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Method of Making Sutureless Couplings for Medical Device Access to Anatomical Structures

Abstract

Methods for creating medical device access across walls of anatomical structures by providing connectors and a medical device access conduit coupled to the connectors The connectors and their variants are each characterized by having at least one mechanically active tine that are actuated by extension or compression of a mechanical mechanism linking the active tines to a frame. The mechanical mechanism may actuate by one or more of shape memory, superelastic, elastic deformation, plastic deformation, electromechanical and/or other motive mechanism operably associated with the at least one mechanically active tines and the frame to rotate the tines about a hinge region under the influence of the mechanical mechanism.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS [0001] This application is related to and claims priority to co-pending U.S. Provisional patent application Ser. No. 63/554,871, filed Feb. 16, 2024. This application is also related to co-pending U.S. patent application Ser. No. 18/458,398, filed Aug. 30, 2023, which is hereby incorporated by reference in its entirety.

BACKGROUND OF THE DISCLOSURE
[0002] The present disclosure pertains generally to methods of making sutureless connections for medical device access to anatomical structures. The connectors of the present disclosure are each characterized by having at least one mechanically active tines that are actuated by extension or compression of a mechanical mechanism linking the active tines to a frame. The mechanical mechanism may actuate by one or more of the following properties: shape memory, superelastic, elastic deformation, plastic deformation, electromechanical and/or other mechanical mechanism operably associated with the at least one mechanically active tines and the frame.
[0003] The at least one mechanically active tines are generally elongated members, optionally, having a taper along their longitudinal axis to a distal point to facilitate penetration into anatomic tissue. Each of the at least one mechanically active tines are coupled to a mechanism that is adapted to either extend or compress the at least one mechanically active tines without employing an anvil. Rather, the mechanism that is adapted to either extend or compress the at least one mechanically active tines consists generally of a support frame, at least one actuating member, and at least one tine projecting from the actuating member.
[0004] The support frame may be configured as a planar frame, a linear frame, a ring frame, an undulating frame, or a plurality of arcuate frame members adapted to form a ring. The at least one actuating member is coupled to the support frame and movable in a substantially co-planar relationship relative to the support frame. The at least one mechanically active tine is coupled to both the support frame and the at least one actuating member. The at least one mechanically active tine is configured to move in an opposite direction from movement of the at least one actuating member, e.g., the at least one mechanically active tine will move proximally as the at least one actuating member is moved distally and to move distally as the at least one actuating member is moved proximally.
[0005] Where plural mechanically active tines are provided with a common support frame, plural actuating members will also be provided with an actuating member coupled with a mechanically active tine. The plural actuating members and the plural mechanically active tines may be actuated individually or simultaneously by either axial compression or expansion of the plural actuating members.
[0006] Each actuating member, mechanically active tine coupled thereto, support frame, and associated elements, such as stabilizing members, expansive members, tension members, compression members, as hereinafter described, define a tine assembly and plural tine assemblies may be provided on a common individual support frame or on plural support frames.
[0007] In accordance with one aspect of the present disclosure, where plural mechanically active tines are employed, the mechanically active tines have a length configured such that when the mechanically active tines are fully deployed, the anatomic tissue and/or non-anatomic device is compressed between the mechanically active tine and its associated actuating member without substantial regions of uncompressed anatomic tissue and/or non-anatomic device. This results from the length of each mechanically active tine being configured to spatially abut or be spatially

adjacent to another, immediately adjacent, mechanically active tine.
[0008] Those skilled in the art will appreciate that the sutureless connector of the present disclosure functions in a manner similar to a surgical staple, however, without the necessity of an anvil to deform legs of the surgical stable. Moreover, where plural actuating members and plural mechanically active tines are provided on a common frame, each support frame carries a plurality of plural actuating members and plural mechanically active tines.
SUMMARY OF THE DISCLOSURE
[0009] It is an object of the present disclosure to provide a sutureless connector for coupling to anatomic tissue to facilitate end-to-end or end-to-side connections between anatomic tissue and/or between anatomic tissue and other non-anatomical devices.
[0010] It is a further object of the present disclosure to provide a sutureless connector for coupling to anatomic tissue that includes a frame and at least one of a plurality of mechanically tine assemblies arrayed in series on the frame.
[0011] It is another object of the present disclosure to provide a sutureless connector having at least one mechanically active tine that is adapted to allow the at least one mechanically active tine to penetrate into anatomic tissue and/or non-anatomic devices and, upon actuation of the sutureless connector to compress the at least one mechanically active tine against the anatomic tissue and/or non-anatomic device such that a portion of the anatomic tissue and/or non-anatomic device is compressed between the at least one mechanically active tine and the at least one actuating member and/or support frame of the sutureless connector.
[0012] It is a further object of the present disclosure to provide a sutureless connector having at least one mechanically active tine that is adapted to allow the at least one mechanically tine to penetrate into anatomic tissue and/or non-anatomic devices and, upon actuation of the sutureless connector to decompress the at least one mechanically active tine away from the anatomic tissue and/or non-anatomic device such that a portion of the anatomic tissue and/or non-anatomic device is released from the at least one mechanically active tine.
[0013] It is yet another object of the present disclosure to provide a sutureless connector having a frame, at least one mechanically active tine, and an actuation mechanism coupled to the frame and to the at least one mechanically active tine.
[0014] It is still another object of the present disclosure to provide a frame that is planar, curved, arcuate, or a ring structure.
[0015] It is yet another further object of the present disclosure to provide at least one mechanically active tine that is linear or arcuate and, optionally, has a taper along its longitudinal axis.
[0016] It is still another further object of the present disclosure to provide the at least one mechanically active tine with a hinge region at or proximate to a junction between a proximal end of the at least one mechanically active tine and the frame and the actuation mechanism.
[0017] It is still yet another object of the present disclosure that the frame further include a projection that joins with the hinge region of the at least one mechanically active tine.
[0018] It is a further object of the present disclosure that the projection from the frame is configured to bear a compression force upon extension of the at least one actuating member relative to the frame member and a tension force upon contraction of the at least one actuating member relative to the frame member.
[0019] It is still another object of the present disclosure that the projection from the frame is configured to bear a tension force upon extension of the at least one actuating member relative to the frame member and a compression force upon contraction of the at least one actuating member relative to the frame member.
[0020] It is still a further objective of the present disclosure that the actuating member have a projection that is configured to bear a compression force upon extension of the at least one actuating member and a tension force upon contraction of the at least one actuating member relative to the frame member.

[0021] These and other objects, features, and advantages of the present disclosure will be more apparent to those skilled in the art from the following more detailed description of the disclosure and its variants taken with reference to the accompanying figures.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] FIG. **1** is a perspective view of an end-to-end anastomosis of two anatomical lumen tissues illustrating a variant of the coupling of the present disclosure.

[0023] FIG. **2** is a perspective view of an exemplary end-to-side anastomosis of an anatomical tissue with a tubular medical graft illustrating a variant of the coupling of the present disclosure

[0024] FIG. **3** is a side elevational view of a section of a first variant of the sutureless mechanically active tine connector in accordance with the present disclosure.

[0025] FIG. **4** is a side elevational view of a section of a second variant of the sutureless mechanically active tine connector in accordance with the present disclosure.

[0026] FIG. **5** is a side elevational view of a section of a third variant of the sutureless mechanically active tine connector in accordance with the present disclosure.

[0027] FIG. **6** is a side elevational view of a section of a fourth variant of the sutureless mechanically active tine connector in accordance with the present disclosure.

[0028] FIG. **7** is a side elevational view of a section of a fifth variant of the sutureless mechanically active tine connector in accordance with the present disclosure.

[0029] FIG. **8** is a side elevational view of a section of a sixth variant of the sutureless mechanically active tine connector in accordance with the present disclosure.

[0030] FIG. **9** is a side elevational view of a section of a seventh variant of the sutureless mechanically active tine connector in accordance with the present disclosure.

[0031] FIG. **10** is a side elevational view of a section of an eighth second variant of the sutureless mechanically active tine connector in accordance with the present disclosure.

[0032] FIG. **11** is a side elevational view of a section of a ninth variant of the sutureless mechanically active tine connector in accordance with the present disclosure.

[0033] FIG. **12** is a side elevational view of a section of a tenth variant of the sutureless mechanically active tine connector in accordance with the present disclosure.

[0034] FIG. **13** is a side elevational view of a section of an eleventh variant of the sutureless mechanically active tine connector in accordance with the present disclosure.

[0035] FIG. **14** is a side elevational view of a section of a twelfth variant of the sutureless mechanically active tine connector in accordance with the present disclosure.

[0036] FIG. **15** is a side elevational view of a section of a thirteenth variant of the sutureless mechanically active tine connector in accordance with the present disclosure.

[0037] FIG. **16** is a side elevational view of a section of a fourteenth variant of the sutureless mechanically active tine connector in accordance with the present disclosure.

[0038] FIG. **17** is a side elevational view of a section of a fifteenth variant of the sutureless mechanically active tine connector in accordance with the present disclosure.

[0039] FIG. **18** is a first variant of a mechanically active tine staple connector in accordance with the present disclosure.

[0040] FIG. **19** is a side elevational view of second variant of a mechanically active tine staple connector in accordance with the present disclosure.

[0041] FIG. **20** is a side elevational view of a third variant of a mechanically active tine staple connector in accordance with the present disclosure.

[0042] FIG. **21** is a photograph illustrating pre-compression testing a variant of the sutureless mechanically active tine connector connected to a surface of artificial tissue through a piece of polytetrafluoroethylene felt.

[0043] FIG. **22** is a photograph illustrating the tines passing through the opposite surface of the artificial tissue depicted in FIG. **21**.

[0044] FIG. **23** is a photograph illustrating post-compression testing of the variant of the sutureless mechanically active tine connector embedded into a surface of artificial tissue through a piece of polytetrafluoroethylene felt.

[0045] FIG. **24** is a photograph illustrating the tines fully deployed and passing through the opposite surface of the artificial tissue depicted in FIG. **23**.

[0046] FIG. **25** is a perspective view of a mechanically active tine connector ring in accordance with the present disclosure.

[0047] FIG. **26** is a perspective view of a single unit mechanically active tine connector of the mechanically active tine connector ring of FIG. **25**.

[0048] FIG. **27** is a plan view of an everting connector ring in accordance with the present disclosure.

[0049] FIG. **28** is a perspective view of a variant of an everting connector ring in accordance with the present disclosure.

[0050] FIG. **29** is a perspective view of a single ring frame member variant of the sutureless mechanically active tine connector in accordance with the present disclosure.

[0051] FIG. **30** is a perspective view of a dual ring frame member variant of the sutureless mechanically active tine connector in accordance with the present disclosure.

DETAILED DESCRIPTION

[0052] For purposes of clarity, the following terms used in this patent application will have the following meanings:

[0053] The terminology used herein is for the purpose of describing example variants only and is not intended to be limiting. As used herein, the singular forms “a,” “an,” and “the” may be intended to include the plural forms as well, unless the context clearly indicates otherwise. The terms “comprises,” “comprising,” “including,” and “having,” are inclusive and therefore specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof. The method steps, processes, and operations described herein are not to be construed as necessarily requiring their performance in the order discussed or illustrated, unless specifically identified as an order of performance. It is also to be understood that additional or alternative steps may be employed.

[0054] When an element or layer is referred to as being “on,” “engaged,” “connected,” or “coupled” to or with another element, it may be directly on, engaged, connected, or coupled to the other element or layer, or intervening elements or layers may be present. In contrast, when an element is referred to as being “directly on,” “directly engaged to,” “directly connected to,” or “directly coupled to” or with another element or layer, there may be no intervening elements or layers present. Other words used to describe the relationship between elements should be interpreted in a like fashion (e.g., “between” versus “directly between,” “adjacent” versus “directly adjacent,” etc.). As used herein, the term “and/or” includes any and all combinations of one or more of the associated listed items.

[0055] Although the terms first, second, third, etc. may be used herein to describe various elements, components, regions, layers and/or sections, these elements, components, regions, layers and/or sections should not be limited by these terms. These terms may distinguish one element, component, region, layer or section from another region, layer, or section. Terms such as “first,” “second,” and other numerical terms when used herein do not imply a sequence or order unless clearly indicated by the context. Thus, a first element, component, region, layer, or section discussed below could be termed a second element, component, region, layer, or section without departing from the teachings of the example variants.

[0056] Spatially relative terms, such as “inner,” “outer,” “beneath,” “below,” “lower,” “above,” “upper,” and the like, may be used herein for ease of description to describe one element or feature's relationship to another element(s) or feature(s) as illustrated in the figures. Spatially relative terms may be intended to encompass different orientations of the device in use or operation in addition to the orientation depicted in the figures. For example, if the device in the figures is turned over, elements described as “below”, or “beneath” other elements or features would then be oriented “above” the other elements or features. Thus, the example term “below” can encompass both an orientation of above and below. The device may be otherwise oriented (rotated 90 degrees or at other orientations) and the spatially relative descriptors used herein interpreted accordingly.
[0057] “Substantially” is intended to mean a quantity, property, or value that is present to a great or significant extent and less than, more than or equal to total. For example, “substantially vertical” may be less than, greater than, or equal to completely vertical.
[0058] “About” is intended to mean a quantity, property, or value that is present at ±10%. Throughout this disclosure, the numerical values represent approximate measures or limits to ranges to encompass minor deviations from the given values and variants having about the value mentioned as well as those having the precise value mentioned. Other than in the working examples provided at the end of the detailed description, all numerical values of parameters (e.g., of quantities or conditions) in this specification, including the appended claims, are to be understood as being modified in all instances by the term “about” whether or not “about” actually appears before the numerical value. “About” indicates that the stated numerical value allows some slight imprecision (with some approach to exactness in the value; approximately or reasonably close to the value; nearly). If the imprecision provided by “about” is not otherwise understood in the art with this ordinary meaning, then “about” as used herein indicates at least variations that may arise from ordinary methods of measuring and using such parameters. In addition, disclosure of ranges includes disclosure of all values and further divided ranges within the entire range, including endpoints given for the ranges.
[0059] The use of the terms “a” and “an” and “the” and similar referents in the context of describing the disclosure are to be construed to cover both the singular and the plural, unless otherwise indicated herein or clearly contradicted by context. It will be further understood that the terms “comprises,” “comprising,” “includes,” and/or “including,” when used herein, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.
[0060] Recitation of ranges of values herein are merely intended to serve as a shorthand method of referring individually to each separate value falling within the recited range, unless otherwise indicated herein, and each separate value is incorporated into the specification as if it were individually recited herein.
[0061] References to “variant” or “variant”, e.g., “one variant,” “an variant,” “example variant,” “various variants,” etc., may indicate that the variant(s) or variant(s) of the disclosure so described may include a particular feature, structure, or characteristic, but not every variant necessarily includes the particular feature, structure, or characteristic. Further, repeated use of the phrase “in one variant,” or “in an exemplary variant,” do not necessarily refer to the same variant or variant, although they may.
[0062] As used herein the term “method” refers to manners, means, techniques and procedures for accomplishing a given task including, but not limited to, those manners, means, techniques and procedures either known to, or readily developed from known manners, means, techniques and procedures by practitioners of the chemical, pharmacological, biological, biochemical, and medical arts. Unless otherwise expressly stated, it is in no way intended that any method or aspect set forth herein be construed as requiring that its steps be performed in a specific order. Accordingly, where a method claim does not specifically state in the claims or descriptions that the steps are to be

limited to a specific order, it is in no way intended that an order be inferred, in any respect. This holds for any possible non-express basis for interpretation, including matters of logic with respect to arrangement of steps or operational flow, plain meaning derived from grammatical organization or punctuation, or the number or type of aspects described in the specification.

[0063] The terms “configured to” or “adapted to” are used synonymously and are intended to mean that a recited structure is intended to perform a particular recited function or assume a particular recited configuration and is not merely capable thereof.

[0064] The terms “proximal” or “distal” are intended to be relative positional references and are used with reference either to a direction of blood flow relative to a device or device component or with reference to a longitudinal axis of a device or device component. For example, with reference to the connector of the present disclosure, the proximal end of the connector refers to a portion of the connector away from the tissue being connected and the distal end of the connector refers to a portion of the connector closest to the tissue being connected.

[0065] The term “ring” is intended to refer to a structure or structures that are configured to subtend substantially a 360-degree arc and may be a single continuous structure or plural arcuate structures. A ring may have a circular or non-circular profile, e.g., elliptical, oval, kidney-shaped, or the like.

[0066] The term “graft” is intended to refer to any type of tubular structure and may be comprised of polymeric, biological, composite, or metal materials.

[0067] The term “anatomic tissue” is intended to refer to any anatomic structure within a mammalian body.

[0068] The term “anatomic passageway” is intended to refer to any anatomical structure having a lumen. Examples of anatomic passageways are blood vessels, the gastrointestinal track, including the esophagus, stomach, small intestine, large intestine, and rectum, or airway passages, such as the trachea and bronchi.

[0069] The terms “major vessel” and/or “aorta” as used herein reference specific and non-limiting examples of anatomic passageways. It is intended that the terms “anatomic passageway,” “major vessel,” and/or “aorta” are used interchangeably and synonymously.

[0070] The term “flange” is intended to refer to any type of radially extending projection, including, without limitation, a projection that extends less than or equal to 360 degrees relative to the element that the projection extends from. Further, a flange may have a longitudinal component to its projection orientation relative to the element that the projection extends from.

[0071] The term “operably coupled” is intended to mean that a first element or elements are coupled to a second element or other elements in a manner in which the first element(s) acts upon the second element(s) to cause the second element(s) to operate, e.g., move, in some defined manner.

[0072] The term “mechanically active” is intended to refer to a mechanism by which the at least one tine is either contracted or extended about a longitudinal axis of the at least one tine by virtue of the at least one tine and/or elements cooperating with or acting upon the at least one tine having shape memory, superelastic, elastic, and/or plastic deformation properties.

[0073] This detailed description of exemplary variants references the accompanying drawings, which show exemplary variants by way of illustration. While these exemplary variants are described in sufficient detail to enable those skilled in the art to practice the disclosure, it should be understood that other variants may be realized and that logical changes and adaptations in design and construction may be made in accordance with this disclosure and the teachings herein without departing from the spirit and scope of the disclosure. Thus, the detailed description herein is presented for purposes of illustration only and not for purposes of limitation.

[0074] Turning now to the accompanying Figures in which there are illustrated exemplary variants of the connector of the present disclosure. FIG. **1**A depicts a conventional method of a sutured end-to-end anastomosis of two anatomical vessels. Such sutured anastomosis is typically conducted with one or more continuous uninterrupted suture(s) about the circumference of both anatomical vessels being coupled. As shown in FIG. **1**B and FIG. **1**C, the connector **100** of the present disclosure, together with its variants, is suitable for use in an end-to-end anastomosis **4** or an end-to-end anastomosis with eversion of the ends of the anatomical vessels **6**.

[0075] The connector **100**, and its variants, is also capable of use as an end-to-side anastomosis connector as illustrated in FIG. **2**A and FIG. **2**B. An exemplary use of connector **100** is in forming an end-to-side anastomosis with the aorta **11**. As is described in greater detail in co-pending U.S. patent application Ser. No. 18/458,398, filed Aug. 30, 2023, which is hereby incorporated by reference in its entirety, the connector **100** is coupled to a graft **12** and a plurality of mechanically active tines **106** extend into and through a hemostatic ring **14**, such as a polytetrafluoroethylene felt ring. When brought into approximation with anatomical tissue, the mechanically active tines **106** penetrate into the anatomic tissue and draw the graft **12** and the connector **100** distally into connection with the anatomic tissue with the hemostatic ring **14** abutting the anatomic tissue and the mechanically active tines embedded into the anatomic tissue. As noted, the anatomic tissue may be, for example, a major blood vessel, e.g., the aorta **11**, as illustrated in FIG. **2**B. Alternatively, the anatomic tissue may be a peripheral blood vessel, skin, an anatomic passageway, or other anatomic tissue or non-anatomic tissue, such as another synthetic graft. In this manner, the graft **12** will serve as a conduit for fluid flow or access through a lumen of the graft **12** and into the anatomic or non-anatomic tissue to which it is attached via connector **100**, or its variants described herein.

[0076] Thus, those skilled in the art will understand and appreciate that the connector **100** and its variants of the present disclosure are configured for making end-to-end and/or end-to-side connections, including, without limitations, end-to-end anastomosis and/or end-to-side anastomosis of anatomic tissues. Further, where an end-to-end anastomosis is desired, the anastomosis may be a butt-end anastomosis or an everted anastomosis in which one or both ends of the tissue being joined are everted to form a flange that is then joined together, such as is illustrated in FIGS. **1**B and **1**C.

[0077] The variants of connector **100** of the present disclosure generally include mechanically active tine rings, mechanically active serpentine tine rings, mechanically active tine staples, and/or mechanically active everting tine rings as depicted in the accompanying Figures and described herein. It is expressly intended and contemplated that the hereinafter described elements of each of the variants of connector **100** are to be considered interchangeable with one another and/or may be assembled in different configurations such that the functionality of each variant is preserved. For example, the configurations or geometries of the expansive members, the stabilizing members, the tension members, the compression members, the actuating members, may all be varied consistent with their intended operation and function as components of the hereinafter described tine assemblies and the connector variants.

[0078] Turning now to the specific variants of connector **100** illustrated in the accompanying Figures, a first connector variant **100** consists generally of a frame **102** that defines a ring or a linear or planar structure, an actuating member **104**, and a tine **106**. The tine **106** is operably coupled to the actuating member **104** by a first projection **108** extending from the actuating member **104**. The tine **106** is also operably coupled to the frame **102** by a second projection **109** that extends from the frame. The tine **106** further has a hinge region **107** at a proximal end of the tine **106** that is coupled to both the first projection **108** and the second projection **109**. The hinge region **107** is configured to act as a fulcrum to allow the tine **106** to traverse an arcuate path proximally and/or distally relative to the frame **102**. An opening **111** separates the first projection **108** from the second projection **109** and terminates at or proximate to the hinge region **107** of the tine **106**. Opening **111** is generally along a longitudinal axis L of the connector **100**. Optionally, a strain relief opening **110** is provided in the hinge region **107** and at the distal end of the opening **111**. Strain relief opening **110** is configured to distribute bending stress and strain forces at the hinge region **107** and tension and compression forces acting on the first projection **108** and the second projection **109** as the tine **106** moves proximally or distally relative to the frame **102**.

[0079] Actuating member **104** is operably coupled to the frame and is configured to translate proximally and distally relative to the frame member **102** along longitudinal axis L. In connector **100**, the actuating member **104** includes a main body **101**, at least one stabilizing member **115**, and at least one expansive member **103**. The main body **101** may, optionally, have a recess or opening **112** configured to receive an engagement portion of a delivery device (not shown) that engages with the recess or opening **112** to translate the main body **101** proximally and/or distally relative to the frame **102**.

[0080] The at least one stabilizing member **115** comprises a deformable member that projects laterally on one end thereof, from the second projection **109** extending from frame **102**. At an opposite end of the deformable member of the at least one stabilizing member **115**, the deformable member connects with the main body **101**. Thus, the at least one stabilizing member **115** extends between the second projection **109** and the main body **101** on a first portion **101***a* of the main body **101**. The at least one stabilizing member **115** may be linear, curvilinear, or have simple or complex curves along its length.

[0081] At a second portion **101***b* of the main body **101**, the at least one expansive member **103** connects to the main body **101** and the frame **102**. The first portion of the main body **101** and the second portion of the main body **101** are preferably located at opposite aspects of the main body **101**. In this manner, translation of the main body **101** along a longitudinal axis of the connector **100**, either proximally or distally relative to the frame **102**, is stabilized by the at least one stabilizing member **115** and the expansive member **103**. Further, in this manner, the main body exerts a linear force to the first projection **108** that is substantially parallel to the longitudinal axis of the connector **100**. The linear force exerted by the first projection **108** acts at the hinge region **107** to deflect the tine **106**. In this manner, either proximal or distal movement of the main body **101** deflects the tine **106** either proximally or distally, respectively.

[0082] The at least one expansive member **103** may have a myriad of configurations, provided that it is configured to expand and/or contract along the longitudinal axis of the connector **100**. The at least one expansive member **103** may be a single generally V-shaped, U-shaped, hemi-elliptical, semi-circular, or similar shapes. Alternatively, the at least one expansive member **103** may be generally V-shaped, U-shaped, hemi-elliptical, semi-circular, or similar shapes, arranged in series or in parallel.

[0083] It is important to note that when the main body **101** is translated proximally relative to the frame **102**, the first projection **108** is in a state of compression and the second projection **109** is in a state of tension, thereby allowing the tine **106** to rotate about the hinge region **107** in a proximal direction. Conversely, when the main body **101** is translated distally relative to the frame **102**, the first projection **108** is in a state of tension and the second projection **109** is in a state of compression, thereby allowing the tine to rotate about the hinge region **107** in a distal direction. As the tine **106** rotates in a proximal direction, the tine **106** will compress anatomic tissue into which the tine **106** is embedded against the main body **101** and the frame **102**. Whereas as the tine **106** rotates in a distal direction, the tine **106** will decompress the anatomic tissue into which the tine **106** is embedded and allow for release or removal of the connector **100** from the anatomic tissue. FIGS. **21-24** illustrate this functionality.

[0084] Connector **100**, and each of its variants, may be made entirely or partially of an elastically or plastically deformable material, such as, for example, stainless steel, cobalt-chromium alloys, a shape memory or superelastic material, such as nickel-titanium based alloys, polymers, or combinations thereof, or may be made of bioresorbable polymeric materials.

[0085] Variants of connector **100** are depicted in FIGS. **4** to **19** and each embodies the same fundamental functional principals as connector **100** described above. That is, each variant has a frame, at least one actuating member, at least one stabilizing member, at least one expansive member, a first projection extending distally from the frame, a second projection extending distally

from the at least one actuating member, and at least one tine projecting from both the first projection and the second projection, with the at least one tine having a hinge region. Moreover, in each of the variants of connector **100**, there is provided a variant of the first projection **108** and the second projection **109** that act to carry compression and/or tension forces as the variant of the actuating member **104** is moved proximally and or distally relative to the variant of the frame **102**.
[0086] Each of the variants of connector **100** may consist of either a single tine assembly **100**A or plural tine assemblies **100**A coupled to the frame. Each tine assembly of each variant includes at least one expansive member, an actuating member, optionally, at least one stabilizing member, a first projection extending distally from the frame, a second projection extending distally from the at least one actuating member, and at least one tine projecting from both the first projection and the second projection, with the at least one tine having a hinge region at its juncture with the first projection and/or the second projection.
[0087] Turning to FIG. **4**, a first connector variant **120** is illustrated. First connector variant **120** comprises a frame **122**, which optionally, may have at least one of a plurality of openings **133** passing therethrough. Like connector **100**, first connector variant **120** may include one or more tine assemblies **120**A, with each tine assembly **120**A including at least one expansive member **123**, at least one actuating member **124**, at least one stabilizing member **135** extending between the frame **122** and the at least one actuating member **124**, an optional opening **132** passing through the at least one actuating member **124**, at least one tine **126**. The at least one tine **126** may be helically oriented in either a clockwise or counterclockwise direction relative to the longitudinal axis of the connector **120**. The at least one time **126** is operably connected to both the frame **122** and to the at least one actuating member **124**, and a hinge region **127** at a proximal aspect of the at least one tine **126**. The at least one tine **126** is preferably tapered distally to a tapered end **125** that assists in penetrating into anatomic tissue. A first projection **128** extends distally from the at least one actuating member **124** and is connected to the hinge region **127** of the at least one tine **126**. A second projection **129** extends distally from the frame **122** and is also connected to the hinge region **127** of the at least one tine **126**. An opening **131** separates the first projection **128** and the second projection **129**. Optionally, opening **131** terminates in a strain relief section **130** at the hinge region **127** of tine **126**.
[0088] The at least one stabilizing member **135** comprises a deformable member that projects laterally on one end thereof, from the second projection **129** extending from frame **122**. At an opposite end of the deformable member of the at least one stabilizing member **135**, the at least one stabilizing member connects with a first portion **121***a* of the main body **121**. Thus, the at least one stabilizing member **135** extends between the second projection **129** and the main body **121** and joins the first portion **121***a* of the main body **121**. The at least one stabilizing member **135** may be linear, curvilinear, or have simple or complex curves along its length.
[0089] At a second portion **121***b* of the main body **101**, the at least one expansive member **123** connects to the main body **121** and the frame **122**. The first portion of the main body **121***a* and the second portion of the main body **121***b* are preferably located at opposite aspects of the main body **121**. In this manner, translation of the main body **121** along a longitudinal axis of the connector **120**, either proximally or distally relative to the frame **122**, is stabilized by the at least one stabilizing member **135** and the expansive member **123**. This arrangement stabilizes the main body **121** and allows the longitudinal translation of both the first portion **121***a* and the second portion **121***b* of the main body to move evenly along the longitudinal axis L. Further, in this manner, the main body exerts a linear force to the first projection **128** that is substantially parallel to the longitudinal axis of the connector **120**. The linear force exerted by the first projection **128** acts at the hinge region **127** to deflect the tine **126**. In this manner, either proximal or distal movement of the main body **121** deflects the tine **126** either proximally or distally, respectively.
[0090] As indicated above, the first projection **128** and the second projection **129** are configured to carry compression and/or tension forces as the at least one actuating member **124** is moved

proximally and or distally relative to the frame **122** and rotates the at least one tine **126** either proximally or distally about the hinge region **127**.

[0091] Frame **122** may also be configured as a ring or a linear or planar structure and be provided with plural first projections **128**, second projections **129**, actuating members **124**, and tines **126**.

[0092] FIG. **5** illustrates a second variant of connector **140** of the present disclosure. Connector **140** is virtually identical to connector **120** of FIG. **4**, with the exception that the at least one stabilizing member **155** has a sinusoidal shape as opposed to the curvilinear shape of the at least one stabilizing member **135** of connector **120**. Otherwise, the connector **140** includes the same functionality and structural elements as connector **120** and consists of one or more tine assemblies **140**A including a frame **142** defining a ring or a linear or planar structure, an actuating member **144**, and at least one tine **146**. The at least one tine **146** may be helically oriented in either a clockwise or counterclockwise direction relative to the longitudinal axis of the connector **140**. The at least one tine **146** is operably coupled to the actuating member **144** by a first projection **148** extending from the actuating member **144**. The at least one tine **146** is also operably coupled to the frame **142** by a second projection **149** that extends from the frame. The tine **146** further has a hinge region **147** at a proximal end of the tine **146** that is coupled to both the first projection **148** and the second projection **149**. The hinge region **147** is configured to act as a fulcrum to allow the tine **146** to traverse an arcuate path proximally and/or distally relative to the frame **142**. An opening **151** separates the first projection **148** from the second projection **149** and terminates at or proximate to the hinge region **147** of the tine **146**. Optionally, a strain relief opening **150** is provided in the hinge region **147** and at the distal end of the opening **151**. Strain relief opening **150** is configured to distribute bending stress and strain forces at the hinge region **147** and tension and compression forces acting on the first projection **148** and the second projection **149** as the tine **146** moves proximally or distally relative to the frame **142**.

[0093] Turning to FIG. **6**, a third connector variant **160** is illustrated. Second connector variant **160** is similar to connector **100**, except that at least two expansive members **163** are provided and arranged in parallel. The at least two expansive members **163** have their vertices oriented in opposite directions relative to the frame **162** and also expand along a longitudinal axis of the frame **162**. The at least two expansive members **163** are each joined with the frame **162** on first end thereof and to an actuating member **164** at a second end thereof. The juncture **161***c* of the at least two expansive members **163** with the frame **162** is positioned at a point between the first portion **161***a* and the second portion **161***b* of the actuating member **164**. As with other variants of connector **100**, at least one stabilizing member **175** is provided that extends laterally from a second projection **169** from frame **162** and joins with the actuating member **164** at or proximate to the first portion **161***a* of the at least one actuating member **164**.

[0094] An optional opening may be provided that passes through the at least one actuating member **164**. The at least one tine **166** operably connected to both the frame **162** and to the at least one actuating member **164**. The at least one tine **166** may be helically oriented in either a clockwise or counterclockwise direction relative to the longitudinal axis of the connector **160**. The at least one tine **166** has a hinge region **167** at a proximal aspect of the at least one tine **166**. The at least one tine **166** is preferably tapered distally to a tapered end **165** that assists in penetrating into anatomic tissue. The first projection **168** extends distally from the at least one actuating member **164** and is connected to the hinge region **167** of the at least one tine **166**. A second projection **169** extends distally from the frame **162** and is also connected to the hinge region **167** of the at least one tine **166**. An opening **171** separates the first projection **168** and the second projection **169** along longitudinal axis L. Optionally, opening **171** terminates in a strain relief section **170** at the hinge region **167** of tine **166**.

[0095] The at least one stabilizing member **175** comprises a deformable member that projects laterally on one end thereof, from the second projection **169** extending from frame **162**. At an opposite end of the deformable member of the at least one stabilizing member **175**, the at least one stabilizing member **175** connects with a first portion **161***a* of the actuating member **164**. Thus, the at least one stabilizing member **175** extends between the second projection **169** and the actuating member **164** and joins to the first portion **161***a* of the actuating member **164**.

[0096] It will be appreciated by those skilled in the art that longitudinal translation of the main body **164** along a longitudinal axis L of the connector **160**, either proximally or distally relative to the frame **162**, is stabilized by the at least one stabilizing member **175** and the at least two expansive members **163**. Further, in this manner, the actuating member **164** exerts a linear force to the first projection **168** that is substantially parallel to the longitudinal axis L of the connector **160**. The linear force exerted by the first projection **168** acts at the hinge region **167** to deflect the tine **166**. In this manner, either proximal or distal movement of the actuating member **164** deflects the tine **166** either proximally or distally, respectively, relative to the frame **162**.

[0097] As indicated above, the first projection **168** and the second projection **169** are configured to carry compression and/or tension forces as the at least one actuating member **164** is moved proximally and or distally relative to the frame **162** and rotates the at least one tine **166** either proximally or distally about the hinge region **167**.

[0098] Frame **162** may also be configured as a ring or a linear or planar structure and be provided with one or plural tine assemblies **160**A including plural first projections **168**, second projections **169**, actuating member(s) **164**, and tines **166**.

[0099] A fourth variant connector **180** is depicted in FIG. **7**. Connector **180** is virtually identical to connector **160**, with the exception that at least one opening **193** is provided and passes through the frame **182** and the at least one stabilizing member **195** joins the actuating member **184** at a different position and is substantially linear rather than the curved configuration of the at least one stabilizing member **175**. The at least one opening **193** is provided and may serve as a coupling point for a delivery device and/or may service as an opening for an adhesive to join the frame **182** to a graft (not shown). Otherwise, connector **180** is substantially the same as connector **160** in that it includes at least two expansive members **183** arranged in parallel. The at least two expansive members **183** have their vertices oriented in opposite directions relative to the frame **182** and also expand along a longitudinal axis of the frame **182**. The at least two expansive members **183** are each joined with the frame **182** on first end thereof and to an actuating member **184** at a second end thereof. The juncture **181***c* of the at least two expansive members **183** with the frame **182** is positioned at a point between the first portion **181***a* and the second portion **181***b* of the actuating member **184**. As with other variants of connector **100**, at least one stabilizing member **195** is provided that extends laterally from a second projection **189** from frame **182** and joins with the actuating member **184** at or proximate to the first portion **181***a* of the at least one actuating member **184**.

[0100] Frame **182** may also be configured as a ring or a linear or planar structure and be provided with one or plural tine assemblies **180**A including plural first projections **188**, second projections **189**, actuating member(s) **184**, and tines **186**. Tines **186** may be helically oriented in either a clockwise or counterclockwise direction relative to the longitudinal axis of the connector **180**.

[0101] Fifth variant connector **200** is shown in FIG. **8**. Like connector **180**, connector **200** employs at least two expansive members **203**. The at least two expansive members **203** are provided and arranged in parallel. The at least two expansive members **203** have their vertices oriented in opposite directions relative to the frame **202** and also expand along a longitudinal axis of the frame **202**. The at least two expansive members **203** are each joined with the frame **202** at substantially a mid-point of a proximal aspect of an actuating member **204**. By positioning the junction between the at least two expansive members **203** at a substantial mid-point of the actuating member **204**, the actuating member **204** will translate substantially along a longitudinal axis without the need for a stabilizing member, such as stabilizing member **195**. Further, like connector **180**, connector **200** has a first projection **208** that extends from the actuating member **204** and a second projection **209** that extends from the frame **202**. Also, connector **200** has a tine **206** joined to each of the first projection **208** and the second projection **209** at a proximal aspect of the tine **206**. An opening **211** extends between the first projection **208** and the second projection **209**. An optional strain relief opening **210** may be positioned at a hinge region **207** at the juncture between the proximal aspect of the tine **206** and its juncture with the first projection **208** and the second projection **209**. Tine **206** may be helically oriented in either a clockwise or counterclockwise direction relative to the longitudinal axis of the connector **200**.

[0102] Distinct from the previously described connector variants, connector **200** employs a plurality of first engagements **212** on each lateral edge of the actuating member **204** and a plurality of engagements **214** on each lateral surface of the second projections extending from the frame **202**. The plurality of first engagements **212** and the plurality of second engagements **214** are configured to mate with each other, allow the actuating member **204** to translate along the longitudinal axis of the frame **202**, and maintain alignment of each lateral surface of the actuating member **204** as it translates within the frame **202** in a linear manner. The plurality of engagements **212** and the plurality of engagements **214** may be any of a wide variety of engaging interfaces, for example, mating projections and detents, rachet, track and follower, or other similarly functional linear motion engagements.

[0103] Frame **202** may also be configured as a ring or a linear or planar structure and be provided with one or plural tine assemblies **200**A including plural first projections **208**, second projections **209**, actuating member(s) **204**, tines **206**, first engagements **212**, and second engagements **214**.

[0104] Sixth connector variant **220** is shown in FIG. **9**. Like connector **180**, connector **220** employs at least two expansive members **223** arranged in parallel to each other. The at least two expansive members **223** may be generally V-shaped, U-shaped, hemi-elliptical, semi-circular, or similar shapes. The at least two expansive members **223** have their vertices oriented toward each other relative to the frame **222** and are capable of expansion and contraction along longitudinal axis L. The at least two expansive members **223** also expand along a longitudinal axis of the frame **222**. The at least two expansive members **223** are each joined with the frame **222** at substantially a mid-point of a proximal aspect of an actuating member **224**. A junction between the at least two expansive members **223** is at a substantial mid-point of the actuating member **224**. In this manner the actuating member **224** will translate substantially along longitudinal axis L without the need for a stabilizing member, such as stabilizing member **195**. Further, like connector **180**, connector **220** has a first projection **228** that extends from the actuating member **224** and a second projection **229** that extends from the frame **222**. Also, connector **220** has a tine **226** joined to each of the first projection **228** and the second projection **229** at a proximal aspect of the tine **226**. Tine **226** may be helically oriented in either a clockwise or counterclockwise direction relative to the longitudinal axis of the connector **220**. An opening **231** extends between the first projection **228** and the second projection **229**. Opening **231** isolates the tension and compression forces applied to the first projection **228** and the second projection **229**. An optional strain relief opening **230** may be positioned at a hinge region **227** at the juncture between the proximal aspect of the tine **226** and its juncture with the first projection **228** and the second projection **229**. Tine **226** may, optionally, be tapered to a distal point **225** to facilitate penetration of the tine **226** into anatomical tissue.

[0105] As with other variants, the first projection **228** and the second projection **229** are configured to act to carry either compression or tension forces depending upon whether the actuating member **224** and the expansive members **223** are being expanded or contracted relative to the longitudinal axis L of connector **220**.

[0106] Like other variants of the connector **100**, the frame **222** of connector **220** may be formed as a planar or linear member or as a ring member. A tine assembly **220**A includes the at least two expansive members **223**, the first projection **229**, the second projection **228**, tine **226**, and, optionally, strain relief section **230**. Plural tine assemblies **220**A may be arrayed in series along the frame **222** with the plurality of tines **226** being having a common orientation relative to the frame **222** or having alternating orientations relative to the frame **222**.

[0107] A seventh connector variant **240** is shown in FIG. **10**. Connector **240** is similar to connector **180** with the major difference being that the actuation member **244** is configured of an open ring structure. The open ring actuation member **244** reduces the mass of the actuation member **244** as compared with another structure or geometry of the actuation member and may, optionally, serve as a coupling for a delivery device. Otherwise, like connector **180**, connector **240** may include one or more tine assemblies **240**A, each tine assembly **240**A including the at least two expansive members **243**, the first projection **249**, the second projection **248**, tine **246**, and, optionally, strain relief section **250**. Plural tine assemblies **240**A may be arrayed in series along the frame **242** with the plurality of tines **246** being having a common orientation relative to the frame **242** or having alternating orientations relative to the frame **242**. Tine **246** or the plurality of tines **246** may be helically oriented in either a clockwise or counterclockwise direction relative to the longitudinal axis of the connector **240**.

[0108] The at least two expansive members **243** may be generally V-shaped, U-shaped, hemi-elliptical, semi-circular, or similar shapes. The at least two expansive members **243** have their vertices oriented away from each other relative to the frame **242** and are capable of expansion and contraction along longitudinal axis L. The at least two expansive members **243** are each joined with the frame **242** on first end thereof and to an actuating member **244** at a second end thereof. The juncture of the at least two expansive members **243** with the frame **242** is positioned at a point intermediate along a length of the actuating member **244**. At least one stabilizing member **255** is provided that extends laterally from a second projection **249** from frame **242** and joins with the actuating member **242**. An elongate opening **251** separates the first projection **248** from the second projection **248** and isolates compression and tension forces applied to the first projection **248** and the second projection **248**. The elongate opening **251** terminates in an optional strain relief opening **250** at a hinge region **247** at a junction between the tine **246** and the first projection **248** and second projection **249**. As with other variants, each of the at least one tine **246** may, optionally, have a distal taper that terminates in a tapered point **245** to facilitate penetration of the at least one tine **246** into anatomic tissue.

[0109] Turning now to other variants of the connector **100** in which there are no expansive members employed that are configured to act upon an actuating member. Rather, in the following variants, the actuating member is joined to a first projection and a second projection only or additionally to plural stabilizing members. In each of the following variants of connector **100**, there may also be provided one or more tine assemblies arrayed along a common frame member.

[0110] According to an eighth connector variant **260** in FIG. **11**, there is provided a connector **260**. Connector **260** foregoes employing expansive members and like other variants has a frame **262**, an actuating member **264**, a first projection **268** extending longitudinally from the frame **262** and a second projection **269** extending from the actuating member **264**. At least one tine **266** is joined to both the first projection **268** and the second projection **269** at a hinge region **267** between a proximal aspect of the tine **266** and distal aspects of each of the first projection **268** and second projection **269**. An elongate opening **271** separates the first projection **268** from the second projection and terminates in an optional strain relief opening **270** at the hinge region **267**. Plural stabilizing members **275** project from opposite ends of the actuating member **264**, with a first set of stabilizing members **275***a* projecting from a first end **264***a* of the actuating member **264** and a second set of stabilizing members **275***b* projecting from a second end **264***b* of the actuating member **264**. Both the first set of stabilizing members **275***a* and the second set of stabilizing members **275***b* join with a respective first projection **268** from the frame **262**. Optionally, an opening **277** is provided that passes through the actuating member **264** that is configured to serve as a coupling point for a delivery device to facilitate translation of the actuating member **264** relative to frame **262**. The at least one tine **266** may be helically oriented in either a clockwise or counterclockwise direction relative to the longitudinal axis of the connector **260**.

[0111] Connector **260** may include one or more tine assemblies **260**A, each tine assembly **260**A including the first projection **269** and the second projection **268** isolated from each other by opening **271**, tine **266**, stabilizing members **264***a* and **264***b*, actuating member **264**, and, optionally, strain relief section **250**. Plural tine assemblies **260**A may be arrayed in series along the frame **262** with the plurality of tines **266** having a common orientation relative to the frame **262** or having alternating orientations relative to the frame **262**.

[0112] It will be understood by those skilled in the art that translation of the actuating member **264** along the longitudinal axis L of the connector **260** will cause the plural stabilizing members **275** to deform synchronously, thereby exerting concomitant tension and compression forces onto the first projection **268** and second projection **269** and provide a motive force to cause rotation of the tine **266** about hinge region **267**. In this manner, the at least one tine **266** will rotate about hinge region **267** to either an open or closed position to allow either the delivery and penetration into anatomic tissue or compression of anatomic tissue between the at least one tine **266** and the actuating member **264**, respectively.

[0113] A ninth connector variant **280** is illustrated in FIG. **12**. According to this ninth connector variant **280**, the actuating member **284** is carried on frame **282** by a tine **286** joined to a first projection **288** on a first end **284***a* of the actuating member **284** and at a second end **284***b* of the actuating member **284** to a second projection **289** extending from frame **282**. A proximal portion of the first projection **288** extends from frame **282** and curves, in a generally hemi-elliptical shape, to join to a proximal end **286***a* of an associated tine **286**. The first end **284***a* of actuating member **284** is joined by an actuating projection **295** to an associated tine **286** distally from the junction of the first projection **288** with the tine **286**. The second end **284***b* of the actuating member **284** is joined to the frame **282** by the second projection **289**. Second projection **289** projects from frame **282** in a generally curved manner, such as a generally serpentine shape, and joins with the second end **284***b* of the actuating member **284**. In this manner, the actuating member **284** joins with both the tine **286** and the frame **282** such that longitudinal translation of the actuating member **284** along the longitudinal axis of connector **280** imparts compression and/or tension forces on the first projection **288** and the second projection **289** and moves the tine **286** in a rotational manner about the first projection **288** due to its curvilinear shape. In this manner, the first projection **288** operates and is configured to function as a hinge about which the tine **286** rotates. Each tine **286** may be helically oriented in either a clockwise or counterclockwise direction relative to the longitudinal axis of the connector **280**.

[0114] Optionally, an opening **287** passes through the actuating member **284** and is configured to engage with a delivery device (not shown) to allow for longitudinal translation of the actuating member **284** and delivery of the connector **280** into anatomic tissue.

[0115] Finally, in contrast to other variants of the connector **100**, connector **280** employs linear tines **286**, as opposed to curved tines, such as those illustrated in connector **260**. To assist in embedding and retention of the tines **286** in the anatomic tissue, where linear tines **286** are employed, it is advantageous, but optional, to provide a barb **287** at a proximal region of the tine **286**.

[0116] Another connector variant **300** is illustrated in FIG. **13**. Connector **300** employs a somewhat different rotational operation of the tines than other variants described herein. Like other connector variants described herein, connector **300** includes a frame **302** that carries at least one of a plurality of connector assemblies **300**A. Each of the at least one of a plurality of tine assemblies **300**A consists of a generally C-shaped tine **306** that is joined at its proximal end to a first projection **308**. Each generally C-shaped tine may be oriented in either a clockwise or counterclockwise direction relative to the longitudinal axis of the connector **300**. First projection **308** extends from frame **302** and is curvilinear. A pivot section **307** is also joined at the proximal end of the generally C-shaped tine **306**. Pivot section **307** consists of a rounded portion having an opening **312**. Opening **312** is configured to engage with a delivery device (not shown) that that is configured to translate the pivot section **307** and rotate the tine **306** about the first projection **308**. In this manner the first projection **308** acts as a hinge to allow the tine **306** to rotate in a plane both proximally and distally about the first projection **308** and allow the distal end **305** of tine **306** to engage anatomic tissue and compress the anatomic tissue between frame **302** and tine **306**. The frame **302** may, optionally, have an abutment portion **313** that is configured to allow the pivot section **307** to abut against frame **302** when the pivot section **307** of tine **306** is in a deployed state with the tine **306** embedded into anatomic tissue. In contrast, when the tine **306** is in a delivery state, the pivot section **308** or tine **306** will be rotated distally away from frame **302**.

[0117] Connector **300** may include one or more tine assemblies **300**A, each tine assembly with plural tine assemblies **300**A may be arrayed in series along the frame **302** with the plurality of tines **306** having a common orientation relative to the frame **302** or having alternating orientations relative to the frame **302**.

[0118] FIG. **14** illustrates an eleventh connector variant **320**. Unlike other variants, connector **320** does not employ an actuating member. Thus, connector **320** is well suited to be made of shape memory or superelastic materials. In connector variant **320**, a frame **322** carries at least one tine assembly **320**A, with each tine assembly **320**A consisting of a linear tine **326** joined at its proximal end **327** to a first projection **328** and a second projection **329**. Each of the first projection **328** and the second projection **329** are also joined to the frame **322** and have a generally curvilinear shape, with the first projection **328** having a generally semi-circular profile and the second projection **329** having a generally serpentine profile. The first projection **328** is configured to projects axially from the proximal end **327** of tine **326**, while the second projection **329** is joined to a lateral surface of the proximal end **327** of tine **326** and positioned distally from the junction of the first projection **328** with tine **326**. In this manner, the junctions of the first projection **328** and the second projection **329** with the tine **326** acts as a lever to allow the tine **326** to rotate about the junctions in a hinge-like manner. Each linear **326** may be helically oriented in either a clockwise or counterclockwise direction relative to the longitudinal axis of the connector **320**.

[0119] As with other variants, the tine **326** has a distal taper and terminates in a distal tip **325** that is configured to permit the tine to penetrate and embed in anatomic tissue. While not shown in FIG. **14**, an optional barb may project from a lateral surface of tine **326** proximate to proximal end **326** of the tine **326** to further assist in embedding the tine **326** in the anatomic tissue.

[0120] Connector **320** may include one or more tine assemblies **320**A, each tine assembly with plural tine assemblies **320**A may be arrayed in series along the frame **322** with the plurality of tines **326** having a common orientation relative to the frame **322** or having alternating orientations relative to the frame **322**.

[0121] FIG. **15** illustrates a twelfth variant connector **340**. Connector **340** is similar to connector **320** in that it has a frame **342**, a first projection **348** from frame **342**, a second projection **349** from frame **342**, with both the first projection **348** and the second projection being joined at a second end to a proximal end **347** tine **346**. Each tine **346** may be helically oriented in either a clockwise or counterclockwise direction relative to the longitudinal axis of the connector **340**. The first projection **348** has a generally C-shaped curvature while the second projection **349** has a generally S-shaped curvature, with both the first projection **348** and the second projection **349** joining at the proximal end **347** of tine **346**. Tine **346** has a curvilinear profile that curves proximally, i.e., toward the frame **362**, and tapers to a distal tip **345**.

[0122] Connector **340** may include one or more tine assemblies **340**A, each tine assembly with plural tine assemblies **340**A may be arrayed in series along the frame **342** with the plurality of tines **346** having a common orientation relative to the frame **342** or having alternating orientations relative to the frame **342**. Like connector **320**, connector **340** does not employ an actuation member and is, therefore, well suited for use with shape memory or superelastic materials to actuate the tine **346**.

[0123] A thirteenth variant connector **360**, which is similar to connector **340**, is depicted in FIG. **16**. Like connector **340**, connector **360** does not employ an actuation member. Connector **360** may include one or more tine assemblies **360**A, each tine assembly with plural tine assemblies **360**A may be arrayed in series along the frame **362** with the plurality of tines **366** having a common orientation or having alternating orientations relative to the frame **362**. Connector **360** includes a frame **362**, a first projection **368** extending from the frame **362**, a second projection **369** extending from the frame **362**, and a curvilinear tine **366** that curves proximally, i.e., toward the frame **362**, and tapers to a distal tip **365**. The first projection **368** has a generally C-shaped profile with an elongated leg **373** that extends distally and joins with a hinge region **367** at a proximal end **363** of the tine **366**. The second projection **369** has a generally S-shaped serpentine profile and also has an elongated leg **375** that extends distally and joins with the proximal end **363** of tine **366** at the hinge region **367**. An elongate opening **371** separates the elongated leg **375** of the second projection **369** from the elongated leg **373** of the firs projection **368**. Optionally, a strain relief section **370** may be provided at the hinge region **367** to distribute stress and strain forces as the tine rotates about the hinge region **367**.

[0124] FIG. **17** illustrates a fourteenth variant connector **380**. Connector **380** is similar to connector **240** in that it has a frame **382** and at least one mechanically active tine assembly **380**A. Each of the at least one mechanically active tine assemblies **380**A consist of an actuation member **384** that is configured as an open ring structure, at least two expansive members **383**, a first projection **388** that extends distally from the actuation member **384**, a second projection **389** that extends distally from the frame **382**, and a tine **386** joined to distal ends of both the first projection **388** and the second projection **389**. Each tine **386** may have a helically orientation in either a clockwise or counterclockwise direction relative to the longitudinal axis of the connector **120**. The open ring actuation member **384** reduces the mass of the actuation member **384** as compared with a solid structure of the actuation member and may, optionally, serve as a coupling for a delivery device. Otherwise, like connector **240**, connector **380** includes at least two expansive members **383** arranged in parallel such that they are configured to longitudinally expand and contract substantially simultaneously as the open ring actuation member is longitudinally translated relative to the frame **382**. The at least two expansive members **383** are generally V- or U-shaped and have their respective vertices oriented in opposite directions relative to the frame **382** and also expand along a longitudinal axis of the frame **382**. Other configurations of the at least two expansive members **383** are expressly contemplated as well, including, for example, serpentine shapes, provided that the expansive members **383** are capable of substantially simultaneous expansion and contraction in the longitudinal axis of the connector **380**.

[0125] Connector **380** may include one or more tine assemblies **380**A, each tine assembly with plural tine assemblies **380**A may be arrayed in series along the frame **382** with the plurality of tines **386** having a common orientation or having alternating orientations relative to the frame **382**.

[0126] The at least two expansive members **383** are each joined with the frame **382** at first ends thereof and, at second ends thereof to the actuating member **384**. The juncture of the at least two expansive members **383** with the frame **382** is positioned at a point intermediate along a length of the actuating member **384**. An elongate opening **391** separates the first projection **388** from the second projection **389** and terminates in an optional strain relief opening **390** at a hinge region **387** at a junction between the tine **386** and the first projection **383** and second projection **389**. The first projection **388**

[0127] As with other variants, each of the at least one tine **246** may, optionally, have a distal taper that terminates in a tapered point **245** to facilitate penetration of the at least one tine **246** into anatomic tissue. Unlike connector **240**, no stabilizing member is provided to connect the actuation member **384** with the that extends laterally from a second projection **389** from frame **382**.

[0128] The second projection **389** has a curvilinear configuration such that the proximal end and the distal end of the second projection **389** are offset from each other along the longitudinal axis of the connector **380**.

[0129] Turning now to FIGS. **18** to **20** there is illustrated variants of staple-like mechanically active tine connectors **400**, **420**, and **440**, respectively. Functionally, the staple-like mechanically active tine connectors **400**, **420**, and **440** operate similarly to the foregoing described variants of connector **100**, with the major exception being that the mechanically active tine connectors **400**, **420**, and **440** employ dual opposing tines that deflect centrally inward and toward each other.

[0130] FIG. **18** illustrates a first variant of the staple-like connector **400** in which a frame **402** has a first frame projection **409***a* and a second frame projection **409***b* extending distally from the frame **402**. At least one expansive member **403** is joined to the frame **402** on one end thereof and to an actuating member **404** on a second end. The actuating member **404** has at least a first actuating projection **408***a* and a second actuating projection **408***b* that extend distally from the actuating member **404**. The first frame projection **409***a* and the first actuating projection **408***a* join to a proximal end of a first tine **407** at hinge region **407***a*, while the second frame projection **409***b* and the second actuating projection **408***b* join with a proximal end of a second tine **406** at hinge region **407***b*. Hinge regions **407***a*, **407***b*, serve as fulcrum points to allow the first and second tines **407**, **406** to rotate proximally and/or distally under the influence of tension and/or compression forces exerted by translational movement of the actuating member **404** and the at least one expansive member **403**. An optional strain relief opening **410** may be provided at the hinge regions **407***a*, **407***b* to distribute stress and strain forces at the hinge regions **407***a*, **407***b*. An opening **411** separates the first and second frame projections **409***a*, **409***b* from the first and second actuating projections **408***a*, **408***b* and allows for independent transfer of tension and/or compression forces from either the frame **402** and/or the actuating member **404** to the hinge regions **407***a*, **407***b* to actuate movement of the first and second tines **407**, **406**.

[0131] FIG. **19** illustrates a second variant of the staple-like connector **420**. Staple-like connector **420** also consists of a frame **422** having a first frame projection **429***a* and a second frame projection **429***b* extending distally from frame **422**. At least two expansive members **423** are joined to the frame **422** at a first lateral portion **422***a* and a second lateral portion **422***b* of frame **422** at a first end of each of the at least two expansive members **423**. The least two expansive members **423** are connected to an actuating member **424** at second ends thereof. In staple-like connector **420**, the at least two expansive members **423** are configured as longitudinally expansive U-shaped or V-shaped members. It is contemplated, however, that the at least two expansive members **423** may have any shape provided that they are capable of expanding along the longitudinal axis of the staple-like connector **420** as the actuating member **424** is translated along the longitudinal axis of the staple-like connector **420**. A frame opening **435** may, optionally, be provided in frame **422**, and an actuating opening **433** may, optionally, be provided in actuating member **424**. Frame opening **435** and actuating opening **433**, when provided, may be configured to engage a delivery device (not shown) that actuates translational movement of the actuating member **424** relative to frame **422**.

[0132] An elongate opening **431** that, optionally, terminates in a strain relief opening **430**, separates the first and second frame projections **429***a*, **429***b* from the first and second actuating projections **428***a*, **428***b*. In this manner, longitudinal translation of the actuating member **433** will exert tension and/or compression forces in the first and second frame projections **429***a*, **429***b* from the first and second actuating projections **428***a*, **428***b* and provide a motive force to first and second tines **425**, **426** to rotate the first and second tines **425**, **426** about hinge region **426**, with distal ends of each of the first and second tines **425**, **426** being brought into an approximating relationship when the staple-like connector **420** is in its closed position as depicted in FIG. **19**.

[0133] FIG. **20** illustrates another variant of staple-like connector **440**. Staple-like connector **440** also includes a frame **442** having a first frame projection **449***a* and a second frame projection **449***b* extending distally from the frame **442** and joined to a proximal end of a tine **445**, **447**, respectively, at a distal end of each of the first frame projection **449***a* and the second frame projection **449***b*. Expansive members **443** are joined at one end thereof to the frame **442** and at their other end to an actuating member **444**. The expansive members **443** are configured as longitudinally expansive U-shaped or V-shaped members. It is contemplated, however, that the expansive members **433** may have any shape provided that they are capable of expanding along the longitudinal axis of the staple-like connector **440** as the actuating member **444** is translated along the longitudinal axis of the staple-like connector **440**.

[0134] At least one of a plurality of engagements **453** are provided on an inner surface of each of the first frame projection **449***a* and the second frame projection **449***b*, i.e., that surface facing toward the actuating member **444**. The at least one of a plurality of engagements **453** engage with a corresponding cooperating engagement **455** provided on lateral surfaces of the actuating member **444**, i.e., the surfaces of the actuating member **444** facing the first frame projection **449***a* and the second frame projection **449***b.* The cooperating engagement between the at least one of a plurality of engagements **453** and the engagement **455** on the actuating member **444** is configured to allow for a substantially linear translation of the actuating member along the longitudinal axis of the connector **440**. The engagement will also permit bidirectional adjustability of the positions of tines **445**, **446** into a fixed position relative to frame **442** by the relative position of the actuating member relative to the frame **442**.

[0135] With the exception of the cooperating engagement interface between the at least one of a plurality of engagements **453** and the engagement **455** on the actuating member **444**, an opening **451** is provided between the first and second frame projections **449***a*, **449***b*, and a first actuating projection **448***a* and a second actuating projection **448***b*, respectively. Opening **51** permits the first and second frame projections **449***a*, **449***b*, to operate in tension and/or compression modes substantially independently of the first and second actuating projections **448***a*, **448***b* to transfer force to the respective tines **445**, **447** and allow then to rotate about hinge region **447** at a proximal end of each tine **445**, **447**.

[0136] FIG. **21** illustrates attachment of representative connector variant **500**, in this case connector **100**, to synthetic tissue **506** through a hemostatic felt **504**, such as woven polytetrafluoroethylene (PTFE), and such that the tines **505** penetrate into and through the synthetic tissue **506**. Tines **505** are, however, not fully deployed as indicated the position of actuating member **508**, the expansive member **512**, and the stabilizing members **510**. As illustrated in FIG. **21**, the expansive member **512** is expanded or uncrimped and open, while the actuating member **508** is longitudinally spaced from the frame **502** of the connector **500**. Further, the distal tips of the tines **505** are not compressing the synthetic tissue **506**, as illustrated in FIG. **22**.

[0137] In contrast, FIGS. **23** and **24** illustrate connector **500** in its deployed state. FIG. **23** depicts the proximal side view **540** whereas FIG. **24** depicts the distal side view of the synthetic tissue **506**. As is seen in FIGS. **23** and **24**, in its deployed state, the actuating member **508** has been translated proximally toward the frame **502**, the expansive members **512** are in a collapsed or compressed state, and the stabilizing members **510** have also been deformed proximally relative to frame **502**. As is seen in FIG. **24**, the tines **505** are compressed the distal surface of the synthetic tissue **506** such that the synthetic tissue **506** and the hemostatic felt **504** are compressed between the tines **505**, the actuating member **508**, and frame **502**, thereby securing the synthetic tissue **506** there between.

[0138] A final set of variants of the mechanically active tine connectors of the present disclosure are presented in FIGS. **25** to **28**. Common to each of the connector variants **600**, **700**, **800** are that they are ring structures made of plural active tine components and the ring structures are configured to and capable of everting about their central axis and allow the plural active tine components to embed in tissue. The everting nature of the ring structures of connector variants **600**, **700**, **800**, make them particularly well suited for end-to-end anastomosis of tubular structures of anatomic or synthetic origin.

[0139] Connector variant **600** is a ring structure composed of plural active tine assemblies **602**, as illustrated in FIG. **25**. An individual active tine assembly **620** is shown in FIG. **26**. Each individual active tine assembly **620** may be configured in a variety of manners, including, without limitation, configuring active tine assembly **620** in a manner similar to staple-like connectors **400** **420**, and/or **440**, described above. Alternatively, as illustrated in FIG. **26**, the active tine assembly **620** may be configured to have a frame **622**, with a first frame projection **629***a* and a second frame projection **629***b*. Each of the first frame projection **629***a* and second frame projection **629** join at their distal ends to a hinge region at proximal ends of each of tine **625***a* and **625***b*. The first frame projection **629***a* and second frame projection **629***b* are also joined to adjacent individual active tine assemblies **620** to form the ring structure of connector variant **620**.

[0140] An actuating member **624** is provided that is joined to the frame **622** by at least one expansive member **623**. The at least one expansive member **623** is configured as longitudinally expansive U-shaped or V-shaped members. It is contemplated, however, that the expansive members **623** may have any shape provided that they are capable of expanding along the longitudinal axis of the connector variant **600** as the actuating member **624** is translated along the longitudinal axis of the connector **600**. While two expansive members **623** are shown in FIG. **26**, the illustrated example of connector variant **600** may alternatively employ any number of expansive members **623** so long as the actuating member **624** is capable of substantially linear movement along the longitudinal axis of the connector **620**.

[0141] A first actuating projection **628***a* and a second actuating projection **629***b* extend distally from opposing ends of the actuating member **624**. A proximal end of each tine **625***a*, **625***b* may, optionally, be configured to receive a distal end of either the first actuating projection **628***a* or the second actuating projection **628***b* therein to allow for the first actuating projection **628***a* or the second actuating projection **628***b* to bear upon the proximal end of the respective tine **625***a*, **625***b* and exert either a tension or compression force to move the tine in a rotational manner about hinge region **627** at the juncture between each tine **625***a*, **625***b* and the first frame projection **629***a* and the second frame projection **629***b*. In this configuration, longitudinal translation of the actuating member **624** imparts either a tension or compression force to the respective tine **625***a*, **625***b* and imparts rotational movement of the respective tine about the hinge region **27** to open and/or close the position of the tines **625***a*, **625***b*.

[0142] When plural active tine assemblies **620** are joined in a ring structure, each active tine assembly **620** has a common proximal-distal orientation with other active tine assemblies **620**, as illustrated in FIG. **25**, and is assembled in a serpentine or zig-zag configuration into the ring structure. Optionally, the ring structure of connector **600** is capable of being everted about its central axis, with the proximal aspect of each assembly **620** being at the distal aspect of the ring structure, and the distal aspect of each assembly **620** being at the proximal aspect of the ring structure, when the connector **600** is in a pre-deployment delivery state. Upon deployment, the ring structure of connector **600** is everted about the central axis such that the frame **622** at the proximal aspect of connector **600** is oriented proximally and the tines **625***a*, **625***b* at the distal aspect of connector **600** are oriented distally.

[0143] Another variant of everting connector **700** is shown in FIG. **27**. Everting connector **700** consists mainly of a serpentine frame **702** defining the ring structure, a plurality of tine seats **704** at troughs **703** of the serpentine frame **702**, and a plurality of arcuate tines **706**. Each of the plurality of arcuate tines **706** are coupled at a first, proximal end thereof to the tine seats **704**, with a second, distal end of each of the plurality of arcuate tines **706** extending circumferentially outward and radially outwardly displaced from the peaks **705** of the serpentine frame **702**. When the serpentine frame **702** is everted about its central axis, the orientation of the plurality of arcuate tines **706** and tine seats will be inverted with the second, distal ends of each of the plurality of arcuate tines **706** projecting proximally from an inner circumference of the serpentine frame **702**. This everted state is particular well suited for delivery of the everting connector **700**, whereas the non-everted state, depicted in FIG. **27** is the post-delivery deployed state of the everting connector **700** with the second distal ends of the tines **706** penetrating into anatomic tissue (not shown).

[0144] An advantage of everting connector **700** is that the post-delivery deployed state does not rely upon or require any pivoting or hinging of the plurality of tines **706** relative to the serpentine frame **702**. Rather, the tines **706** rotate about the central axis as the everting connector **700** is deployed from its everted state to its non-everted state.

[0145] Another everting connector variant **800** is shown in FIG. **28**. Similar to everting connector variant **700**, everting connector variant **800** has a continuous serpentine frame **802** having a plurality of structural strut-like members **804** defining a plurality of peaks **805** and troughs **807**. Each peak **805** is configured to have a pointed end **806** that functions in a manner similar to the tines **706**, but is not a discrete component, but is integral and monolithic with the peak **805** and frame **802**. The peaks **805** define an outer circumference of the everting connector variant **800** while the troughs define an inner circumference of the everting connector variant **800**. The peaks **805** are formed to lie in a plane that is spaced apart from a plane defined by the plurality of troughs **807**. In this manner, the continuous serpentine frame **802**, the peaks **805**, the troughs **807**, and the pointed ends **806** define a continuous, integral ring structure without any separate movable components coupled to or attached to the everting connector **800**.

[0146] When the serpentine frame **802** is everted about its central axis, the orientation of the plurality of pointed ends **806** and peaks **805** and the plurality of troughs **807** switch relative positions about the central axis of the serpentine frame **802**. In this everted state, the everting connector **800** is in a delivery and pre-deployment state. By re-everting the serpentine frame, the plurality of pointed ends **806**, the peaks **805**, and troughs **807**, the connector **800** will assume its delivered and deployed state with the pointed ends **806** embedding into anatomic tissue, not shown, about the outer circumference of the everting connector **800**.

[0147] Further variants of connector **100** are illustrated in FIGS. **29** and **30**. A single ring connector **850** is depicted in FIG. **29**, while a dual ring connector member **900** is depicted in FIG. **30**. Single ring connector **850** has a ring frame member **852** and a plurality of tine assemblies **850**A arrayed about a circumference of the ring frame member **852**. Optionally, the ring frame member **852** may have driver engagements **867** that are either projections from the ring frame member **852** or recesses in a proximal edge of the ring frame member **852**.

[0148] Each tine assembly **850**A is similar to tine assembly **100**A in that it includes at least one expansive member **853**, at least one actuating member **854**, at least one stabilizing member **855** extending between the ring frame member **852** and the at least one actuating member **855**, an optional opening **862** passing through the at least one actuating member **854**, and at least one tine **856**. The at least one time **856** is operably connected to both the frame **852** and to the at least one actuating member **854**, and a hinge region **857** at a proximal aspect of the at least one tine **856**. The at least one tine **856** is preferably tapered distally to a tapered end that assists in penetrating into anatomic tissue. A first projection **858** extends distally from the at least one actuating member **854** and is connected to the hinge region **857** of the at least one tine **856**. A second projection **859** extends distally from the ring frame member **852** and is also connected to the hinge region **857** of the at least one tine **156**. An opening **861** separates the first projection **858** and the second projection **859**. Optionally, opening **861** terminates in a strain relief section **860** at the hinge region **857** of tine **856**.

[0149] The at least one stabilizing member **855** comprises a deformable member that projects laterally on one end thereof, from the second projection **859** extending from ring frame member **852**. At an opposite end of the at least one stabilizing member **855**, the at least one stabilizing member **855** connects with a first portion **851***a* of a main body **851** of the actuating member **854**. Thus, the at least one stabilizing member **855** extends between the second projection **859** and the main body **851** and joins the first portion **851***a* of the main body **851**. The at least one stabilizing member **851** may be linear, curvilinear, or have simple or complex curves along its length.

[0150] At a second portion **851***b* of the main body **851**, the at least one expansive member **853** connects to the main body **851** and the ring frame member **852**. The first portion of the main body **851***a* and the second portion of the main body **851***b* are preferably located at opposite aspects of the main body **851**. In this manner, translation of the main body **851** along a longitudinal axis of the connector **850**, either proximally or distally relative to the ring frame member **852**, is stabilized by the at least one stabilizing member **855** and the expansive member **853**. This arrangement stabilizes the main body **851** and allows the longitudinal translation of both the first portion **851***a* and the second portion **851***b* of the main body to move substantially simultaneously and evenly along the longitudinal axis L while maintaining a substantial parallel relationship relative to the circumferential axis of the ring frame member **850**. Further, in this manner, the main body exerts a linear force to the first projection **858** that is substantially parallel to the longitudinal axis of the connector **850**. The linear force exerted by the first projection **858** acts at the hinge region **857** to deflect the tine **856**. In this manner, either proximal or distal movement of the main body **851** of the actuating member **854** deflects the tine **856** either proximally or distally, respectively.

[0151] As indicated above, the first projection **858** and the second projection **859** are configured to carry compression and/or tension forces as the at least one actuating member **854** is moved proximally and or distally relative to the ring frame member **852** and rotates the at least one tine **856** either proximally or distally about the hinge region **857**.

[0152] The dual ring connector **900**, illustrated in FIG. **30**, consists generally of two concentric single ring connectors **850** operably coupled to each other and independently rotatable relative to each other. Dual ring connector **900** includes a first ring frame member **902***a* and a second ring frame member **902***b* concentrically disposed relative to one another. A guide (not shown) is provided between the first ring frame member **902***a* and the second ring member **902***b* to facilitate independent rotation of the first ring frame member **902***a* relative to the second ring member **902***b* about a common circumferential axis C. Each of the first ring member **902***a* and the second ring member **902***b* have common elements associated therewith and differ primarily in the helical orientation of the plurality of tines **906***a*, **906***b*, respectively. Specifically, the plurality of tines **906***a* and **906***b* associated with first ring member **902***a* and second ring member **902***b*, respectively, have opposite helical orientations. It will be appreciated by those skilled in the art that this opposite helical orientation facilitates greater penetration into anatomic tissue and/or non-anatomic devices, as well as provides greater resistance to pull-out from the anatomic tissue and/or non-anatomic tissue.

[0153] Each of the first ring member **902***a* and the second ring member **902***b* has a plurality of driver engagements **917***a*, **917***b* that are either projections from or recesses in a proximal aspect of the first ring member **902***a*, **902***b*, respectively. Similarly, each of the first ring member **902***a* and the second ring member **902***b* has a plurality of tine assemblies **900**A, **900**B, respectively, projecting distally therefrom. Each of the plurality of tine assemblies **900**A, **900**B have at least one expansive member **903***a*, b, at least one actuating member **904***a*, **904***b*, at least one stabilizing member **905***a*, **905***b* extending between a respective ring frame member **902***a*, **902***b* and the at least one actuating member **905***a*, **905***b*, an optional opening passing through the at least one actuating member **904***a*, **904***b*, and at least one tine **906***a*, **906***b*. The at least one tine **906***a*, **906***b* is operably connected to both the ring frame member **902***a*, **902***b* and to the at least one actuating member **904***a*, **904***b*, and a hinge region **907***a*, **907***b* at a proximal aspect of the at least one tine **906***a*, **906***b*. The at least one tine **906***a*, **906***b* is preferably tapered distally to a tapered end that assists in penetrating into anatomic tissue or a non-anatomic device. A first projection **908***a*, **908***b* extends distally from the at least one actuating member **904***a*, **904***b* and is connected to the hinge region **907***a*, **907***b* of the at least one tine **906***a*, **906***b*. A second projection **909***a*, **909***b* extends distally from its respective ring frame member **902***a*, **902***b* and is also connected to the hinge region **907***a*, **907***b* of the respective at least one tine **906***a*, **906***b*. An opening **911***a*, **911***b* separates each first projection **908***a*, **908***b* from an adjacent second projection **909***a*, **909***b*. Optionally, opening **911***a*, **911***b* terminates in a strain relief section **910***a*, **910***b* at the hinge region **907***a*, **907***b* of the associated tine **906***a*, **906***b*.

[0154] The at least one stabilizing member **905***a*, **905***b* comprises a deformable member that projects laterally on one end thereof, from the second projection **909***a*, **909***b* extending from ring frame member **902***a*, **902***b*. At an opposite end of the at least one stabilizing member **905***a*, **905***b*, it joins with a first portion of a main body **901***a*, **901***b* of the actuating member **904***a*, **904***b*. Thus, the at least one stabilizing member **905***a*, **905***b* extends between the second projection **909***a*, **909***b* and the main body **901***a*, **901***b* and joins the first portion of the main body **901***a*, **901***b*. The at least one stabilizing member **901***a*, **901***b* may be linear, curvilinear, or have simple or complex curves along its length.

[0155] The at least one expansive member **903***a*, **903***b* connects to the main body **901***a*, **901***b* of the actuating member **904***a*, **904***b* and the ring frame member **902***a*, **902***b*. The first portion of the main body and the second portion of the main body are preferably located at opposite aspects of the main body **901***a*, **901***b*. In this manner, translation of the main body **901***a*, **901***b* along a longitudinal axis of the connector **900**, either proximally or distally relative to the ring frame member **902***a*, **902***b*, is stabilized by the at least one stabilizing member **905***a*, **905***b* and the expansive member **903***a*, **903***b*. This arrangement stabilizes the main body **901***a*, **901***b* and allows the longitudinal translation of both the first portion and the second portion of the main body **901***a*, **901***b* to move substantially simultaneously and evenly along the longitudinal axis L while maintaining a substantial parallel relationship relative to the circumferential axis C of the dual ring connector **900**. Further, in this manner, movement of the main body **901***a*, **901***b* exerts a linear force to the first projection **908***a*, **908***b* that is substantially parallel to the longitudinal axis of the connector **850**. The linear force exerted by the first projection **908***a*, **908***b* acts at the respective hinge region **907***a*, **907***b* to deflect the associated tine **906***a*, **906***b*, which each, in turn, rotate in opposite directions about their hinge regions **907***a*, **907***b* given their opposite helical orientations. In this manner, either proximal or distal movement of the main body **901***a*, **901***b* of the actuating member **904***a*, **904***b* deflects the tines **906***a*, **906***b* either proximally or distally, respectively, in their opposite circumferential orientations about circumferential axis C.

[0156] The foregoing described variants of connector **100**, **120**, **140**, **160**, **180**, **200**, **220**, **240**, **260**, **280**, **300**, **320**, **340**, **360**, **380**, **850**, and/or **900**, including the staple-like connectors **400**, **420**, **440**, and the everting connectors **600**, **700**, **800** are provided as examples of the disclosed connectors useful for end-to-side and/or end-to-end anastomosis of tubular structures of anatomic or synthetic origin. It is expressly intended that the illustrated and described variants of the connectors of the present disclosure that aspects and component parts and structures of the various variants may be interchanged or be made interchangeable among the different variants so as not to limit the scope of the disclosure to the illustrated and described variants. For example, the barb **287** on tine **286** depicted in FIG. **12** may be employed on any of the illustrated and described tines across all variants of the present disclosure. Similarly, the different illustrated configurations and conformations of the actuating members may be used with different variants of the present disclosure. Accordingly, the scope of the present disclosure is intended to be limited only by the appended claims taken in view of the illustrated and described exemplary variants.

[0157] Those of skill in the art will understand and appreciate that modifications may be made to the above description and still remain within the scope of the disclosure. For example, with respect to all disclosed variants of the sutureless connectors, the frame may be a linear structure, a ring structure, a tubular structure, a curvilinear structure, such as a generally sinusoidal shape, a zig-zag shape, or the like, the tines may be curved, linear, tapered, or untampered, the actuating member may have a wide variety of shapes including generally rectangular, square, oval, elliptical, or other polygonal shapes, and stabilizing members may have one, two, three or more arms, be curved, linear, sinusoidal, or zig-zag shaped, or the like.

[0158] The size of the connector device may cover a wide range and may depend on the type of procedure it is adapted for. This may include larger dimensions for more robust procedures in more open spaces and smaller dimensions for more delicate procedures in more constrained spaces. The material of the device may be adapted based on the flexibility or rigidity appropriate for a given type of use. Any combination of these modifications may be included and considered with one another for providing a suitable instrument.

[0159] Although the present invention has been described with reference to preferred variants, persons skilled in the art will recognize that changes may be made in form and detail without departing from the spirit and scope of the invention.

Claims

1. A method for making a medical device access opening in a wall of an anatomical structure, comprising the steps of: a. positioning a frame member having a plurality of tines projecting distally from the frame against an outer wall surface of the anatomic structure, the anatomic structure having an inner wall and an outer wall; b. penetrating the plurality of tines into and past the inner wall of the anatomic structure; c. actuating the plurality of tines to bear against the inner wall of the anatomic structure and axially compress the frame against the outer wall of the anatomic structure; and d. a medical device access conduit coupled to the frame member.
2. The method of claim 1, wherein step of positioning the frame member further comprises the step of providing a frame member having a ring structure and the plurality tines project helically from a distal surface of the ring structure.
3. The method of claim 1, wherein the actuating step further comprises the step of stabilizing an actuating member coupled to the ring frame member and to the plurality of tines.
4. The method of claim 3, wherein the step of translating the actuating member further comprises the step of applying a compressive force to the ring member.
5. The method of claim 3, the step of translating the actuating member further comprises the step of stabilizing the actuating member such that the actuating member translates along a longitudinal axis of the ring frame member.
6. The method of claim 5, wherein the step of stabilizing the actuating member further includes the step of maintaining the actuating member substantially parallel to a circumferential axis of the ring structure.
7. The method of claim 2, wherein the step of positioning the frame member further comprises the step of providing a frame member having a frame member having one of a frame tension member or a frame compression member projecting therefrom; at least one actuating member connected to the frame member by a stabilizing member and one of an actuating tension member or an actuating compression member and movable relative to the frame member in a substantially co-planar manner; at least one tine coupled to one of a frame tension member or a frame compression member and one of an actuating tension member or an actuating compression member, whereby axial movement of the frame member relative to the at least one actuating member imparts movement to the at least one tine; and a tubular conduit coupled to the frame member and projecting proximally from the frame member.
8. The method of claim 7, wherein the step of actuating the plurality of tines further comprises the step of creating a hemostatic fluid flow coupling between the tubular conduit and the anatomic structure.
9. A method for making a fluid coupling to an anatomical structure having an inner wall and outer wall thereof, comprising the steps of: a. positioning a fame member having a medical device access conduit coupled thereto, the frame member comprising a ring structure against the outer wall of the anatomical structure, the ring structure being comprised of a plurality of tine assemblies, each of the plurality of tine assemblies comprising one of a frame tension member or a frame compression member projecting distally from the ring structure therefrom, at least one actuating member connected to the frame member by a stabilizing member and one of an actuating tension member or an actuating compression member and movable relative to the frame member, at least one of a plurality of tines, each of the plurality of tines being coupled to one of the frame tension member or a frame compression member and one of an actuating tension member or an actuating compression member, whereby axial movement of the ring structure relative to the at least one actuating

member imparts movement to the at least one tine; and a tubular conduit coupled to an inner wall of the ring structure and projecting proximally from the ring structure; b. penetrating the plurality of tines into and past the inner wall of the anatomic structure; c. actuating the plurality of tines to bear against the inner wall of the anatomic structure and axially compress the ring structure and the medical device access conduit against the outer wall of the anatomic structure; and d. creating an opening in the anatomic structure through the outer wall and inner wall of the anatomic structure sufficient to allow passage of a medical device through the tubular conduit and ring structure.

10. The method of claim 9, wherein the plurality tines project helically from a distal surface of the ring structure.

11. The method of claim 9, wherein the actuating step further comprises the step of stabilizing an actuating member coupled to the ring frame member and to the plurality of tines.

12. The method of claim 11, further comprises the steps of applying a compressive force to the ring member and actuating the actuating member.

13. The method of claim 12, the step of actuating the actuating member further comprises the step of stabilizing the actuating member.

14. The method of claim 13, wherein the step of stabilizing the actuating member further includes the step of maintaining the actuating member substantially parallel to a circumferential axis of the ring structure.