the rings' circular shape may help maximize a size of the passageway through which fluid and/or other matter can flow through the tissue lumen at the location thereof having the tubular member 900 deployed therein. In other implementations, a tubular member's rings can have another shape, such as ovular.

[00220] Each of the rings 908a, 908b, 908c can have a same diameter as one another, or any one or more of the rings 908a, 908b, 908c can have a different diameter than any of the other rings 908a, 908b, 908c. All of the rings 908a, 908b, 908c having a same diameter results in the tubular member 900 having a substantially constant diameter along its longitudinal length. A person skilled in the art will appreciate that the tubular member's diameter may not be precisely constant along its longitudinal length due to any one or more factors, such as sensitivity of measurement devices and flexibility of the support member 910 extending between the rings 908a, 908b, 908c. Alternatively, one or more of the rings 908a, 908b, 908c having different

diameters results in the tubular member 900 having a non-constant diameter along its longitudinal length. As shown in Figure 45 and Figure 47, the tubular member 900 has a non-constant diameter along its longitudinal length, with a diameter 918a of the top-most ring 908a being greater than a diameter 918c of the bottom-most ring 908c. The tubular member 900 thus has a tapered funnel shape from top to bottom due to the differing ring diameters. The middle ring 908b has a same diameter 918b as the top-most ring 908b in this illustrated implementation.

[00221] The rings 908a, 908b, 908c can be configured to be crush-resistant. This resistance may facilitate the radial expansion/contraction of the tubular member 900 without the tubular member 900 breaking or otherwise reducing in structural integrity. The rings 908a, 908b, 908c can be made from a variety of materials to facilitate the crush resistance, as will be appreciated by a person skilled in the art, such as one or more biocompatible polymers.

[00222] The support member 910 can have a variety of sizes, shapes, and configurations. In general, the support member 910 can be configured to attach the rings 908a, 908b, 908c together and hold the rings 908a, 908b, 908c in substantially constant axial positions along the tubular member's longitudinal axis 900A. A person skilled in the art will appreciate that the rings' axial positions may not be precisely constant along the longitudinal axis 900A due to any one or more factors, such as sensitivity of measurement devices, flexibility of the support member 910, and movement of the rings 908a, 908b, 908c during radial expansion/constriction of the tubular member 900.

[00223] In general, the support member 910 can be configured to provide axial strength to the tubular member 900. The support member 910 can extend transversely to the rings 908a, 908b, 908c, which may help provide further structural stability to the tubular member 900. The support member 910 can extend vertically so as to be parallel to the tubular member's longitudinal axis 900A and/or can extend at a non-perpendicular angle to longitudinal axis 900A. In other words, the support member 910 can extend transversely to first, second, and third substantially parallel planes defined by the first, second, and third rings 908a, 908b, 908c, respectively. In this illustrated implementation, the support member 910 has a cross-hatched pattern. Although the support member 910 does not extend horizontally at all in this illustrated embodiment, a support member in another implementation may include some horizontally-

extending portions, which may help provide additional horizontal stability to the tubular member at axial positions between the tubular member's rings.

[00224] As shown, the support member 910 can include a plurality of fibers that together define the support member 910 and that are woven together to define the cross-hatched pattern. The fibers can be woven, braided, knitted, or otherwise interconnected, similar to that discussed above regarding an adjunct's fiber-based lattice. The fibers can have at least some space therebetween, thereby allowing the one or more medicant(s) 906 to leak or otherwise pass therethrough. Instead of including a plurality of fibers woven together, a support member can include a single fiber wound in a pattern.

[00225] The support member 910 can be exposed on an interior surface of the tubular member 900, as shown in Figure 47. In other words, the adjunct material 904 can cover only an exterior surface of the scaffold, thereby leaving the interior surface of the scaffold adjunct-free. In at least some implementations, the adjunct material 904 may cover some portion of the scaffold's interior surface while leaving another portion of the scaffold's interior surface adjunct-free. The exposed fibers of the support member 910 on the scaffold's interior surface can be configured to facilitate tissue growth. Cells may attach to the fibers of the support member 910 on the exposed interior surface, which may facilitate tissue healing as discussed herein, e.g., by facilitating ECM formation. The fibers can be configured to encourage tissue growth to be in a certain direction and/or discourage tissue growth in a certain area and/or on a certain structure, similar to the fiber-based lattice adjunct mentioned above and as further described in U.S. Pat. App. No. [ ] entitled "Adjunct Material To Promote Tissue Growth" filed on even date herewith [Attorney Docket No. 47364-162F01US (END7625USNP)]. Additionally, since the adjunct 904 covering the scaffold can be configured to disintegrate, as discussed herein, an exterior surface of the support member 910 that was previously covered by the adjunct 904 can become exposed to an external environment over time due to the adjunct's disintegration. Once exposed, cells may attach to the fibers of the support member 910 from an exterior side of the tubular member 900 and thereby encourage tissue growth to be in a certain direction and/or discourage tissue growth in a certain area and/or on a certain structure.

[00226] The tubular member 900 can include one or more bioabsorbable ties (not shown), e.g., one or more bioabsorbable fibers, configured to reduce a size of the tubular member 900 to facilitate insertion of the tubular member 900 into a patient's body and/or into a tissue lumen. The one or more ties can be configured to collapse the tubular member 900 to a reduced diameter by causing the rings 908a, 908b, 908c to fold, bend, or otherwise compress in size and/or by causing the support member 910 to fold, bend, or otherwise compress in size. It may therefore be easier for the tubular member 900 to be inserted into a tissue lumen and/or into a body of a patient through an incision formed therein or through a natural orifice thereof. The one or more ties can be configured to bioabsorb very quickly within the tissue lumen, thereby allowing the tubular member 900 to assume its "normal" size and shape and conform to the size of the tissue lumen to which the tubular member 900 is applied. Whether or not the tubular member 900 includes one or more bioabsorbable ties, the tubular member 900 can be manually compressed to help the tubular member 900 be inserted into a tissue lumen and/or into a patient's body. The rings 908a, 908b, 908c and the support member 910 can thus be flexible (e.g., be able to bend without breaking or permanently deforming in form) to facilitate insertion of the tubular member 900.

[00227] The second tubular member 902 of Figure 46 and Figure 47 can have a variety of sizes, shapes, and configurations. As shown, the second tubular member 902 is the same as the first tubular member 900 and includes a scaffold or buttress including a plurality of rings 922a, 922b, 922c, including a support member 924, and configured to support an adjunct material 926 thereon, and hence also support one or more medicants 928 releasably retained by the adjunct material 926. The adjunct material 926 is shown partially cutaway from the scaffold in Figure 46 for clarity of illustration. The adjunct material 926 fully covers an exterior surface of the illustrated scaffold (see also Figure 47 and Figure 49).

[00228] Figure 48 illustrates another implementation of a tubular member 930. The tubular member 930 can alone define a tubular construct or can be used with at least one additional tubular member to together define a tubular construct similar to the first and second tubular members 900, 902 together defining a tubular construct. The tubular member 930 can generally be configured and used similar to the first tubular member 900 and can include a scaffold or buttress including a plurality of rings 932a, 932b, 932c, including a support member 934, and

configured to support an adjunct material 936 thereon, and hence also support one or more medicants 938 releasably retained by the adjunct material 936. The adjunct material 936 is shown partially cutaway from the scaffold in Figure 48 for clarity of illustration. The adjunct material 936 fully covers exterior and interior surfaces of the illustrated scaffold.

[00229] Like the first tubular member 900, the tubular member 930 includes three horizontally-extending rings 932a, 932b, 932c, with the upper two rings 932a, 932b having a same diameter and the lower ring 932c having a smaller diameter such that the tubular member 930 has a tapered funnel shape. Also like the first tubular member 900, the support member 934 of the tubular member 930 includes a plurality of fibers. The fibers in this illustrated implementation extend transversely to the rings 932a, 932b, 932c, with some of the fibers extending substantially parallel to the tubular member's longitudinal axis 930A and substantially perpendicular to planes defined by each of the rings 932a, 932b 932c between the upper two rings 932a, 932b and with some of the fibers extending transversely to the to the member's longitudinal axis 930A between the bottom two rings 932b, 932c. At least some of the fibers thus extend vertically. A person skilled in the art will appreciate that the fibers extending between the upper two rings 932a, 932b may not be precisely parallel to the member's longitudinal axis 930A or precisely perpendicular to planes defined by each of the rings 932a, 932b 932c due to any one or more factors, such as sensitivity of measurement devices, flexibility of the fibers, and movement of the rings 932a, 932b 932c during radial expansion/constriction of the tubular member 930.

[00230] In general, a tubular construct having an adjunct disposed thereon, the adjunct releasably retaining at least one medicant, can be configured to be applied to tissue by a surgical stapler in conjunction with staples. The at least one medicant can be configured to be released along the staple line defined by the staples, which can help target the at least one medicant's desired functionality to where the wounded tissue is typically weakest. The at least one medicant may thus help prevent the tissue along the staple line from becoming too weak during the wound healing process. The construct can be configured to be positioned on both sides of the staple line, which may help provide structural stability to the tissue around the staple line during the process of wound healing. For example, a first tubular member of the construct can be positioned on one side of the staple line, and a second tubular member of the construct can be positioned on the other side of the staple line.

[00231] A tubular construct having an adjunct disposed thereon that is releasably retaining at least one medicant may be applied to a tissue lumen, as mentioned above. Tissue structure of a tissue lumen is generally organized to facilitate radial expansion or stretching (distension) and to limit longitudinal expansion or stretching (e.g., expansion or stretching along a longitudinal axis of the colon). Additionally, an anastomosis performed in a surgical procedure, such as in a colectomy, a Roux en-Y gastric bypass (RYGB), or an esophagectomy, using a stapler leaves a staple line within the tissue lumen. The tubular construct being radially conformable may facilitate radial expansion or stretching of the tissue lumen and may limit longitudinal expansion or stretching and, thus, be well suited for delivery to a tissue lumen. The adjunct can be configured to focus encouraged tissue growth in a direction in accordance with the lumen's natural radial expansion and contraction. This encouragement can be caused in any number of ways, as further discussed in previously mentioned U.S. Pat. App. No. [ ] entitled "Adjunct Material To Promote Tissue Growth" filed on even date herewith [Attorney Docket No. 47364-162F01US (END7625USNP)]. The construct, and hence the adjunct and medicant(s) coupled thereto, may be applied to the tissue lumen adjacent the staple line to reflect the endolumenal nature of the staple line, to provide strength along the staple line where anastomosis tissues are attached together, and/or to help focus the wound healing benefits of the adjunct and/or its associated medicant(s) along the area where leaks are most common. For colorectal procedures in particular, leaks at an anastomosis wound site are a common and potentially life-threatening event. Adjuncts and medicants configured to facilitate leak identification and/or leak sealing, such as via color change, foaming, or a change in adjunct conformation, are further described in U.S. Pat. App. No. [ ] entitled "Surgical Adjuncts With Medicants Affected By Activator Materials" filed on even date herewith [Attorney Docket No. 47364-169F01US (END7632USNP)], which is hereby incorporated by reference in its entirety.

[00232] Figure 47 illustrates the first and second tubular members 900, 902 loaded on an implementation of a circular surgical stapler for delivery to a tissue. For clarity of illustration, only a distal portion of the stapler is shown in Figure 47. The first tubular member 900 is loaded on an anvil 940 of the stapler, and the second tubular member 902 is loaded on a cartridge assembly 942 of the stapler. As discussed above, the cartridge assembly 942 can have a plurality of staples 944 loaded therein that are configured to be driven therefrom toward staple-forming cavities 946 formed in the anvil 940. Thus, tissue positioned in a space 952 between opposed

tissue-facing surfaces 948, 950 of the anvil 940 and the cartridge assembly 942 can have the staples 944 driven therethrough.

[00233] The first tubular member 900 can be loaded on the anvil 940 with its lower diameter end, e.g., the bottom end 916b, facing proximally toward the cartridge assembly 942 and hence toward the second tubular member 902 loaded on the cartridge assembly 942. The second tubular member 902 can be loaded on the cartridge assembly 942 with its lower diameter end facing distally toward the anvil 940 and hence toward the first tubular member 900 loaded on the anvil 940. In this way, when the tubular construct is applied to tissue, the lower diameter bottom ends will face one another such that the tubular construct has an hourglass shape, as shown for example in Figure 49, which is discussed further below. The hourglass shape can facilitate passage of fluid and/or other matter through the construct, similar to that discussed above. The radially conformable nature of the first and second tubular members 900, 902 may facilitate their loading onto the stapler, as may one or more bioabsorbable ties (not shown) coupled to one or both of the first and second tubular members 900, 902.

[00234] At least one of the anvil 940 and the cartridge assembly 942 can be movable relative to the other to facilitate the deployment of the staples 944, as discussed herein. Accordingly, at least one of the first and second tubular members 900, 902 can be movable relative to the other to facilitate the deployment of the tubular construct.

[00235] Figure 49 illustrates one implementation of the tubular construct including the first and second tubular members 900, 902 delivered to a tissue lumen 954 with the plurality of staples 944 in an end-to-end anastomosis procedure using the circular surgical stapler of Figure 47 attaching together two tissues 954, 954b defining the lumen 954. The implementation of Figure 49 is described with respect to the tubular members 900, 902 of Figure 45 and Figure 46, but other tubular constructs can be similarly applied. Also, the implementation of Figure 49 is described with respect to the tubular members 900, 902 being applied to the tissue lumen 954 using the stapler of Figure 47, but this or other tubular constructs can be delivered to this or to another tissue using a different surgical stapler.

[00236] The staples 944 can secure both of the first and second tubular members 900, 902 to the tissue 954, as shown. The positioning of the first and second tubular members 900, 902 on the

stapler shown in Figure 47 facilitates this stapling since both of the first and second tubular members 900, 902 are positioned between the staples 944 and the staple cavities 946 prior to the deployment of the staples 944. The staples 944 may help hold the tubular construct in place relative to the staple line, which may facilitate delivery of the one or more medicants 906, 928 along the staple line where they may best facilitate wound healing.

[00237] As shown, the tubular construct, e.g., the first and second tubular members 900, 902, is intralumenally placed, e.g., is located within an inner passageway 956 of the tissue lumen 954, with the adjunct material 904, 926 facing an interior surface of the lumen 954 and abutting thereagainst. The radial conformability of the tubular construct may allow the construct to conform to the lumen's natural size and shape, as shown. The staple line formed by the staples 944 may extend generally transverse to the tissue lumen's natural direction of distension, as shown. The horizontal extension of the rings 908a, 908b, 908c, 922a, 922b 922c relative to the longitudinal axes 900A, 902A of the tubular members 900, 902, and hence to a longitudinal axis 958 of the tissue lumen 954, may help relieve pressure on the tissue and/or may help urge the inner passageway 956 wider to help fluid and/or other matter flow therethrough.

[00238] The tubular construct deployed within the tissue lumen 954 is configured to reinforce the wounded tissue during its process of healing starting at a time the staples 944 are applied since the construct is delivered in conjunction with the staples 944. The construct can be configured to reinforce the wounded tissue throughout the entire process of wound healing (e.g., through all of the hemostasis, inflammation, proliferation, and remodeling stages) or through a partial portion thereof (e.g., from the time of stapling to a time at some point in one of the four stages before the remodeling stage ends). The construct can be configured to disintegrate, in any of the ways discussed herein (e.g., by being formed of bioabsorbable material, etc.), so as to stop providing structural support to the lumen 954 after its disintegration or at some point when the construct has partially disintegrated to a point of lost structural integrity.

[00239] A person skilled in the art will appreciate that the present invention has application in conventional minimally-invasive and open surgical instrumentation as well application in robotic-assisted surgery.

[00240] The devices disclosed herein can be designed to be disposed of after a single use, or they can be designed to be used multiple times. In either case, however, the device can be reconditioned for reuse after at least one use. Reconditioning can include any combination of the steps of disassembly of the device, followed by cleaning or replacement of particular pieces and subsequent reassembly. In particular, the device can be disassembled, and any number of the particular pieces or parts of the device can be selectively replaced or removed in any combination. Upon cleaning and/or replacement of particular parts, the device can be reassembled for subsequent use either at a reconditioning facility, or by a surgical team immediately prior to a surgical procedure. Those skilled in the art will appreciate that reconditioning of a device can utilize a variety of techniques for disassembly, cleaning/replacement, and reassembly. Use of such techniques, and the resulting reconditioned device, are all within the scope of the present application.

[00241] One skilled in the art will appreciate further features and advantages of the invention based on the above-described embodiments. Accordingly, the invention is not to be limited by what has been particularly shown and described, except as indicated by the appended claims. All publications and references cited herein are expressly incorporated herein by reference in their entirety.

What is claimed:

1. A surgical device, comprising:

a tubular construct having an inner lumen extending therethrough, the tubular construct being configured to be delivered to a tissue lumen and be positioned therein so as to provide structural support to the tissue lumen, the tubular construct being radially collapsible;

a biocompatible adjunct material disposed on the tubular construct, the adjunct material being configured to be delivered to the tissue lumen with the tubular construct; and

an effective amount of at least one medicant disposed within and releasable from the adjunct material, each of the at least one medicants being effective to provide a desired effect on tissue in a predetermined manner.

2. The device of claim 1, wherein the adjunct material is in the form of at least one of a fiber lattice and a film.

3. The device of claim 1, wherein the tubular construct includes a scaffold having a plurality of pores configured to facilitate tissue ingrowth.

4. The device of claim 1, wherein the tubular construct includes a funnel shape with a smaller diameter at a first end of the shape than at a second, opposite end of the shape.

5. The device of claim 1, wherein the tubular construct includes at least two rings extending circumferentially therearound, the tubular construct includes at least one support structure extending between the at least two rings, and the adjunct material is disposed as a covering over the at least two rings and the at least one support structure.

6. The device of claim 1, wherein the tubular construct includes first and second independent tubular members.

7. A method of using the surgical device of claim 1, the method comprising:

positioning a circular surgical stapler at a target location within a patient within a lumen of a tissue of the patient, the stapler having releasably coupled to a distal end thereof the tubular construct having the adjunct material disposed thereon;

with the stapler positioned at the target location, actuating the stapler to deploy staples

from the stapler and into the tissue, the deployed staples securing the tubular construct within the lumen of the tissue; and

removing the stapler from the patient, the tubular construct remaining within the lumen.

8. The method of claim 7, wherein the tubular construct includes first and second independent tubular members;

prior to the actuation of the stapler, the first tubular member is releasably retained on an anvil of the stapler and the second tubular member is releasably retained on an cartridge assembly of the stapler; and

the actuation releases the first tubular member from the anvil and releases the second tubular member from the cartridge assembly.

9. The method of claim 7, wherein the adjunct material is in the form of a fiber lattice having at least two distinct heterogeneous fiber lattice sections, the at least two distinct heterogeneous fiber lattice sections including a first fiber lattice section having fibers extending along a longitudinal axis of the tubular construct and a second fiber lattice section having fibers extending annularly around the longitudinal axis of the tubular construct, the longitudinal axis of the tubular construct being substantially parallel to a longitudinal axis of the lumen having the tubular construct secured therein.

10. The method of claim 7, wherein the tissue includes one of an intestine and an esophagus.

11. An end effector for a circular surgical stapler, comprising:

a cartridge assembly having a cartridge body removably attached thereto, the cartridge body having on a tissue-facing surface thereof a plurality of annularly-arranged staple cavities configured to seat staples therein;

an anvil having a plurality of annularly-arranged staple forming cavities formed on a tissue-facing surface thereof, at least one of the cartridge assembly and the anvil being movable relative to the other;

a tubular construct releasably retained on each of the cartridge assembly and the anvil, the tubular construct having an inner lumen extending therethrough, the tubular construct being configured to be delivered to a tissue lumen by deployment of the staples in the cartridge body, the tubular construct being radially collapsible;

a biocompatible adjunct material disposed on the tubular construct, the adjunct material being configured to be delivered to the tissue lumen with the tubular construct; and

an effective amount of at least one medicant disposed within and releasable from the adjunct material, each of the at least one medicants being effective to provide a desired effect on tissue in a predetermined manner.

12. The end effector of claim 11, wherein the adjunct material is in the form of at least one of a fiber lattice and a film.

13. The end effector of claim 11, wherein the tubular construct includes a scaffold having a plurality of pores configured to facilitate tissue ingrowth.

14. The end effector of claim 11, wherein the tubular construct includes a funnel shape with a smaller diameter at a first end of the shape than at a second, opposite end of the shape.

15. The end effector of claim 11, wherein the tubular construct includes at least two rings extending circumferentially therearound, the tubular construct includes at least one support structure extending between the at least two rings, and the adjunct material is disposed as a covering over the at least two rings and the at least one support structure.

16. The end effector of claim 11, wherein the tubular construct includes first and second independent tubular members.

17. The end effector of claim 16, wherein the first tubular member is releasably retained on the anvil, and the second tubular member is releasably retained on the cartridge assembly.

18. A method of using the end effector of claim 11, the method comprising:

positioning a circular surgical stapler at a target location within a patient within a lumen of a tissue of the patient, the stapler having the end effector at a distal end thereof;

with the stapler positioned at the target location, actuating the stapler to deploy the staples from the cartridge body and into the tissue, the deployed staples securing the tubular construct within the lumen of the tissue; and

removing the stapler from the patient, the tubular construct remaining within the lumen.

19. The method of claim 18, wherein the adjunct material is in the form of a fiber lattice having at least two distinct heterogeneous fiber lattice sections, the at least two distinct heterogeneous fiber lattice sections including a first fiber lattice section having fibers extending along a longitudinal axis of the tubular construct and a second fiber lattice section having fibers extending annularly around the longitudinal axis of the tubular construct, the longitudinal axis of the tubular construct being substantially parallel to a longitudinal axis of the lumen having the tubular construct secured therein.

20. The method of claim 18, wherein the tissue includes one of an intestine and an esophagus.

INCORPORATED BY REFERENCE (RULE 20.6)

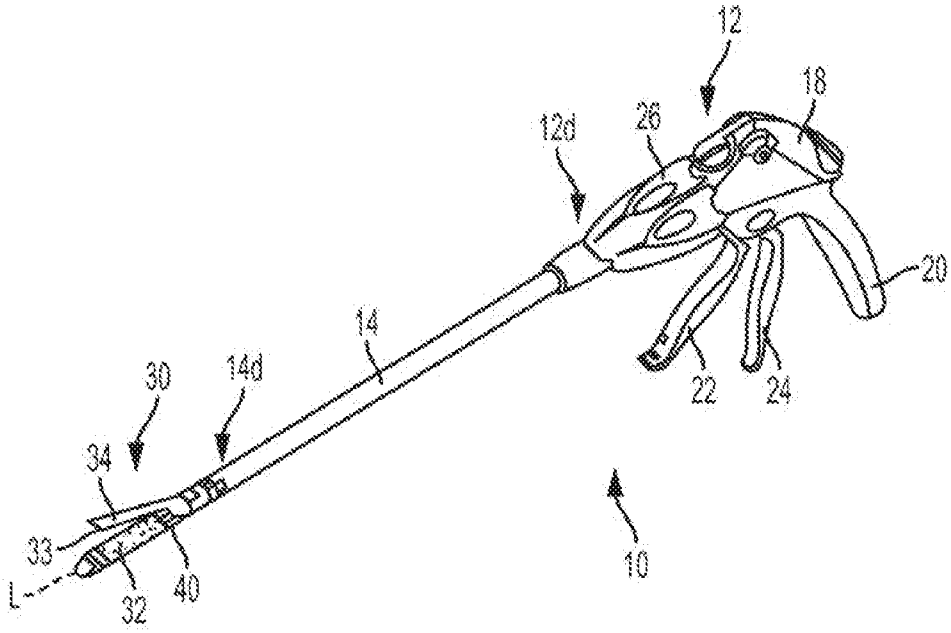


FIG. 1

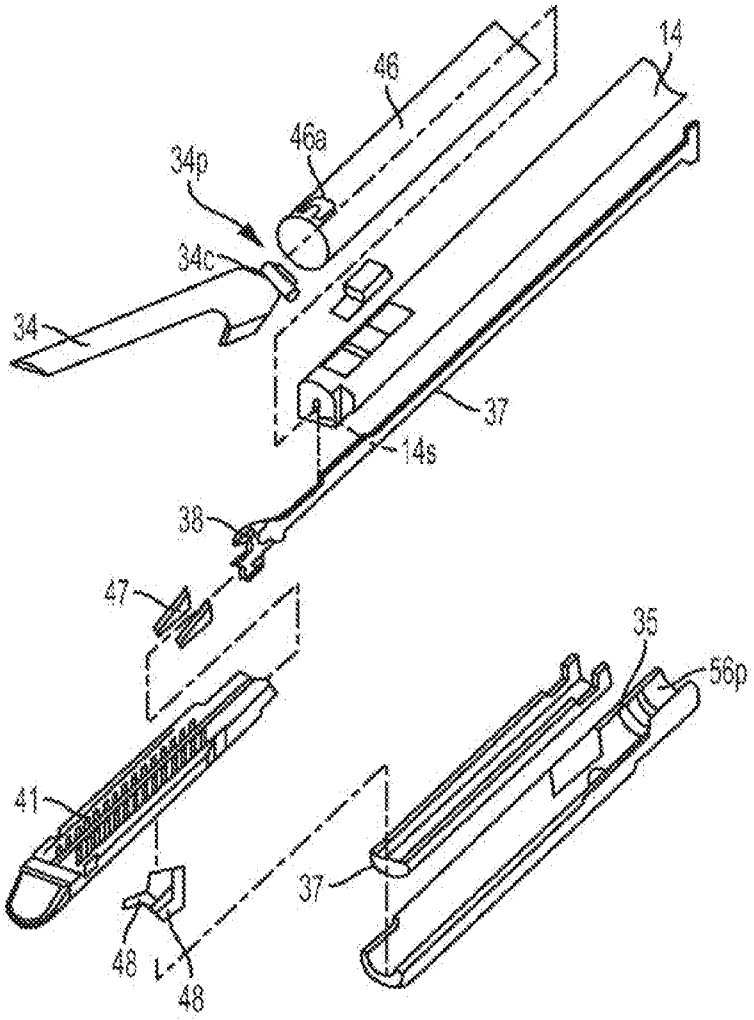


FIG. 2

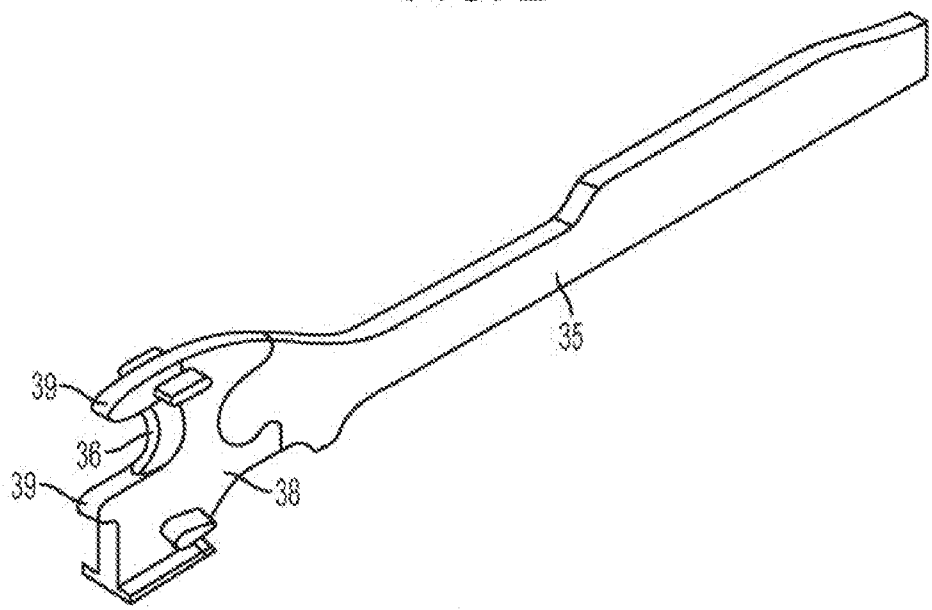


FIG. 3

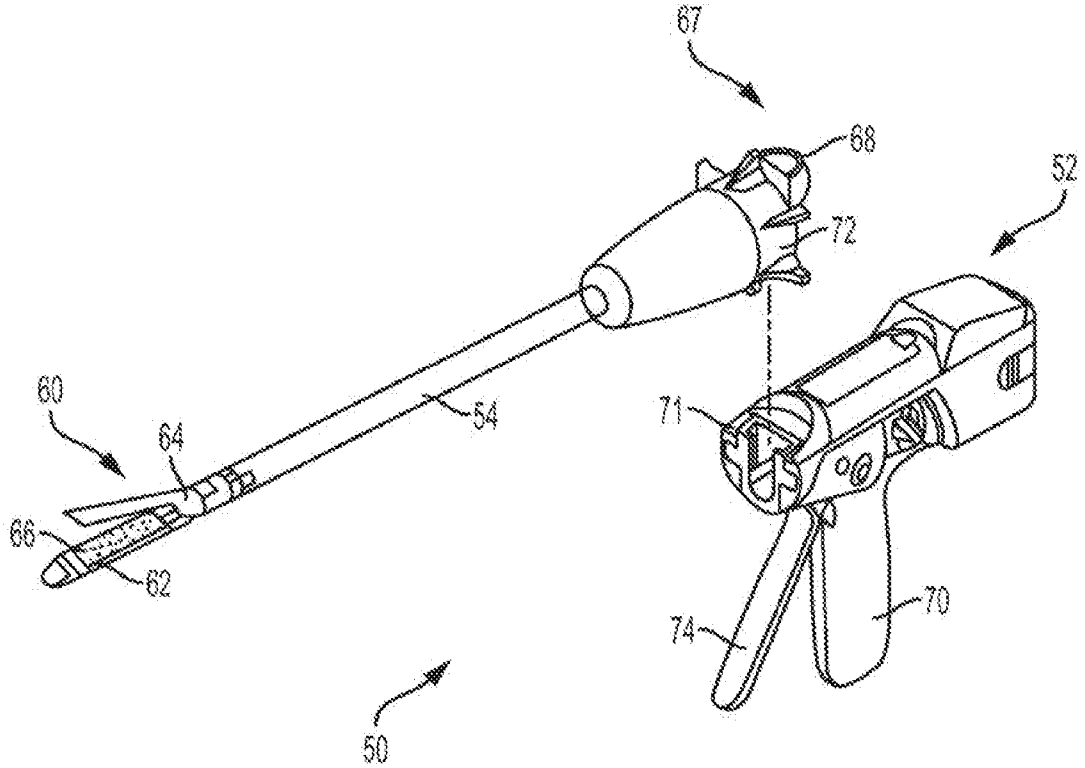


FIG. 4

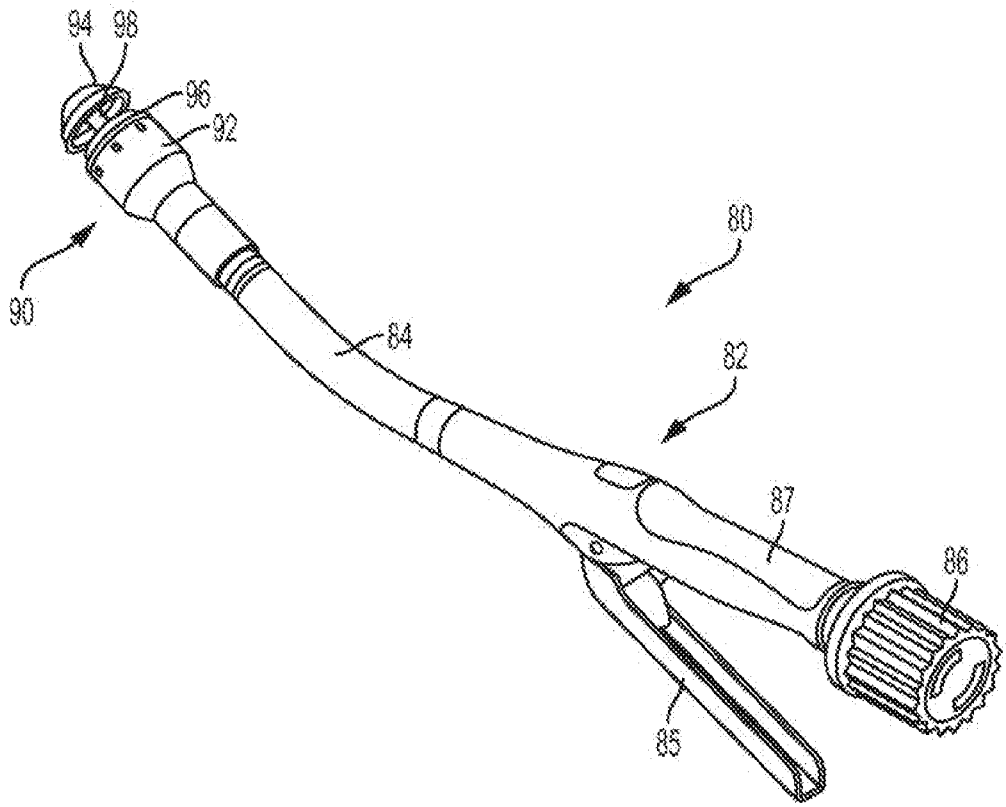


FIG. 5

INCORPORATED BY REFERENCE (RULE 20.6)

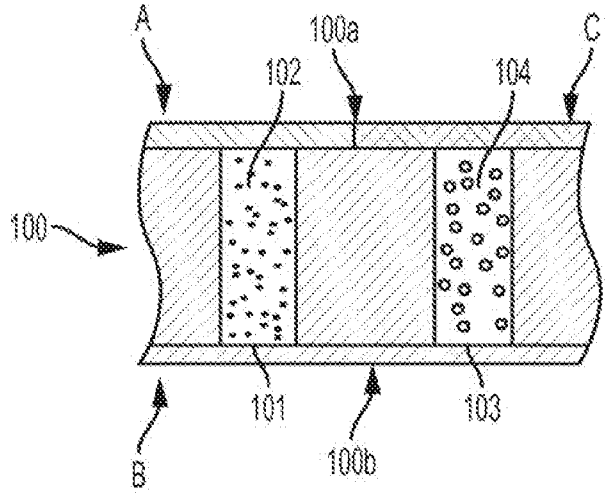


FIG. 6

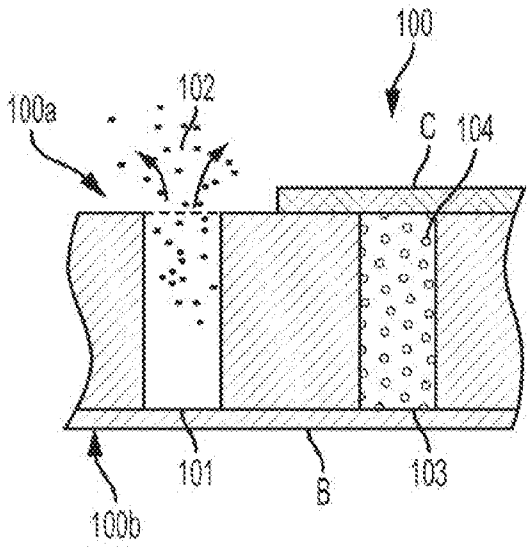


FIG. 7

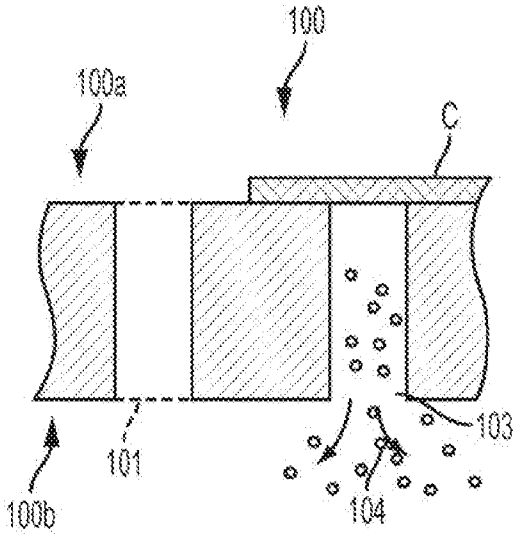


FIG. 8

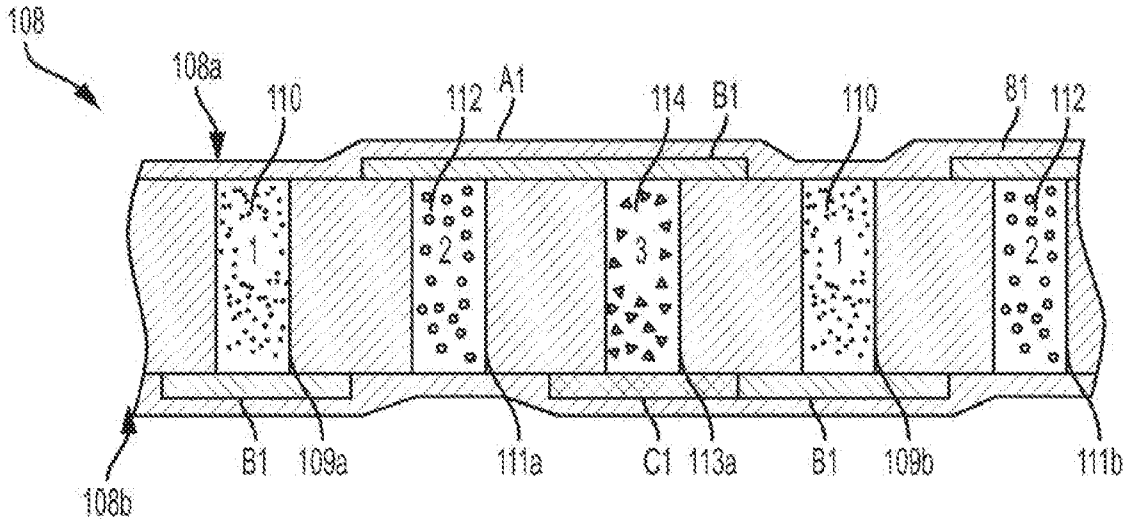


FIG. 9

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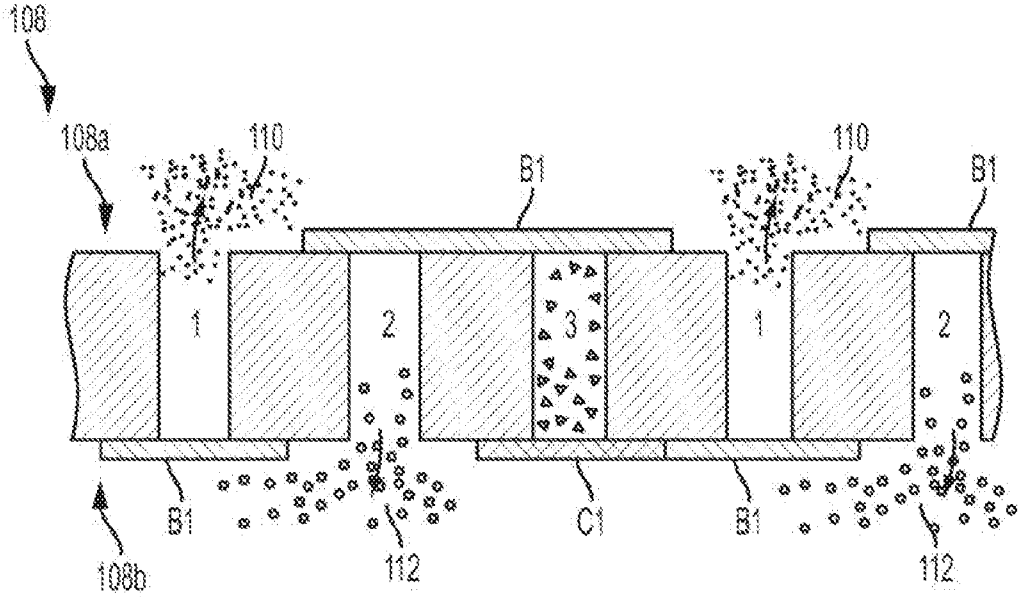

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108b
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112

FIG. 10

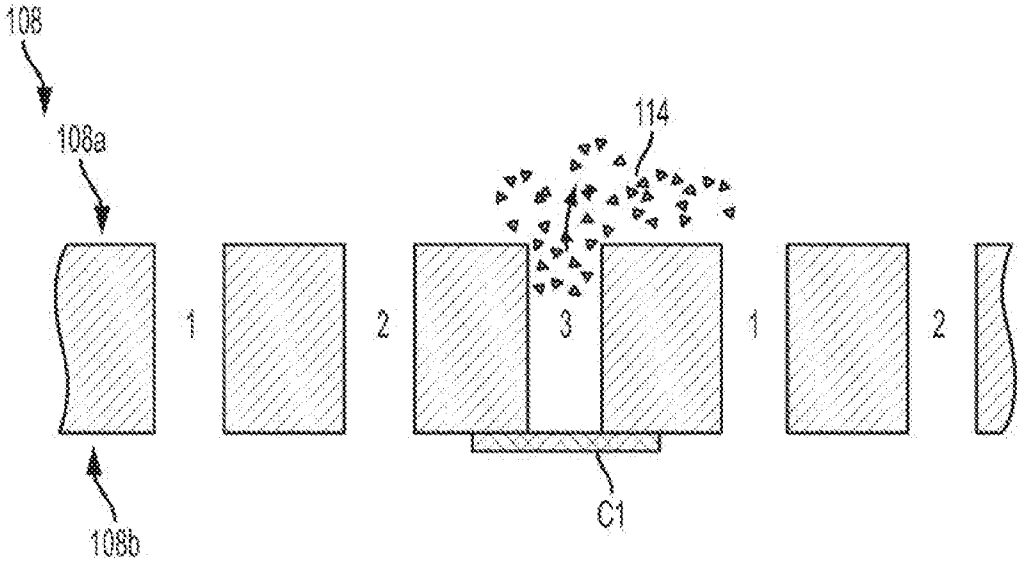

108
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2
C1
108b

FIG. 11

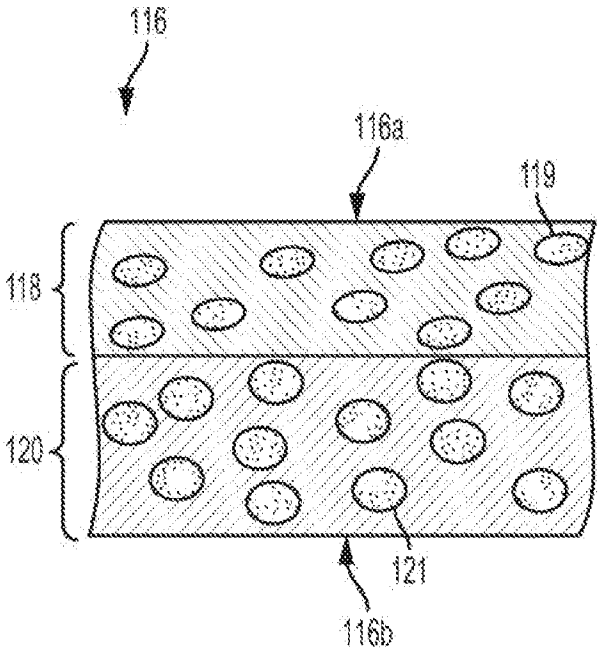


FIG. 12

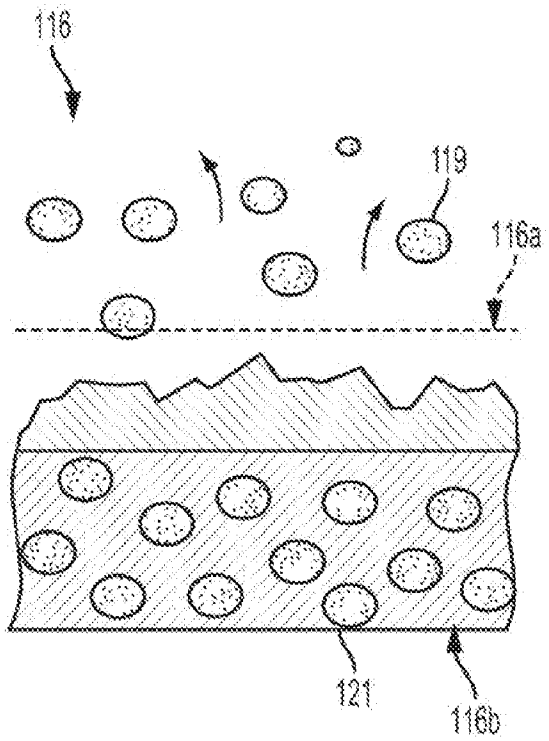


FIG. 13

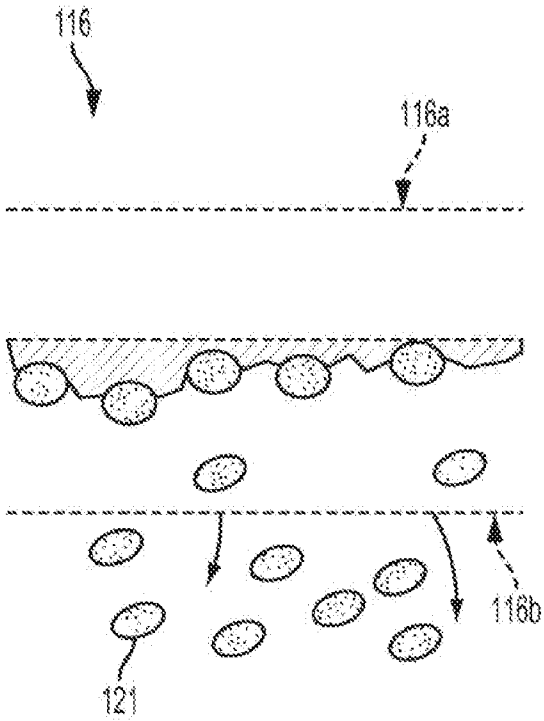


FIG. 14

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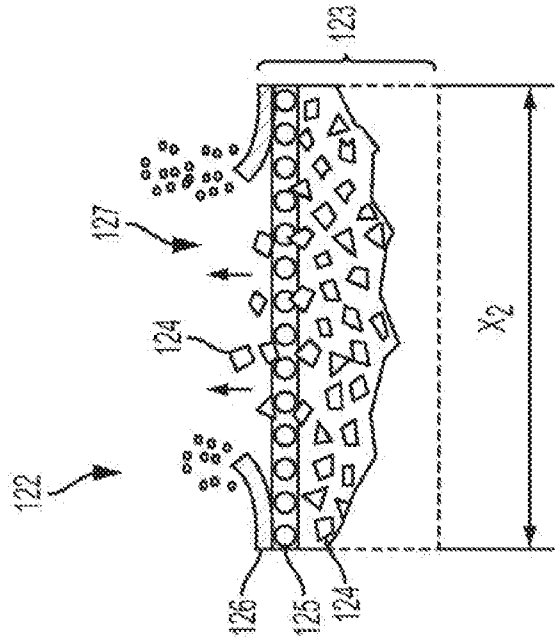


FIG. 16

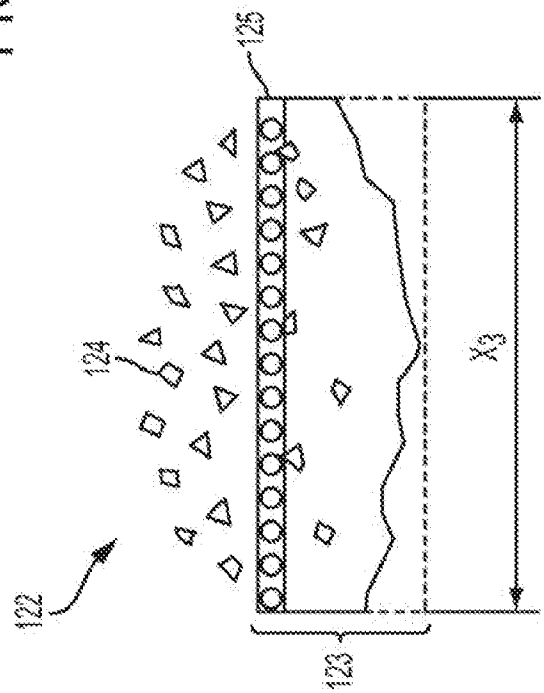


FIG. 17

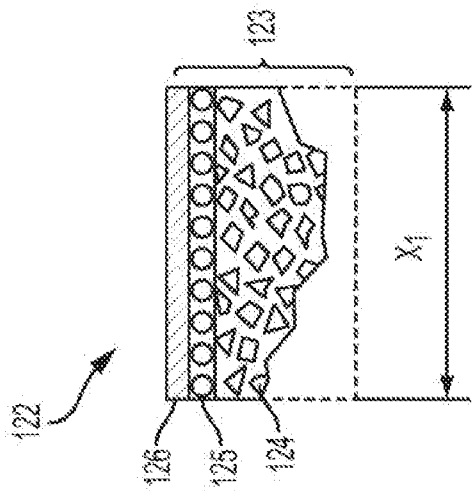


FIG. 15

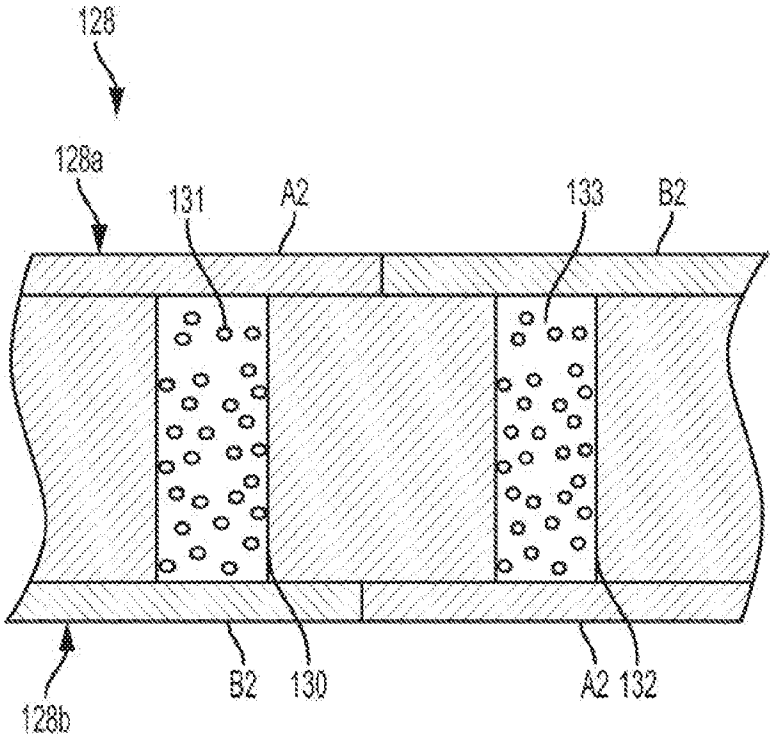


FIG. 18

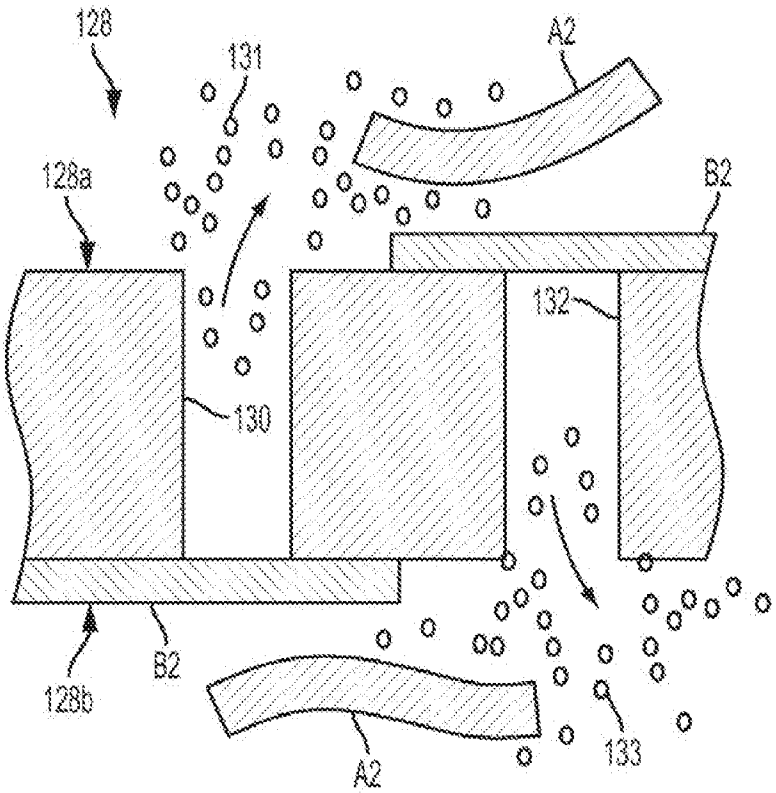


FIG. 19

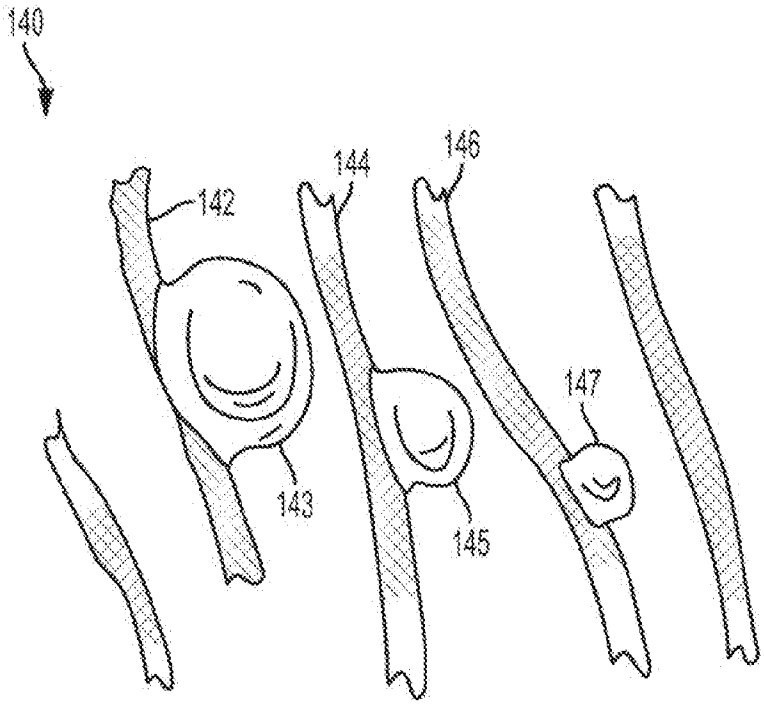


FIG. 20

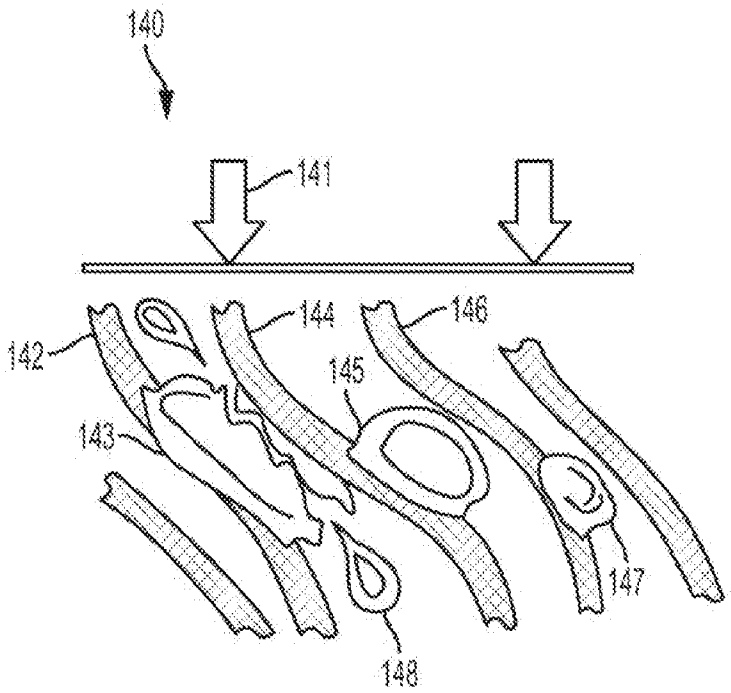


FIG. 21

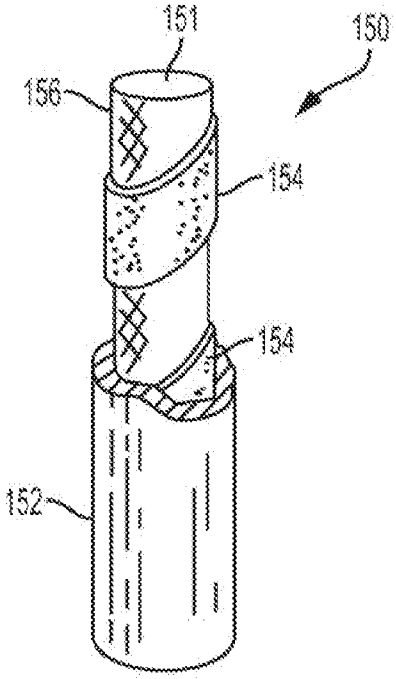


FIG. 22

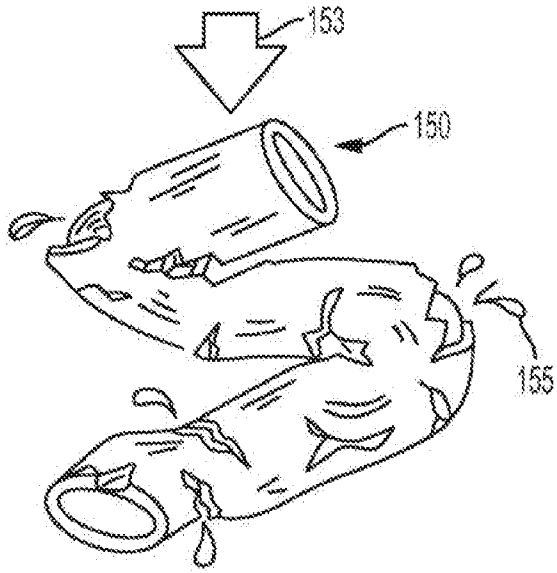


FIG. 23

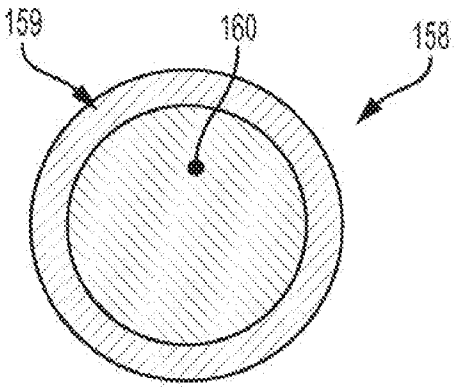


FIG. 24

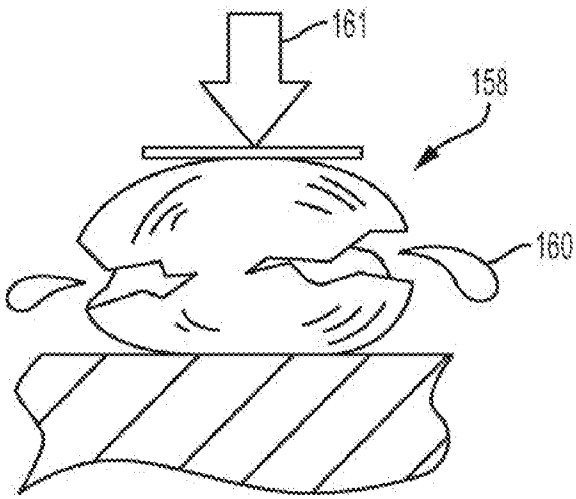


FIG. 25

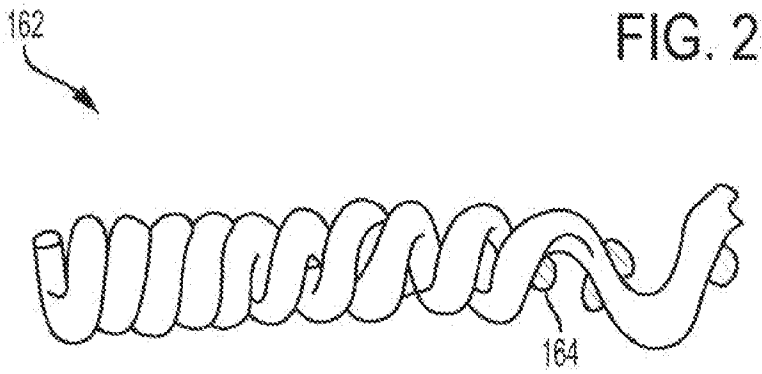


FIG. 26

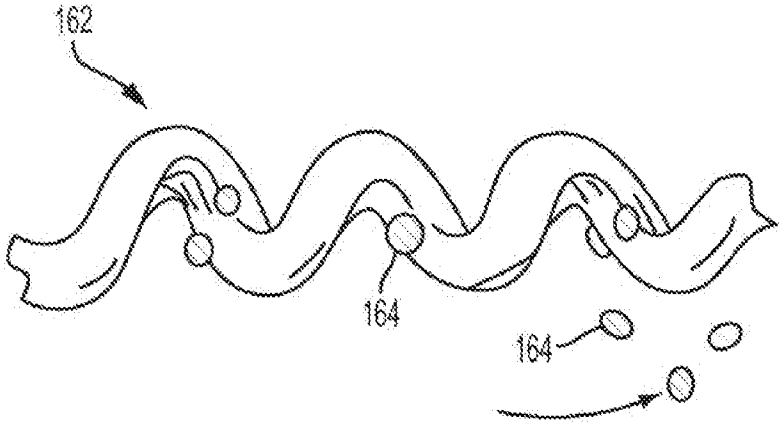


FIG. 27

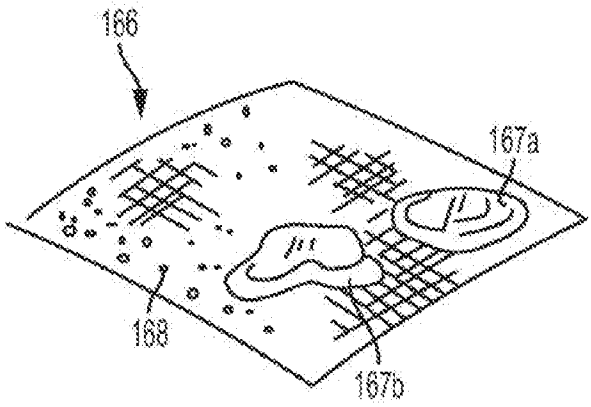


FIG. 28

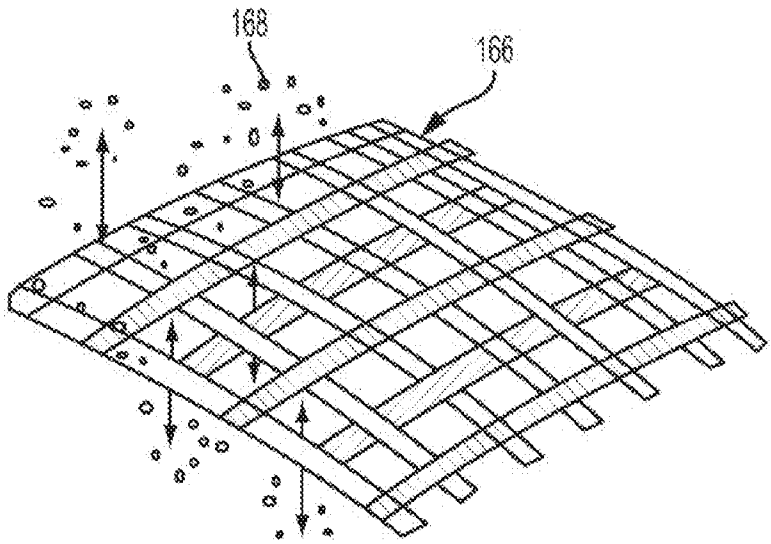


FIG. 29

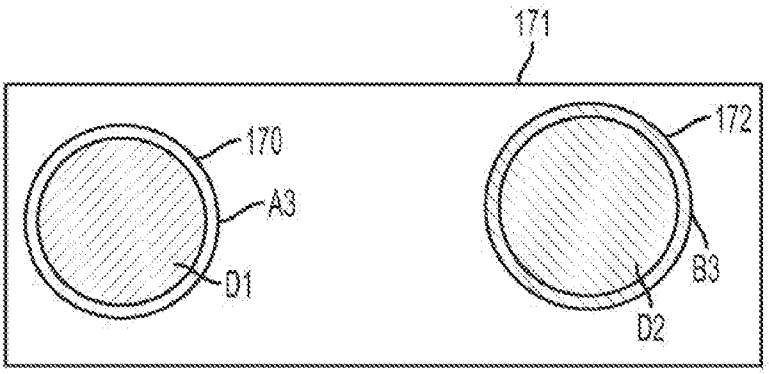


FIG. 30

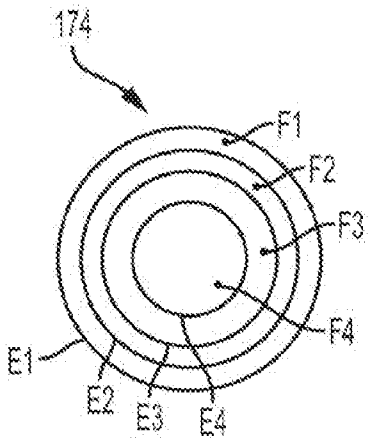


FIG. 31

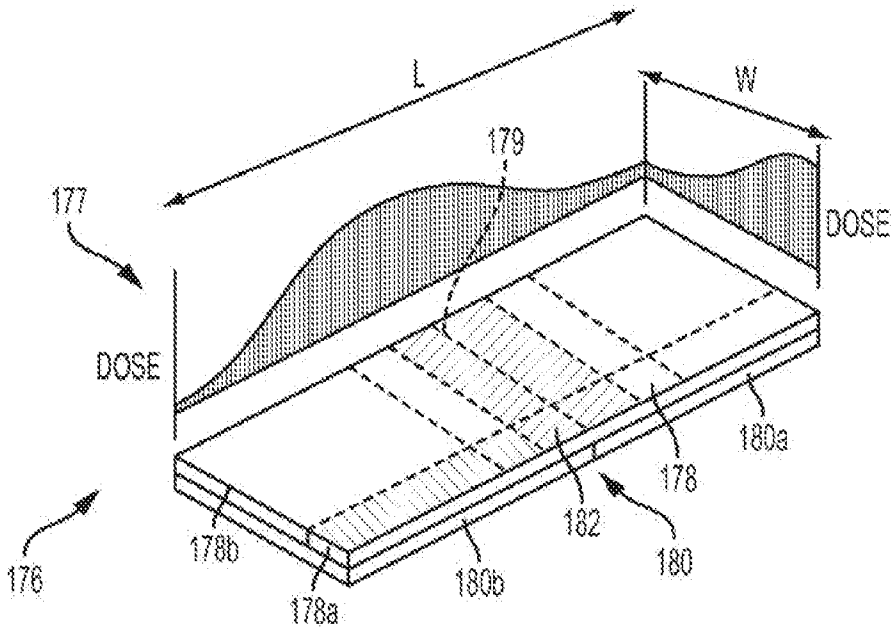


FIG. 32

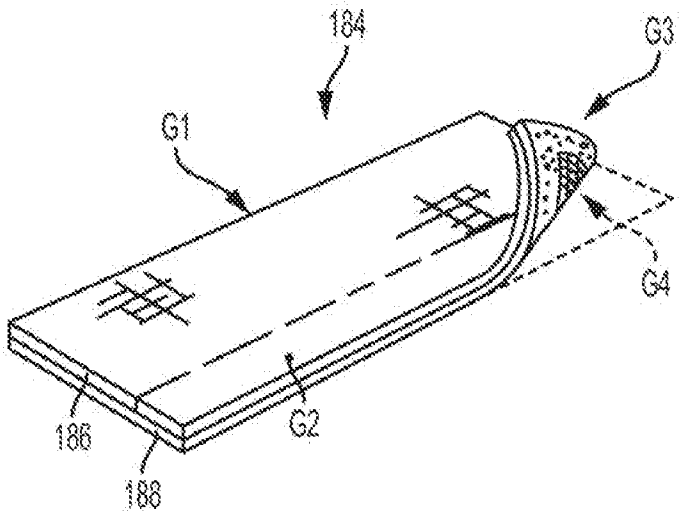


FIG. 33

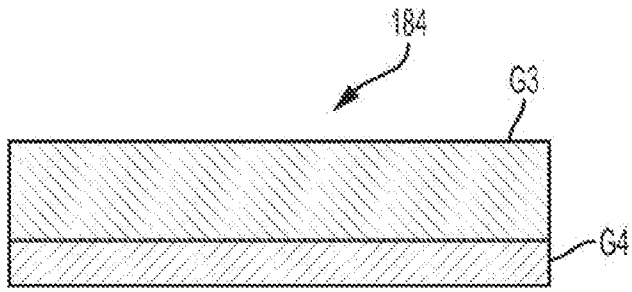


FIG. 34

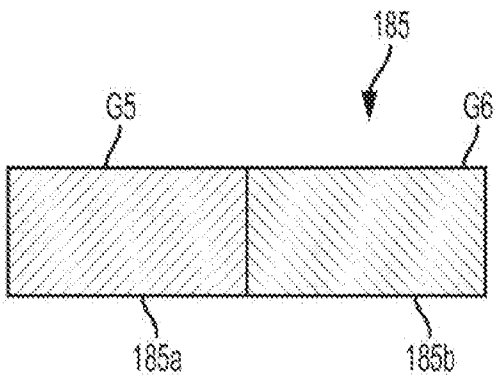


FIG. 35

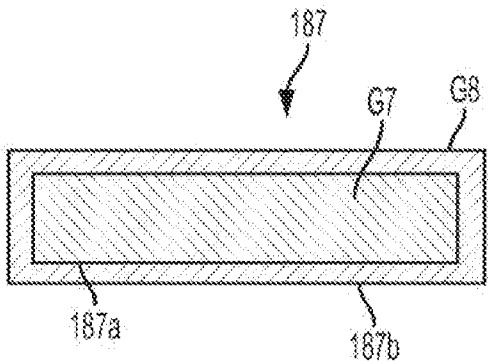


FIG. 36

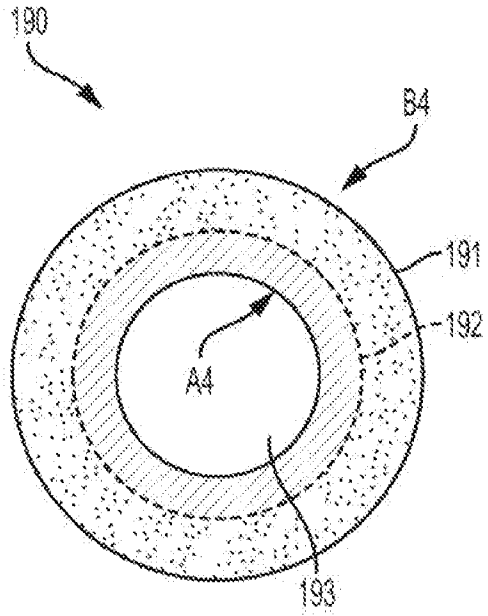


FIG. 37

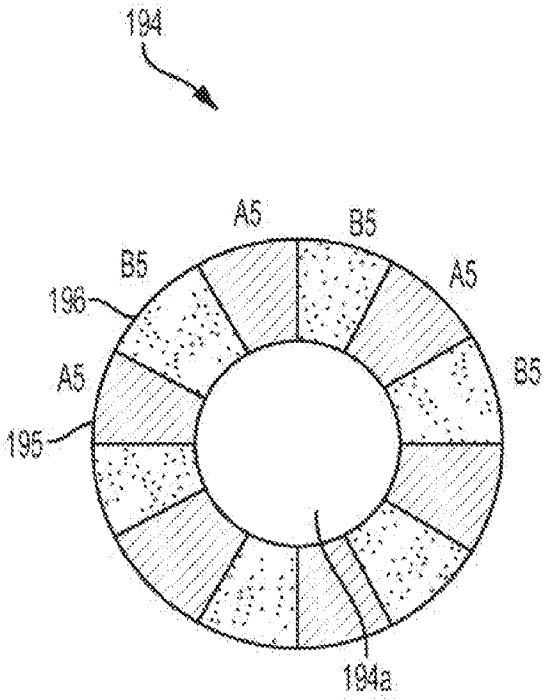


FIG. 38

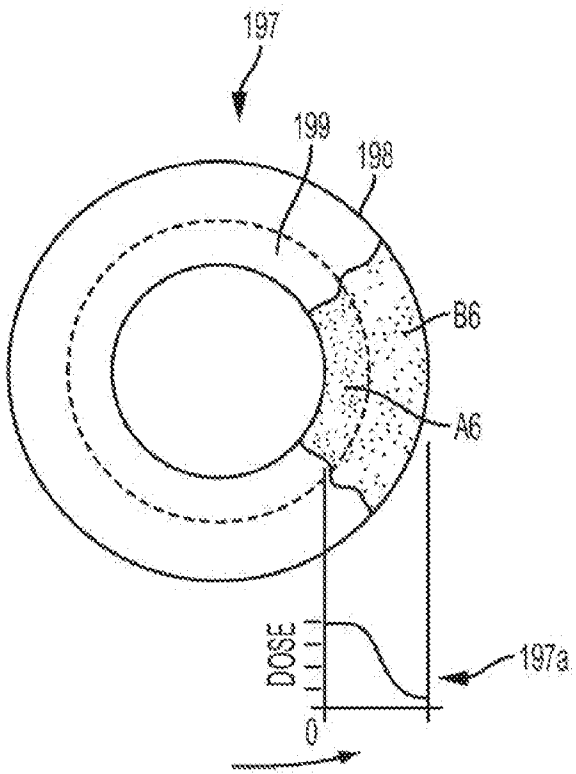


FIG. 39

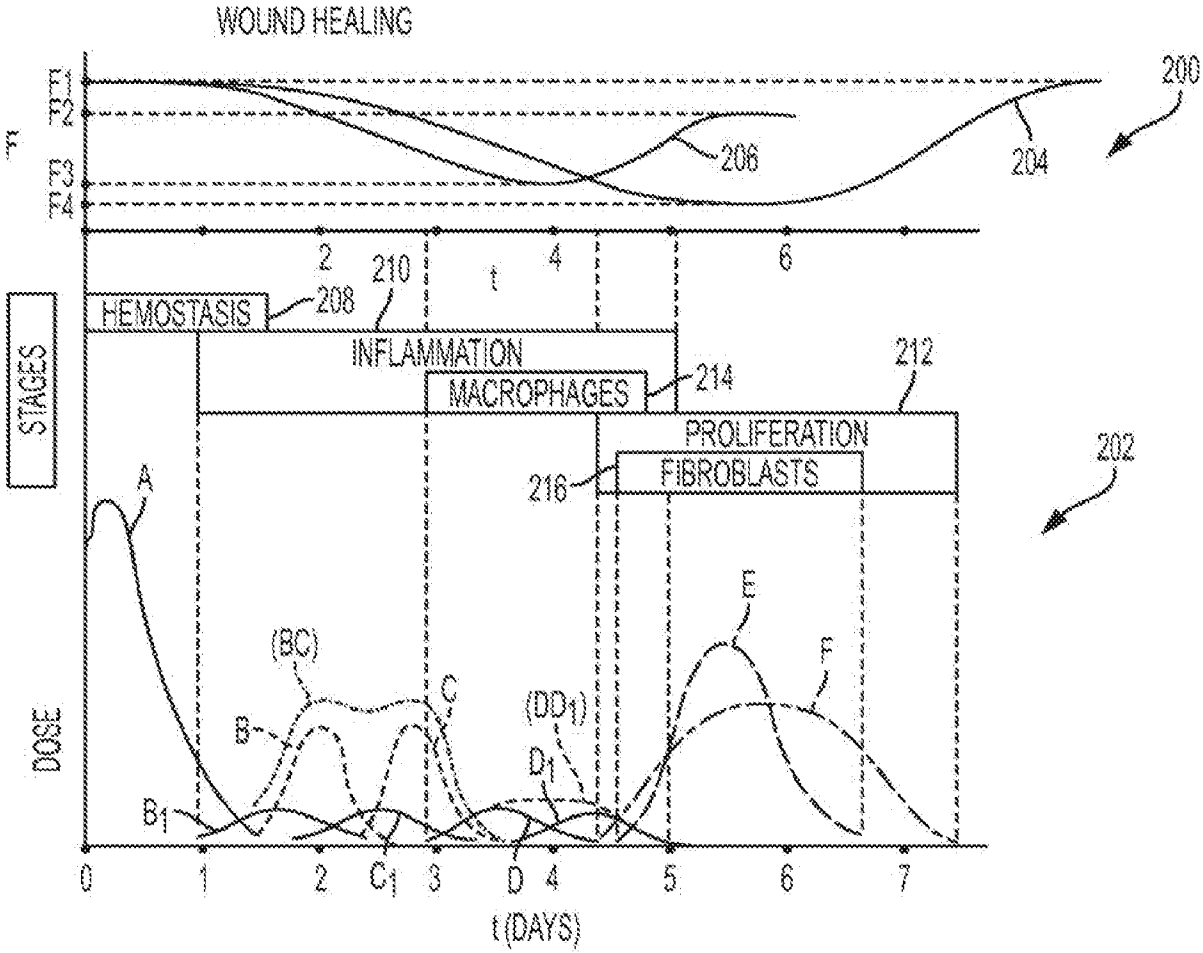

WOUND HEALING
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MACROPHAGES
214
212
PROLIFERATION
FIBROBLASTS
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FIG. 40

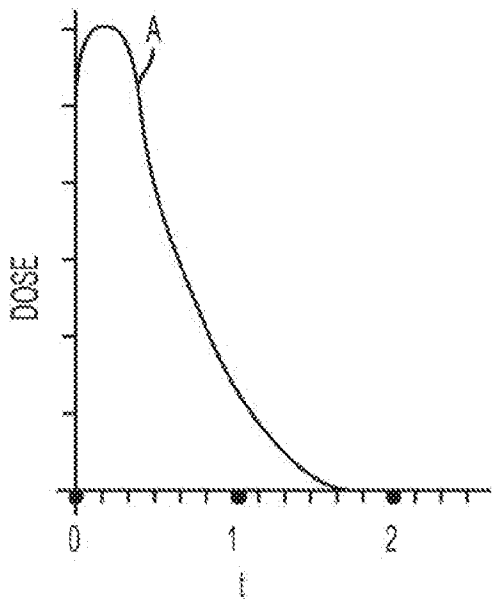

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FIG. 41

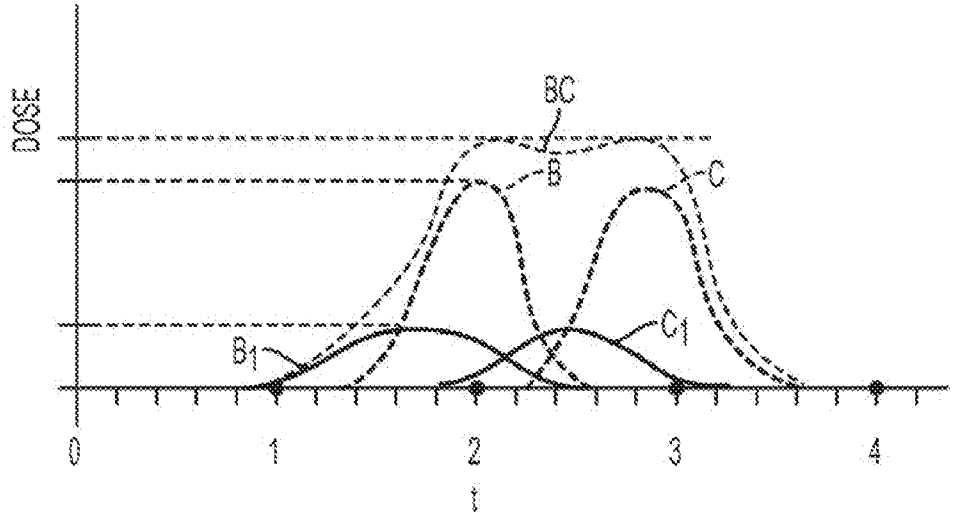


FIG. 42

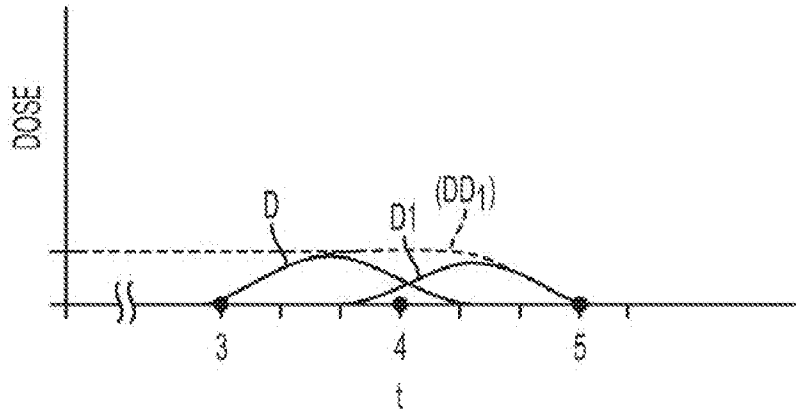


FIG. 43

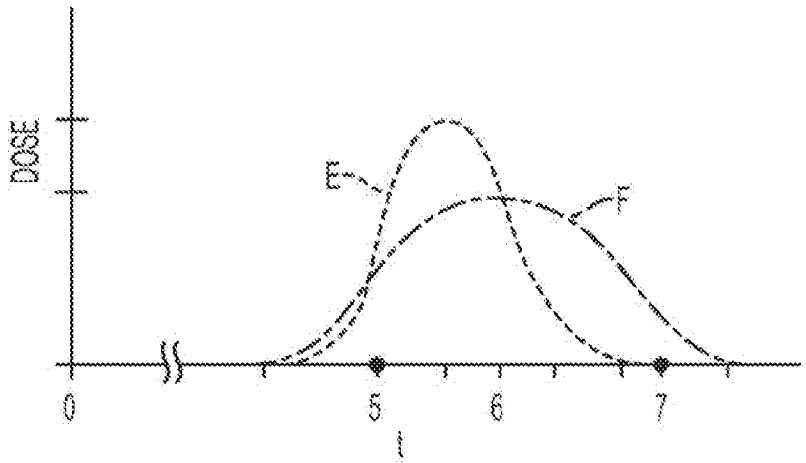


FIG. 44

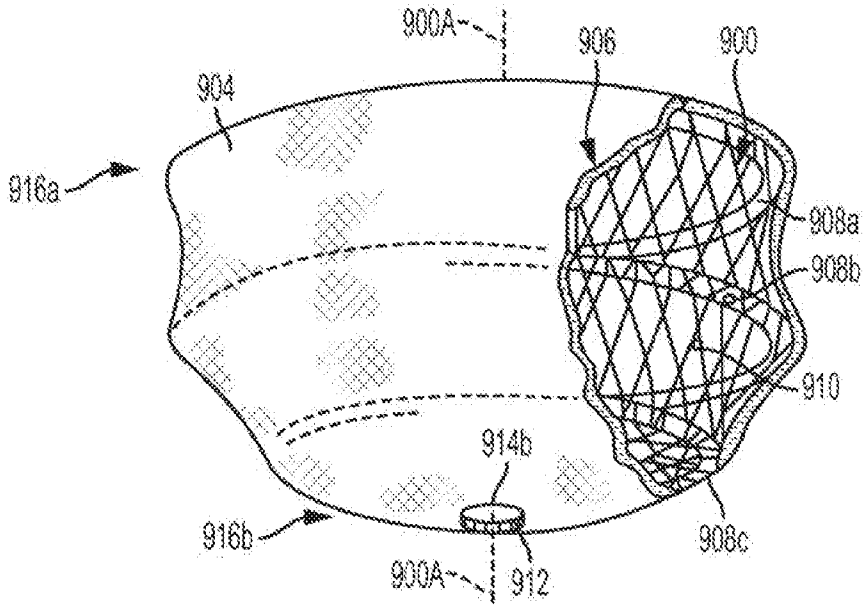

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FIG. 45

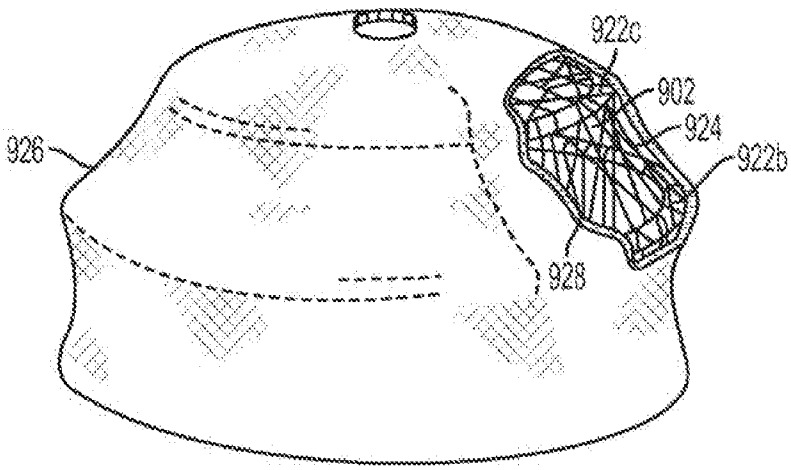

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FIG. 46

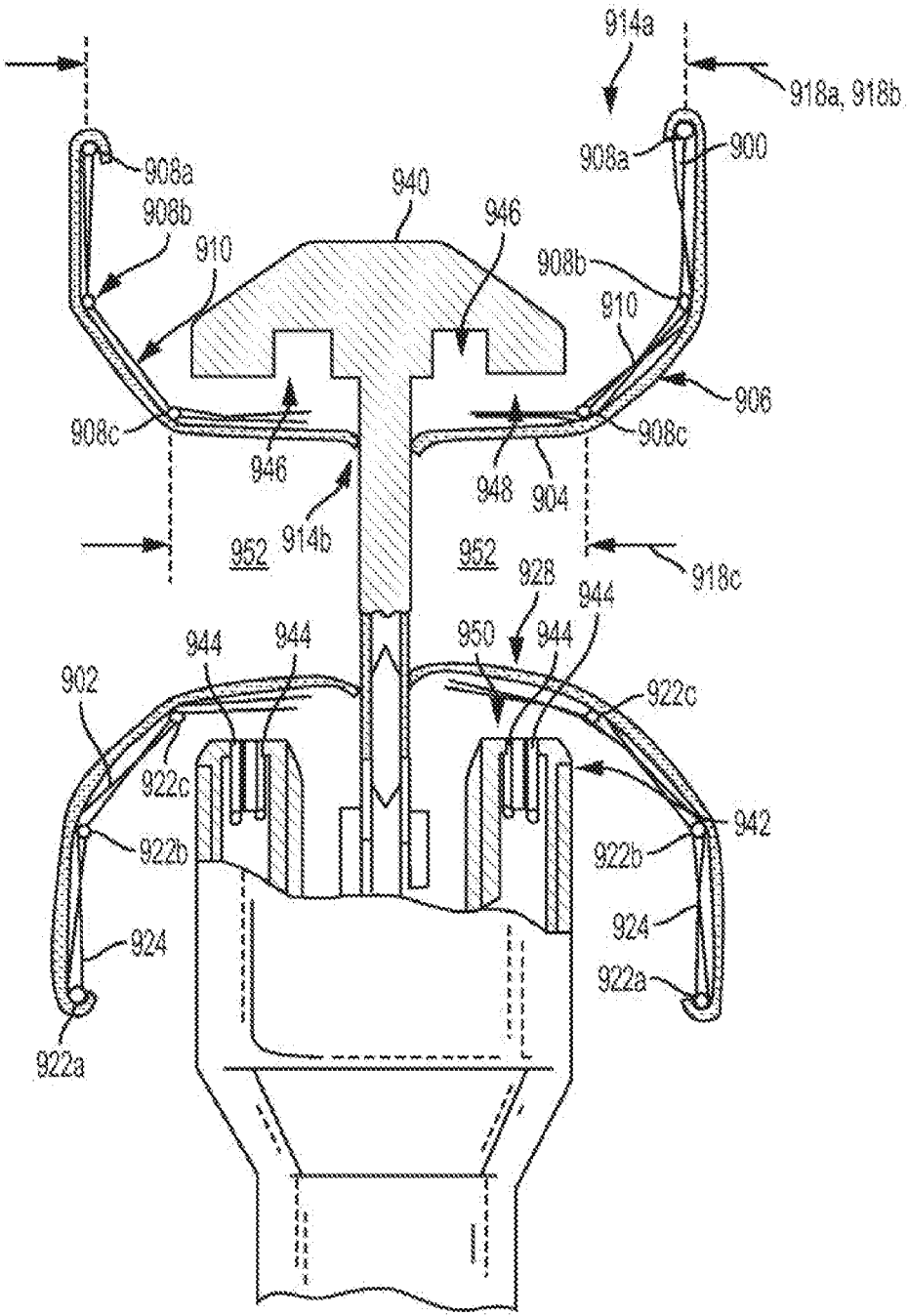

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FIG. 47

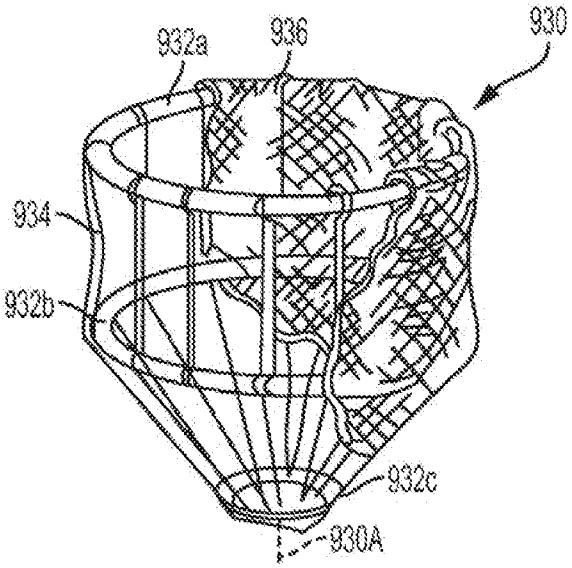

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FIG. 48

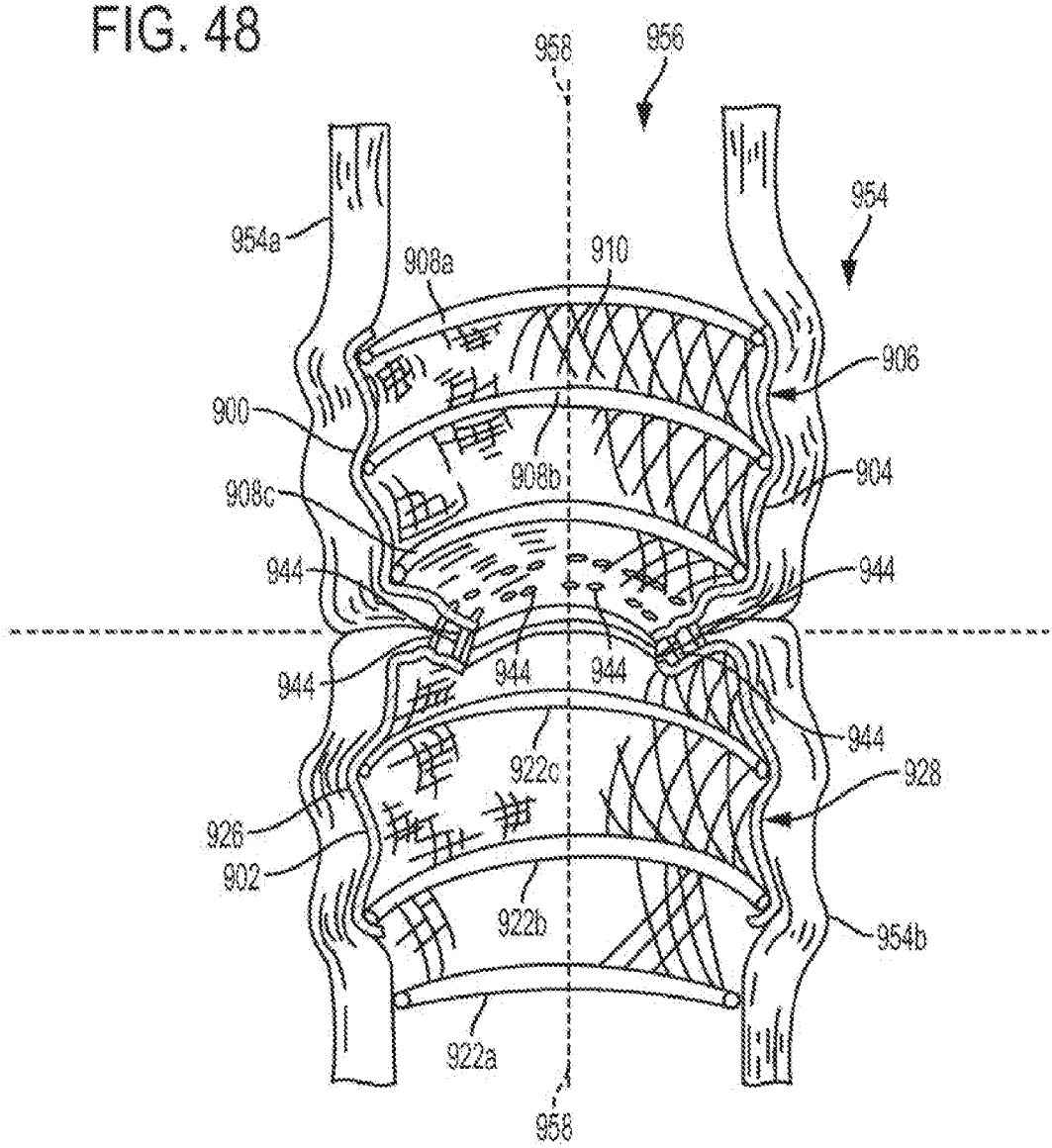

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FIG. 49

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/048606

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B17/072 A61B17/115
ADD. A61B17/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A61B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2006/044490 A2 (TYCO HEALTHCARE [US]; BETTUCHI MICHAEL [US]; FOWLER DAVID N [US]; VIOL) 27 April 2006 (2006-04-27) paragraph [0083] - paragraph [0086] paragraph [0074] - paragraph [0076]; figures 10-15	1-4,6, 11-14, 16,17
X	US 2009/043334 A1 (BAUMAN ANN M [US] ET AL) 12 February 2009 (2009-02-12) paragraph [0045] paragraph [0066] - paragraph [0068]; figures 7A-8B	1-6, 11-17
X	US 2006/108393 A1 (HEINRICH RUSSELL [US] ET AL) 25 May 2006 (2006-05-25) paragraph [0038] paragraph [0135] - paragraph [0140]; figure 28	1,11

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
24 November 2016	06/12/2016

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Strazdauskas, Gedas

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/048606

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2015/005809 A1 (AYRES BRIDGET B [US] ET AL) 1 January 2015 (2015-01-01) paragraph [0093] - paragraph [0099]; figures 1A,1C -----	1-6
X	US 2014/364941 A1 (EDMISTON DARYL R [US] ET AL) 11 December 2014 (2014-12-11) paragraph [0115] paragraph [0121]; figures 18,19 -----	1-6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2016/048606

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. [X] Claims Nos.: 7-10, 18-20
because they relate to subject matter not required to be searched by this Authority, namely:

Rule 39.1(iv) PCT - Method for treatment of the human or animal body by surgery;Rule 39.1(iv) PCT - Method for treatment of the human or animal body by therapy.

2. [ ] Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. [ ] Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. [ ] As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. [ ] As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. [ ] As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. [ ] No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

[ ] The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

[ ] The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

[ ] No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2016/048606

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