

Listing of Claims

1. A delivery apparatus configured to provide visual feedback of radial expansion of a prosthetic valve, the delivery apparatus comprising:
a first portion configured to maintain a fixed spatial relationship relative to a first end of the prosthetic valve and a second portion configured to maintain a fixed spatial relationship relative to a second end of the prosthetic valve during radial expansion of the prosthetic valve;
wherein the first portion comprises one or more reference radiopaque markers and the second portion comprises an indicator radiopaque marker, wherein a position of the indicator radiopaque marker relative to the one or more reference radiopaque markers measures an axial distance between the first and second ends of the prosthetic valve indicative of a corresponding diameter of the prosthetic valve as it is radially expanded from a radially compressed state to a radially expanded state.
2. The delivery apparatus of claim 1, wherein the first portion is configured to be detachably connected to the prosthetic valve and the second portion is configured to move axially relative to the first portion as the prosthetic valve is radially expanded from the radially compressed state to the radially expanded state.
3. The delivery apparatus of claim 1, wherein the second portion is configured to be detachably connected to the prosthetic valve and the first portion is configured to move axially relative to the second portion as the prosthetic valve is radially expanded from the radially compressed state to the radially expanded state.
4. The delivery apparatus of any of claims 1-3, wherein the reference and indicator radiopaque markers are configured to be positioned outside of a frame of the prosthetic valve.
5. The delivery apparatus of any of claims 1-4, wherein the one or more reference radiopaque markers comprise a first reference radiopaque marker and a second

reference radiopaque marker spaced apart from the first reference radiopaque marker, and wherein while the prosthetic valve is expanded from the radially compressed state to the radially expanded state, alignment of the indicator radiopaque marker with the first reference radiopaque marker indicates a first expanded diameter of the prosthetic valve, and alignment of the indicator radiopaque marker with the second reference radiopaque marker indicates a second expanded diameter of the prosthetic valve.

6. The delivery apparatus of any of claims 1-5, wherein the first portion and the second portion are configured to interface with an expansion mechanism of the prosthetic valve such that relative movement between the first and second portions in a first direction causes the prosthetic valve to expand from the radially compressed state to the radially expanded state, and relative movement between the first and second portions in a second direction opposite the first direction causes the prosthetic valve to compress from the radially expanded state to the radially compressed state.

7. The delivery apparatus of claim 6, wherein the expansion mechanism comprises a locking mechanism configured to lock the prosthetic valve in a fixed diameter, wherein the locking mechanism is actuated when a locking member is moved to a locking position by the first or second portion.

8. The delivery apparatus of claim 7, wherein at least one of the indicator and reference radiopaque markers is configured to align with a radiopaque portion of the prosthetic valve when the locking member is moved to the locking position.

9. A prosthetic valve delivery assembly comprising:
a prosthetic valve having an inflow end and an outflow end; and
a delivery apparatus comprising a first portion and a second portion;
wherein the second portion is configured to move axially relative to the first portion as the prosthetic valve is radially expanded from a radially compressed state to a radially expanded state;

wherein the first portion comprises one or more reference radiopaque marker and the second portion comprises an indicator radiopaque marker, wherein a position of the indicator radiopaque marker relative to the one or more reference radiopaque markers measures an axial length of the prosthetic valve indicative of a corresponding diameter of the prosthetic valve.

10. The assembly of claim 9, wherein the first portion maintains a fixed spatial relationship relative to the outflow end and the second portion maintains a fixed spatial relationship relative to the inflow end during radial expansion of the prosthetic valve.

11. The assembly of claim 9, wherein the first portion maintains a fixed spatial relationship relative to the inflow end and the second portion maintains a fixed spatial relationship relative to an outflow end during radial expansion of the prosthetic valve.

12. The assembly of any of claims 9-11, wherein the prosthetic valve comprises a valve expansion mechanism, the valve expansion mechanism comprising an inner member received at least partially within an outer member, wherein axial movement of the inner member relative to the outer member causes radial expansion or compression of the prosthetic valve.

13. The assembly of claim 12, wherein the first portion is configured to be connected to the outer member and the second portion is configured to be connected to the inner member such that retracting the second portion axially relative to the first portion causes axial movement of the inner member relative to the outer member.

14. The assembly of any of claims 9-13, wherein the reference and indicator radiopaque markers are configured to be positioned outside of a frame of the prosthetic valve such that the reference and indicator radiopaque markers are visible under fluoroscopy during radial expansion of the prosthetic valve.

15. The assembly of any of claims 9-14, wherein the at least one reference radiopaque marker comprises a first reference radiopaque marker and a second reference radiopaque marker spaced apart from the first reference radiopaque marker, and wherein while the prosthetic valve is expanded from the radially compressed state to the radially expanded state, alignment of the indicator radiopaque marker with the first reference radiopaque marker indicates a first expanded diameter of the prosthetic valve, and alignment of the indicator radiopaque marker with the second reference radiopaque marker indicates a second expanded diameter of the prosthetic valve.

16. A delivery apparatus configured to provide visual feedback of radial expansion of a prosthetic valve, the delivery apparatus comprising:

a first portion and a second portion that are configured to interface with a valve expansion mechanism of the prosthetic valve;

wherein the second portion is configured to move axially relative to the first portion when actuating the valve expansion mechanism for radial expansion or compression of the prosthetic valve;

wherein the first portion comprises one or more reference radiopaque markers, and the second portion comprises an indicator radiopaque marker;

wherein a position of the indicator radiopaque marker relative to the one or more reference radiopaque markers indicates a radial diameter of the prosthetic valve.

17. The delivery apparatus of claim 16, wherein the first portion is configured to maintain a fixed spatial relationship relative to an inflow end of the prosthetic valve and a second portion is configured to maintain a fixed spatial relationship relative to an outflow end of the prosthetic valve during radial expansion of the prosthetic valve.

18. The delivery apparatus of any of claims 16-17, wherein the first portion is releasably connected to a first member of a valve expansion mechanism and the second portion is releasably connected to a second member of the valve expansion mechanism, wherein axial movement of the second portion relative to the first portion is associated with

corresponding axial movement of the second member relative to the first member of the valve expansion mechanism which causes radial expansion or compression of the prosthetic valve.

19. The delivery apparatus of claim 18, wherein the second portion is configured to move a locking member mounted on the second member of the expansion mechanism to a locking position so as to lock the prosthetic valve in a fixed diameter.

20. The delivery apparatus of claim 19, wherein the indicator radiopaque marker is configured to align with a proximal end portion of the first member of a valve expansion mechanism when the locking member is moved to the locking position.

21. The delivery apparatus of any of claims 16-20, wherein the indicator radiopaque marker is configured to be positioned outside of a frame of the prosthetic valve during radial expansion or compression of the prosthetic valve.

22. The delivery apparatus of any of claims 16-21, wherein the one or more reference radiopaque markers comprise a first reference radiopaque marker and a second reference radiopaque marker spaced apart from the first reference radiopaque marker, and wherein while the prosthetic valve is expanded from a radially compressed state to a radially expanded state, alignment of the indicator radiopaque marker with the first reference radiopaque marker indicates a first expanded diameter of the prosthetic valve, and alignment of the indicator radiopaque marker with the second reference radiopaque marker indicates a second expanded diameter of the prosthetic valve.

23. The delivery apparatus of claim 22, wherein the second reference radiopaque marker is located proximal to the first reference radiopaque marker and the second expanded diameter is larger than the first expanded diameter.

24. The delivery apparatus of any of claims 16-23, wherein the one or more reference radiopaque markers comprise at least three reference radiopaque markers that are spaced with equal distance between any pair of adjacent reference radiopaque markers.

25. The delivery apparatus of any of claims 16-23, wherein the one or more reference radiopaque markers comprise at least three reference radiopaque markers that are spaced with unequal distance between pairs of adjacent reference radiopaque markers.

26. The delivery apparatus of any of claims 16-25, wherein the indicator radiopaque marker is one of a plurality of indicator radiopaque markers, wherein a distance between at least a pair of adjacent indicator radiopaque markers is different from a distance between at least a pair of adjacent reference radiopaque markers.

27. A delivery apparatus configured to provide visual feedback of radial expansion of a prosthetic valve, the delivery apparatus comprising:

- a support tube;

- a locking tool extending through a lumen of the support tube; and

- an actuator member extending through a lumen of the locking tool;

wherein the support tube is configured to interface with a sleeve of a valve expansion mechanism, the locking tool and the actuator member are configured to interface with an actuator screw of the valve expansion mechanism, and wherein axial movement of the actuator screw relative to the sleeve causes radial expansion or compression of the prosthetic valve;

wherein the support tube comprises one or more reference radiopaque markers and the locking tool comprises an indicator radiopaque marker, wherein a position of the indicator radiopaque marker relative to the one or more reference radiopaque markers indicates a radial diameter of the prosthetic valve.

28. The delivery apparatus of claim 27, wherein a distal end of the support tube is configured to abut a proximal end of sleeve so as to prevent the support tube and the sleeve from moving further toward each other, and a distal end portion of the actuator member is configured to be releasably connected to a proximal portion of the actuator screw such that axial movement of the actuator member relative to the support tube can cause axial

movement of the actuator screw relative to the sleeve, thereby causing radial expansion or compression of the prosthetic valve.

29. The delivery apparatus of any of claims 27-28, wherein the locking tool is threadably coupled to the actuator member such that rotation of the locking tool causes the locking tool to move axially along the actuator screw.

30. The delivery apparatus of claim 29, wherein a distal end of the locking tool is configured to engage or disengage a locking nut mounted on the actuator screw such that rotation of the locking tool in a first direction causes the locking tool to engage the locking nut, whereas rotation of the locking tool in a second direction opposite the first direction causes the locking tool to disengage the locking nut.

31. The delivery apparatus of claim 30, wherein further rotation of the locking tool in the first direction after engaging the locking nut causes the locking nut to move distally along the actuator screw to a locking position located at a distal end of the sleeve so as to lock the prosthetic valve in a fixed diameter.

32. The delivery apparatus of claim 31, wherein the indicator radiopaque marker is configured to align with a proximal end portion of the sleeve when the locking nut is moved to the locking position.

33. The delivery apparatus of any of claims 27-32, wherein the indicator radiopaque marker is configured to be positioned outside of a frame of the prosthetic valve during radial expansion or compression of the prosthetic valve.

34. The delivery apparatus of any of claims 27-33, wherein a distal end portion of the support tube comprises a radiolucent material such that the indicator radiopaque marker on the locking tool is visible under fluoroscopy.

35. The delivery apparatus of any of claims 27-34, wherein a distal end portion of the support tube comprises a cut-out window such that the indicator radiopaque marker on the locking tool is visible through the cut-out window under fluoroscopy.

36. The delivery apparatus of any of claims 27-35, wherein the one or more reference radiopaque markers are so spaced on the support tube that during radial expansion of the prosthetic valve, alignment of the indicator radiopaque marker with the one or more reference radiopaque markers indicates a corresponding diameter of the prosthetic valve.

37. A prosthetic valve delivery assembly comprising:
a prosthetic valve comprising a valve expansion mechanism; and
a delivery apparatus comprising a first portion and a second portion that interface with the valve expansion mechanism;

wherein the second portion is configured to move axially relative to the first portion when actuating the valve expansion mechanism for radial expansion or compression of the prosthetic valve;

wherein the first portion comprises one or more reference radiopaque markers, and the second portion comprises an indicator radiopaque marker;

wherein a position of the indicator radiopaque marker relative to the one or more reference radiopaque markers indicates a radial diameter of the prosthetic valve.

38. The assembly of claim 37, wherein the first portion is configured to maintain a fixed spatial relationship relative to an inflow end of the prosthetic valve and a second portion is configured to maintain a fixed spatial relationship relative to an outflow end of the prosthetic valve during radial expansion of the prosthetic valve.

39. The assembly of any of claims 37-38, wherein the valve expansion mechanism comprises an inner member received at least partially within an outer member, wherein axial movement of the inner member relative to the outer member causes radial expansion or compression of the prosthetic valve.

40. The assembly of claim 39, wherein the first portion is configured to be connected to the outer member and the second portion is configured to be connected to the inner member such that axial movement of the inner member relative to the outer member causes corresponding axial movement of the second portion relative to the first portion.

41. The assembly of any of claims 39-40, wherein a distal end of the first portion is configured to abut a proximal end of outer member so as to prevent the first portion and the outer member from moving further toward each other.

42. The assembly of claim 41, wherein the delivery apparatus further comprises an actuator member, wherein a distal end portion of the actuator member is configured to be releasably connected to a proximal portion of the inner member such that axial movement of the actuator member can cause corresponding axial movement of the inner member relative to the outer member, thereby causing radial expansion or compression of the prosthetic valve.

43. The assembly of any of claims 39-42, wherein the second portion is threadably coupled to the inner member such that rotation of the second portion causes the second portion to move axially along the inner member.

44. The assembly of claim 43, wherein a distal end of the second portion is configured to engage or disengage a locking member mounted on the inner member such that rotation of the second portion in a first direction causes the second portion to engage the locking member, whereas rotation of the second portion in a second direction opposite the first direction causes the second portion to disengage the locking member.

45. The assembly of claim 44, wherein the locking member is configured to lock the prosthetic valve in a fixed diameter when the locking member is located at a predefined locking position inside the outer member.

46. The assembly of claim 45, wherein further rotation of the second member in the first direction after engaging the locking member causes the locking member to move along the inner member to the predefined locking position.

47. The assembly of claim 46, wherein the indicator radiopaque marker is configured to align with a proximal end portion of the outer member when the locking member is moved to the predefined locking position.

48. The assembly of any of claims 37-47, wherein the indicator radiopaque marker is configured to be positioned outside of a frame of the prosthetic valve during radial expansion or compression of the prosthetic valve.

49. The assembly of any of claims 37-48, wherein the one or more reference radiopaque markers are so spaced on the first portion that during radial expansion of the prosthetic valve, alignment of the indicator radiopaque marker with the one or more reference radiopaque markers indicates a corresponding diameter of the prosthetic valve.

50. The assembly of any of claims 37-49, wherein the one or more reference radiopaque markers are configured to be visually distinguishable from the indicator radiopaque marker under fluoroscopy.