[0013] The stent can further include an adjustment mechanism to exerting a force to urge the strut members about the rotatable joint within a range of motion.

[0014] The stent can include a prosthetic valve coupled to the strut members.

[0015] Specific embodiments of the invention can include prosthetic valves that are rotatable or conventional.

[0016] A rotatable prosthetic valve can include a first structural member coupled to the strut members, a second structural member rotatable relative to the first structural member, and a plurality of pliable valve members connecting the first structural member with the second structural member such that rotation of the second structural member relative to the first structural member can urge the valve members between an open and a closed state. In particular, the rotation of the second structural member can be responsive to the natural flow of a biological fluid.

[0017] A conventional prosthetic valve can include a plurality of pliable valve leaflets having commissures at the intersection of two strut members. The prosthetic valve can further include a skirt material coupled to the strut members.

[0018] These structures can also be interconnected in various combinations.

[0019] A particular advantage of a support structure in accordance with embodiments of the invention is that it enables a prosthetic valve to be readily retrieved and repositioned in the body. If following deployment, the valve is malpositioned or deemed dysfunctional, the support structure allows the valve to be readily repositioned and re-deployed at a new implant site, or removed from the body entirely. This feature of the device can prevent serious complications and save lives by enabling the repair of mal-positioned devices in the body.

[0020]

According to an aspect of the present invention, there is provided a biocompatible articulated support structure, comprising a tubular support body with a proximal opening, a distal opening, and a lumen and a longitudinal axis between the proximal and distal openings; wherein the tubular support body comprises a plurality of discrete struts coupled by a plurality of rotatable hinge joints, each rotatable hinge joint comprising an axis of rotation with a radial orientation; wherein the plurality of rotatable hinge joints comprise: a set of proximal rotatable hinge joints configured to reside in a proximal plane with the proximal opening; a set of distal rotatable hinge joints configured to reside in a distal plane with the distal opening; a first set of middle rotatable hinge joints, located between the proximal plane and the distal plane; and at least one commissural point hinge joint distal to the distal plane; wherein the plurality of discrete struts and the rotatable hinge joints therebetween intrinsically provide a self-expansion force; and wherein the plurality of discrete struts comprise a plurality of inner struts and a plurality of outer struts.

The support structure may have at least one commissural point articulation is linked by at least two of the plurality of discrete struts to two commissural base articulations. The two commissural base articulations may be located at or proximal to the distal plane. When the tubular support body is in an expanded state, the first set of middle rotatable articulations, may be located closer to the proximal plane than the distal plane. The plurality of discrete struts may comprise a plurality of inner struts, a plurality of outer struts, and at least a pair of an inner commissural strut and an outer commissural strut. Each of the plurality of inner struts may be coupled to two of the plurality of outer struts, and either a third strut from the plurality of outer struts or one of the at least one outer commissural struts. Each of the plurality of outer struts is coupled to two of the plurality of inner struts, and either a third strut from the plurality of inner struts or one of the at least one inner commissural struts. When the tubular support body is in an expanded state, the average angle of the at least one commissural point articulation may be less than the average angle of the set of distal rotatable articulations. Each of the plurality of inner

struts that is not coupled to a commissural strut and each of the plurality of outer struts that is not coupled to a commissural strut has a first length, and wherein each of the plurality of inner struts that is coupled to a commissural strut and each of the plurality of outer struts coupled to a commissural strut has a second length, and the second length may be different from the first length, or the second length may shorter than the first length. When the tubular support body is in the expanded state, a distance between the at least one commissural point articulation and the distal plane may be at least 20% of a longitudinal distance between the proximal and distal planes. The support structure may further comprise an expandable hourglass securing body comprising a proximal opening, and a distal opening, with a lumen and a longitudinal axis between the proximal and distal openings, and wherein the tubular support body may be configured to reside within the lumen of the expandable hourglass securing body. The expandable hourglass structure may comprise a distal tapered section, a proximal tapered section, and a narrow section therebetween, and wherein the tubular support body may be secured to the narrow section. The expandable hourglass securing body may comprise a

plurality of discrete non-linear struts interconnected by rotatable articulations with a rotation of axis in a radial orientation. The support structure may further comprise at least one locking ring secured to at least one of the distal tapered section and the proximal tapered section. The at least one locking ring may be located within the lumen of the expandable securing body. The at least one locking ring may comprise a plurality of inner struts and a plurality of outer struts interconnected by rotatable articulations with a rotation of axis in a radial orientation.

[0021] Disclosed herein is a biocompatible articulated support structure, comprising a tubular structure comprising a central lumen, a central axis, a plurality of discrete inner struts, and a plurality of discrete outer struts, wherein each of the plurality of discrete inner struts and the plurality of discrete outer struts comprises first end, a second end, and a net length therebetween, and wherein each of the plurality of discrete inner struts comprises articulations with at least two different discrete outer struts of the plurality of discrete outer struts, and wherein each of the plurality of discrete outer struts comprises articulations with at least two different discrete inner struts of the plurality of discrete inner struts, and wherein no discrete inner strut of the plurality of discrete inner struts comprises articulations with any other discrete inner strut of the plurality of discrete inner struts, and wherein no discrete outer strut of the plurality of discrete outer struts comprises articulations with any other discrete outer strut of the plurality of discrete outer struts, and wherein at least one strut from either the plurality of discrete inner struts or the plurality of discrete outer struts comprises first end, a second end, and a net length therebetween, and wherein the first end of the at least one strut is spaced apart from a closest articulation by about at least 25% of the net length of that strut. The first end of each of the plurality of discrete outer struts may be spaced apart from a closest articulation by about at least 25% of its net length. The second end of each of the plurality of discrete outer struts may be spaced apart from a closest articulation by about at least 25% of its net length. The first end of each of the plurality of discrete inner struts may be spaced apart from a closest articulation by about at least 25% of its net length. The second end of each of the plurality of discrete inner struts may be spaced apart from a closest articulation by about at least 25% of its net length.

[0022] Disclosed herein is a biocompatible articulated support structure, comprising a tubular structure comprising a central lumen, a central axis, a plurality of discrete inner struts, a plurality of discrete outer struts, and at least one bow strut,

wherein each of the plurality of discrete inner struts, the plurality of discrete outer struts and the at least one bow strut comprises first end, a second end, and a net length therebetween, and wherein each of the plurality of discrete inner struts comprises articulations with at least two different discrete outer struts of the plurality of discrete outer struts, and wherein each of the plurality of discrete outer struts comprises articulations with at least two different discrete inner struts of the plurality of discrete inner struts, and wherein no discrete inner strut of the plurality of discrete inner struts comprises articulations with any other discrete inner strut of the plurality of discrete inner struts, and wherein no discrete outer strut of the plurality of discrete outer struts comprises articulations with any other discrete outer strut of the plurality of discrete outer struts, and wherein the at least one bow strut comprises a first articulation with a first strut selected from either the plurality of discrete inner struts and the plurality of discrete outer struts, and a second articulation with a second strut selected from the same plurality of discrete inner struts or plurality of discrete outer struts. The first strut and the second struts may be directly adjacent struts. The at least one bow strut may be an inner bow strut wherein the first and second struts may be selected from the plurality of discrete inner struts. The at least one bow strut may be a plurality of inner bow struts. The at least one bow strut may be an outer bow strut wherein the first and second struts may be selected from the plurality of discrete outer struts. The at least one bow strut may be a plurality of outer bow struts. The support structure may further comprise a secondary structure located between the plurality of outer bow struts and the plurality of discrete outer struts. The secondary structure may be a circumferential tubular balloon.

[0023] Disclosed herein is a biocompatible articulated structure, comprising a tubular structure comprising a central lumen, a central axis, a plurality of discrete inner struts, a plurality of discrete outer struts, and at least two radial struts, wherein each of the plurality of discrete inner struts and the plurality of discrete outer struts comprises first end, a second end, and a net length therebetween, and wherein each of the at least two radial struts comprises an outer end, an inner end and a net length therebetween, wherein each outer end is coupled to at least one strut selected from the plurality of discrete inner struts and the plurality of discrete outer struts, and wherein the inner ends of the at least two radial struts are coupled together, and wherein each of the plurality of discrete inner struts comprises articulations with at least three different discrete outer struts of the plurality of discrete outer struts, and wherein each of the plurality of discrete outer struts comprises articulations with at least three different discrete inner struts of the plurality of discrete inner struts, and wherein no

discrete inner strut of the plurality of discrete inner struts comprises articulations with any other discrete inner strut of the plurality of discrete inner struts, and wherein no discrete outer strut of the plurality of discrete outer struts comprises articulations with any other discrete outer strut of the plurality of discrete outer struts. The inner ends of the at least two radial struts may be coupled at centrally aligned coupling apertures. The inner ends of the at least two radial struts may be coupled at coupling apertures using a loop coupling structure. The at least two radial struts may comprise a first plurality of radial struts and a second plurality of radial struts, wherein each outer end of the first plurality of radial struts may be coupled to the first ends of at least one strut selected from the plurality of discrete inner struts and the plurality of discrete outer struts, and wherein each outer end of the second plurality of radial struts may be coupled to the second ends of at least one strut selected from the plurality of discrete inner struts and the plurality of discrete outer struts. The inner ends of the first plurality of radial struts may be coupled together and the inner ends of the second plurality of radial struts may be coupled together. The inner ends of the first plurality of radial struts may be attached to a first deployment structure and the inner ends of the second plurality of radial struts may be attached to a second deployment structure. The inner ends of the first plurality of radial struts may be attached to a first region of a deployment structure and the inner ends of the second plurality of radial struts may be attached to a second region of the deployment structure. The deployment structure may be a screw drive mechanism. The structure may further comprise a delivery catheter permanently attached to the tubular structure. The delivery catheter may comprise a plurality of wires electrically coupled to the tubular structure.

[0024] Disclosed herein is a biocompatible articulated structure, comprising a tubular structure comprising a central lumen, a central axis, a plurality of discrete inner struts, and a plurality of discrete outer struts, wherein each of the plurality of discrete inner struts and the plurality of discrete outer struts comprises first end, a second end, and a net length therebetween, wherein each of the plurality of discrete inner struts comprises articulations with at least four different discrete outer struts of the plurality of discrete outer struts, and wherein each of the plurality of discrete outer struts comprises articulations with at least four different discrete inner struts of the plurality of discrete inner struts, and wherein no discrete inner strut of the plurality of discrete inner struts comprises articulations with any other discrete inner strut of the plurality of discrete inner struts, and wherein no discrete outer strut of the plurality of discrete outer struts comprises articulations with any other discrete outer strut of

the plurality of discrete outer struts, and wherein at least one strut from either the plurality of discrete inner struts or the plurality of discrete outer struts comprises first end, a second end, and a net length therebetween; and wherein the plurality of discrete inner struts, the plurality of discrete outer struts and the articulations therebetween intrinsically provide a self-expansion force. The tubular structure may comprise an intrinsically stable non-expanding collapsed state. The plurality of discrete inner struts and the plurality of discrete outer struts may be configured to form a first set of cells aligned along a first perimeter of the tubular structure and a second set of cells directly adjacent to the first set of cells and aligned along a second perimeter of the tubular structure. The plurality of discrete inner struts comprises articulations with at least five different discrete outer struts of the plurality of discrete outer struts, wherein each of the plurality of discrete outer struts may comprise articulations with at least five different discrete inner struts of the plurality of discrete inner struts, and wherein the plurality of discrete inner struts and the plurality of discrete outer struts may be further configured to form a third set of cells directly adjacent to the second set of cells and aligned along a third perimeter of the tubular structure.

[0025] Disclosed herein is a biocompatible articulated structure comprising a tubular structure comprising a central lumen, a central axis, a plurality of discrete inner struts, a plurality of discrete outer struts, and a plurality of discrete commissure struts, wherein each of the plurality of discrete inner struts and the plurality of discrete outer struts comprises a first end, a second end, and a net length therebetween, and wherein each of the plurality of discrete inner struts comprises articulations with at least three different discrete outer or commissure struts of the pluralities of discrete outer and commissure struts, and wherein each of the plurality of discrete outer struts comprises articulations with at least three different discrete inner or commissure struts of the pluralities of discrete inner and commissure struts, and wherein each of the plurality of discrete commissure struts comprises articulations with one discrete outer or inner strut of the pluralities of discrete outer and inner struts and with one other discrete commissure strut of the plurality of discrete commissure struts, and wherein no discrete inner strut of the plurality of inner struts comprises articulations with any other discrete inner strut of the plurality of discrete inner struts; and wherein no discrete outer strut of the plurality of discrete outer struts comprises articulations with any other discrete outer strut of the plurality of discrete outer struts.

[0026] Disclosed herein is a biocompatible articulated support structure, comprising an hourglass structure comprising a central lumen, a central axis, a plurality of discrete inner struts, and a plurality of discrete outer struts, wherein each of the plurality of discrete inner struts and the plurality of discrete outer struts comprises a first end, a second end, and a net length therebetween; and wherein each of the plurality of discrete inner struts and the plurality of discrete outer struts has a helical configuration with the helical axis aligned with the central axis of the structure; and wherein each of the plurality of discrete inner struts comprises two articulations with a single discrete outer strut of the plurality of discrete outer struts, and at least one articulation with a different discrete outer strut of the plurality of discrete outer struts; and wherein each of the plurality of discrete outer struts comprises two articulations with a single discrete inner strut of the plurality of discrete inner struts, and at least one articulation with a different discrete inner strut of the plurality of discrete inner struts; and wherein no discrete inner strut of the plurality of inner struts comprises articulations with any other discrete inner strut of the plurality of discrete inner struts; and wherein no discrete outer strut of the plurality of discrete outer struts comprises articulations with any other discrete outer strut of the plurality of discrete outer struts; and wherein the diameter of the support structure at either end of the central axis is greater than the diameter of the support structure at the midpoint of the central axis.

[0027] Disclosed herein is a biocompatible articulated support structure, comprising a tubular structure comprising a central lumen, a central axis, a plurality of discrete inner struts, and a plurality of discrete outer struts, wherein each of the plurality of discrete inner struts and the plurality of discrete outer struts comprises a first end, a second end, and a net length therebetween, wherein each of the plurality of discrete inner struts comprises articulations with at least three different discrete outer struts of the plurality of discrete outer struts, and wherein each of the plurality of discrete outer struts comprises articulations with at least three different discrete inner struts of the plurality of discrete inner struts, and wherein no discrete inner strut of the plurality of inner struts comprises articulations with any other discrete inner strut of the plurality of discrete inner struts, and wherein no discrete outer strut of the plurality of discrete outer struts comprises articulations with any other discrete outer strut of the plurality of discrete outer struts, and wherein the support structure is in an unstressed state when in a fully expanded configuration.

[0028] Disclosed herein is a biocompatible articulated support structure, comprising a valve structure, comprising a tubular structure comprising a central lumen, a central axis, a plurality of discrete inner struts, a plurality of discrete outer struts, and a plurality of discrete commissure struts, wherein each of the plurality of discrete inner struts and the plurality of discrete outer struts comprises a first end, a second end, and a net length therebetween, wherein each of the plurality of discrete inner struts comprises articulations with at least three different discrete outer or commissure struts of the pluralities of discrete outer and commissure struts, and wherein each of the plurality of discrete outer struts comprises articulations with at least three different discrete inner or commissure struts of the pluralities of discrete inner and commissure struts, and wherein each of the plurality of discrete commissure struts comprises articulations with one discrete outer or inner strut of the pluralities of discrete outer and inner struts and with one other discrete commissure strut of the plurality of discrete commissure struts, and wherein no discrete inner strut of the plurality of inner struts comprises articulations with any other discrete inner strut of the plurality of discrete inner struts, and wherein no discrete outer strut of the plurality of discrete outer struts comprises articulations with any other discrete outer strut of the plurality of discrete outer struts, and a fixation structure, comprising an hourglass structure comprising a central lumen, a central axis, a plurality of discrete inner struts, and a plurality of discrete outer struts, wherein each of the plurality of discrete inner struts and the plurality of discrete outer struts comprises a first end, a second end, and a net length therebetween, and wherein each of the plurality of discrete inner struts and the plurality of discrete outer struts has a helical configuration with the helical axis aligned with the central axis of the structure, and wherein each of the plurality of discrete inner struts comprises two articulations with a single discrete outer strut of the plurality of discrete outer struts, and at least one articulation with a different discrete outer strut of the plurality of discrete outer struts, and wherein each of the plurality of discrete outer struts comprises two articulations with a single discrete inner strut of the plurality of discrete inner struts, and at least one articulation with a different discrete inner strut of the plurality of discrete inner struts, and wherein no discrete inner strut of the plurality of inner struts comprises articulations with any other discrete inner strut of the plurality of discrete inner struts, and wherein no discrete outer strut of the plurality of discrete outer struts comprises articulations with any other discrete outer strut of the plurality of discrete outer struts, and wherein the diameter of the support structure at either end of the central axis is greater than the diameter of the support structure at the midpoint of the

central axis, at least two locking ring structures, comprising a tubular structure comprising a central lumen, a central axis, a plurality of discrete inner struts, a plurality of discrete outer struts, wherein each of the plurality of discrete inner struts and the plurality of discrete outer struts comprises a first end, a second end, and a net length therebetween, wherein each of the plurality of discrete inner struts comprises articulations with at least three different discrete outer struts of the plurality of discrete outer struts, and wherein each of the plurality of discrete outer struts comprises articulations with at least three different discrete inner struts of the plurality of discrete inner struts, and wherein no discrete inner strut of the plurality of inner struts comprises articulations with any other discrete inner strut of the plurality of discrete inner struts, and wherein no discrete outer strut of the plurality of discrete outer struts comprises articulations with any other discrete outer strut of the plurality of discrete outer struts, and wherein the support structure is in an unstressed state when in a fully expanded configuration, and wherein the central axes of the valve structure, fixation structure, and two locking ring structures are aligned, and wherein the valve structure is attached to at least one point to the fixation structure, and wherein each of the two locking ring structures is attached to at least one point to the fixation structure.

[0029] Disclosed herein is a biocompatible support structure delivery system, comprising an expandable support structure having proximal and distal ends, at least one ring attached to the proximal end of the support structure, at least one ring attached to the distal end of the support structure, wherein the at least one rings are attached to the support structure by loops, such that the rings can rotate freely within the loops, and wherein the rings are configured to attach to a control catheter assembly.

[0030] Disclosed herein is a method for implanting a biocompatible support structure, wherein the biocompatible support structure comprises an expandable support structure having proximal and distal ends, at least one ring attached to the proximal end of the support structure, and at least one ring attached to the distal end of the support structure, and wherein the rings are configured to attach to a control catheter assembly, comprising connecting the at least one ring attached to the proximal end of the support structure to the control catheter assembly, connecting the at least one ring attached to the distal end of the support structure to the control catheter assembly, using the control catheter assembly to move the distal end of the support structure toward the proximal end of the support structure, wherein

CLAIMS

1. A biocompatible articulated support structure, comprising a tubular support body with a proximal opening, a distal opening, and a lumen and a longitudinal axis between the proximal and distal openings;

wherein the tubular support body comprises a plurality of discrete struts coupled by a plurality of rotatable hinge joints, each rotatable hinge joint comprising an axis of rotation with a radial orientation;

wherein the plurality of rotatable hinge joints comprise:

a set of proximal rotatable hinge joints configured to reside in a proximal plane with the proximal opening;

a set of distal rotatable hinge joints configured to reside in a distal plane with the distal opening;

a first set of middle rotatable hinge joints, located between the proximal plane and the distal plane; and

at least one commissural point hinge joint distal to the distal plane;

wherein the plurality of discrete struts and the rotatable hinge joints therebetween intrinsically provide a self-expansion force; and

wherein the plurality of discrete struts comprise a plurality of inner struts and a plurality of outer struts.

2. The biocompatible articulated support structure of claim 1, wherein each of the at least one commissural point hinge joint is linked by at least two of the plurality of discrete struts to two commissural base hinge joints.

3. The biocompatible articulated support structure of claim 2, wherein the two commissural base hinge joints are located at or proximal to the distal plane.

4. The biocompatible articulated support structure of claim 1, wherein the first set of middle rotatable hinge joints, when the tubular support body is in an expanded state, are located closer to the proximal plane than the distal plane.

5. The biocompatible articulated support structure of claim 1, wherein the plurality of inner struts comprises at least one commissural strut, and the plurality of outer struts comprises at least one commissural strut.

6. The biocompatible articulated support structure of claim 1, wherein when the tubular support body is in an expanded state, the average angle of the at least one commissural point hinge joint is less than the average angle of the set of distal rotatable hinge joints.

7. The biocompatible articulated support structure of claim 1, wherein when the tubular support body is in an expanded state, a distance between the at least one commissural point hinge joint and the distal plane is at least 20% of a longitudinal distance between the proximal and distal planes.

8. The biocompatible articulated support structure of claim 1, further comprising an expandable hourglass securing body comprising a proximal opening, and a distal opening, with a lumen and a longitudinal axis between the proximal and distal openings, and wherein the tubular support body is configured to reside within the lumen of the expandable hourglass securing body.

9. The biocompatible articulated support structure of claim 8, wherein the expandable hourglass securing body comprises a distal tapered section, a proximal tapered section, and a narrow section therebetween, and wherein the tubular support body is secured to the narrow section.

10. The biocompatible articulated support structure of claim 9, wherein the expandable hourglass securing body comprises a plurality of discrete non-linear struts interconnected by rotatable hinge joints, each rotatable hinge joint comprising an axis of rotation with a radial orientation.

11. The biocompatible articulated support structure of claim 9, further comprising at least one locking ring secured to at least one of the distal tapered section and the proximal tapered section.

12. The biocompatible articulated support structure of claim 11, wherein the at least one locking ring is located within the lumen of the expandable hourglass securing body.

13. The biocompatible articulated support structure of claim 11, wherein the at least one locking ring comprises a plurality of inner struts and a plurality of outer struts interconnected by rotatable hinge joints, each rotatable hinge joint comprising an axis of rotation with a radial orientation.