

WHAT IS CLAIMED IS:

1. A method of suturing an implant device, the method comprising:
passing, using a first needle gripper and a second needle gripper, a needle through a surface of the implant device, the first needle gripper moving toward the implant device along a needle path;
adjusting a position of the implant device;
passing, using the first needle gripper and the second needle gripper, the needle back through the surface of the implant device, the first needle gripper moving away from the implant device along the needle path;
moving a thread coupled to the needle so that it is clear of the needle path; and
applying a targeted tension to the thread.
2. The method of claim 1, wherein applying the targeted tension includes applying an increasing tension during a portion of the method and applying a steady state tension after the increasing tension exceeds a tension threshold.
3. The method of claim 2, wherein the tension threshold is greater than or equal to about 0.4 N.
4. The method of any one of claims 2-3, wherein the steady state tension is less than or equal to about 0.3 N.
5. The method of any one of claims 1-4, wherein moving the thread to clear the needle path includes moving the thread orthogonal to the needle path.
6. The method of any one of claims 1-5 further comprising releasing the thread after applying the targeted tension to the thread.
7. The method of any one of claims 1-6, wherein adjusting the position of the implant device includes rotating the implant device.

8. The method of any one of claims 1-7, wherein adjusting the position of the implant device includes moving the implant device orthogonal to the needle path.

9. The method of any one of claims 1-8, wherein the needle path is a fixed linear path.

10. The method of any one of claims 1-9 further comprising releasing the thread while the first needle gripper moves away from the implant device along the needle path.

11. The method of any one of claims 1-10 wherein the first needle gripper and the second needle gripper are automated.

12. The method of any one of claims 1-11 wherein applying a targeted tension to the thread is automated.

13. An automated suturing system comprising:

a first automated fixture comprising a plurality of actuator devices and a holder, the first automated fixture being configured to adjust an orientation of a target device when mounted to the holder;

a second automated fixture comprising a first needle gripper and a second needle gripper that are configured to pass a needle back and forth through a surface of the target device to form sutures with a thread coupled to the needle, the first gripper configured to trace a needle path; and

a thread management system comprising a thread movement device configured to move a thread orthogonal to the needle path and a tensioning device configured to apply a targeted tension to the thread.

14. The automated suturing system of claim 13, wherein the target device is a heart valve or a component of a heart valve.

15. The automated suturing system of any one of claims 13-14, wherein the tensioning device includes a tensioning pin that is configured to apply tension to the thread.

16. The automated suturing system of any one of claims 13-15, wherein the automated suturing system is configured to repeatedly perform a suturing pattern to successively form sutures on the target device.

17. The automated suturing system of claim 16, wherein the tensioning device is configured to provide an increasing tension during a portion of the suturing pattern and to provide a steady state tension after the increasing tension exceeds a tension threshold.

18. The automated suturing system of claim 17, wherein the tension threshold is at least about 0.4 N.

19. The automated suturing system of claim 18, wherein the steady state tension is less than or equal to about 0.3 N.

20. The automated suturing system of any one of claims 13-19, wherein the thread movement device includes two or more support pins.

21. A thread management system comprising:
a thread movement device configured to move a thread orthogonal to a needle path to clear the needle path for an automated suturing system; and
a tensioning device configured to apply a targeted tension to the thread to form a stitch in a target device.

22. The thread management system of claim 21, wherein the thread movement device includes a support pin to achieve a targeted direction for the targeted tension relative to the thread.

23. The thread management system of any one of claims 21-22, wherein the tensioning device includes a tensioning pin.

24. The thread management system of claim 23, wherein the tensioning pin is configured to apply the targeted tension to the thread.

25. The thread management system of any one of claims 21-24, wherein the tensioning device is configured to provide an increasing tension

until reaching a tension threshold and to provide a steady state tension after the increasing tension exceeds the tension threshold.

26. The thread management system of any one of claims 21-25, wherein the thread movement device is configured to release the thread while the tensioning device applies tension to the thread.

27. An automated suturing system comprising:

a first automated fixture and a holder, the first automated fixture being configured to adjust an orientation of a target device when held by the holder;

a second automated fixture comprising a first needle gripper and a second needle gripper that are configured to pass a needle back and forth through a surface of the target device to form sutures with a thread coupled to the needle; and

the thread management system of any one of claims 21-26.

28. A method of suturing a target device, the method comprising:

operating an automated suturing system to suture a target device, wherein the automated suturing system is programmed to perform programmed steps, the programmed steps including:

passing, using a first needle gripper and a second needle gripper, a needle through a surface of the target device, the first needle gripper moving toward the target device along a needle path;

adjusting a position of the target device;

passing, using the first needle gripper and the second needle gripper, the needle back through the surface of the target device, the first needle gripper moving away from the target device along the needle path;

moving a thread coupled to the needle so that it is clear of the needle path; and

applying a targeted tension to the thread.

29. The method of claim 28, wherein applying the targeted tension includes applying an increasing tension until a tension threshold is exceeded, and then applying a steady state tension after the tension threshold has been exceeded.

30. The method of claim 29, wherein the tension threshold is greater than or equal to about 0.4 N.

31. The method of any one of claims 29-30, wherein the steady state tension is less than or equal to about 0.3 N.

32. The method of any one of claims 28-31, wherein moving the thread to clear the needle path includes moving the thread orthogonal to the needle path.

33. The method of any one of claims 28-32 wherein the programmed steps further include releasing the thread after applying the targeted tension to the thread.

34. The method of any one of claims 28-33, wherein adjusting the position of the target device includes rotating the target device.

35. The method of any one of claims 28-34, wherein adjusting the position of the target device includes moving the target device orthogonal to the needle path.

36. The method of any one of claims 28-35, wherein the needle path is a fixed linear path.

37. The method of any one of claims 28-36 wherein the programmed steps further include releasing the thread while the first needle gripper moves away from the target device along the needle path.

38. The method of any one of claims 28-37 wherein operating the automated suturing system to suture a target device comprises causing the automated suturing system to perform the programmed steps.