

EXPANDABLE DRUG DELIVERY DEVICES AND METHODS OF USE

CROSS-REFERENCE TO PRIORITY DOCUMENT

[0001] This application claims the benefit of priority of U.S. Provisional Patent Application Serial No. 62/077,829, entitled “Expandable Drug Delivery Devices and Methods of Use,” filed November 10, 2014. Priority of the filing date is hereby claimed and the disclosure of the provisional patent application is hereby incorporated by reference in its entirety.

BACKGROUND

[0002] Diseases that affect vision can be treated with a variety of therapeutic agents, but the delivery of drugs to the eye continues to be challenging. Injections of therapeutic via the eye can be painful, involve some risk of infection, hemorrhage and retinal detachment. Depending on the frequency, intra-ocular injections can be time-consuming for both patient and physician. Consequently, in at least some instances the drug may be administered less often than the prescribed frequency resulting in sub-optimal treatment benefit. Further, bolus intra-ocular injections may not provide the ideal pharmacokinetics and pharmacodynamics. A bolus injection of drug into the vitreous humor of a patient can result in a peak drug concentration several times higher than the desired therapeutic amount and then before the patient is able to get the next injection drop to a drug concentration that is far below therapeutic effectiveness.

SUMMARY

[0002a] According to a first aspect of the present invention, there is provided a drug delivery device configured to be at least partially implanted in an eye, the device comprising: a retention structure positioned near a proximal end region of the device; a penetrable element coupled to and extending within at least a portion of the retention structure; a porous drug release element positioned in fluid communication with an outlet of the device; an elongated core element having a longitudinal axis; and a reservoir positioned around the elongated core element, the reservoir having a volume configured to contain one or more therapeutic agents and to be in fluid communication with the outlet through the porous drug

release element, wherein the device is configured to be at least partially inserted into the eye, and wherein the reservoir is configured to enlarge from an insertion configuration having a first three-dimensional shape to a deployed configuration having a second three-dimensional shape, wherein the second three-dimensional shape is eccentrically positioned relative to the longitudinal axis of the elongated core element.

[0002b] According to a second aspect of the present invention, there is provided a drug delivery device, the device comprising: a proximal end region of the device comprising a retention structure and a penetrable element coupled to and extending within at least a portion of the retention structure; and a distal end region of the device configured to be at least partially implanted into an eye, the distal end region comprising: a porous drug release element positioned in fluid communication with an outlet of the device; an elongated core element; and a reservoir positioned around the elongated core element, the reservoir having a volume configured to contain one or more therapeutic agents and to be in fluid communication with the outlet through the porous drug release element, wherein the reservoir is configured to enlarge from an insertion configuration to a deployed configuration, wherein after at least partial implantation in the eye along an axis of insertion, a wall of the reservoir is configured to unfold asymmetrically relative to the elongated core element towards the deployed configuration.

[0003] **[0002c]** According to a third aspect of the present invention, there is provided a drug delivery device configured to be at least partially implanted in an eye, the device comprising: a reservoir formed of non-compliant material, the reservoir forming a volume configured to contain one or more therapeutic agents; an elongated core element extending through the volume between a proximal end region of the reservoir and a distal end region of the reservoir, the elongated core element having a wall surrounding a lumen, an inlet to the lumen, an outlet from the lumen, and one or more openings extending through the wall of the elongated core element between the inlet and the outlet, wherein the lumen is in fluid communication with the volume of the reservoir via the one or more openings; and a porous drug release element positioned within the outlet and configured to release the one or more therapeutic agents from the volume through the porous drug release element, wherein the non-compliant material of the reservoir is configured to collapse around the elongated core element forming a first three-dimensional shape prior to filling the volume with the one or more therapeutic agents when the device is in an insertion configuration, and wherein the

non-compliant material of the reservoir is configured to eccentrically enlarge away from the elongated core element to form a second three-dimensional shape upon filling the volume with the one or more therapeutic agents when the device is in a deployed configuration. Disclosed herein is a drug delivery device configured to be at least partially implanted in an eye. The device includes a retention structure positioned near a proximal end region of the device; a penetrable element coupled to and extending within at least a portion of the retention structure; a porous drug release mechanism positioned in fluid communication with an outlet of the device; and a reservoir having a volume configured to contain one or more therapeutic agents and to be in fluid communication with the outlet through the porous drug release mechanism. The device is configured to be at least partially inserted into the eye along an axis of insertion. The reservoir is configured to enlarge from

maintain a position of the reservoir. The distal extension of the neck can prevent contact between the reservoir and internal surfaces of the eye adjacent the penetration site. An upper surface of the proximal flange element can indicate orientation of the reservoir in the expanded configuration. The upper surface of the flange element can include an orientation indicator visible to a user from outside the eye. The orientation indicator can be a shape of the flange element or a mark on the upper surface of the flange element. The distal extension of the neck can provide stabilization of the neck to maintain a position of the reservoir as indicated by the orientation indicator.

[0007] Disclosed herein is a drug delivery device that includes a proximal end region of the device having a retention structure and a penetrable element coupled to and extending within at least a portion of the retention structure; and a distal end region of the device configured to be at least partially implanted into an eye. The distal end region can include a porous drug release mechanism positioned in fluid communication with an outlet of the device; and a reservoir having a volume configured to contain one or more therapeutic agents and to be in fluid communication with the outlet through the porous drug release mechanism. The reservoir is configured to enlarge from an insertion configuration to an expanded configuration. After at least partial implantation in the eye along an axis of insertion, the device is configured to be changed from a first shape in which the distal end region of the device is aligned with the axis of insertion to a second shape in which the distal end region of the device is not aligned with the axis of insertion. The second shape can be a curvilinear shape that remains outside the visual axis of the eye and avoids contact with internal surfaces of the eye adjacent a penetration site. The expanded configuration of the reservoir can include a symmetrical expansion. The expanded configuration of the reservoir can be an asymmetrical expansion.

[0008] Disclosed herein is a drug delivery device configured to be at least partially implanted in an eye that includes a reservoir formed of non-compliant material forming a volume configured to contain one or more therapeutic agents. The device includes a central core element extending through the volume between a proximal end region of the reservoir and a distal end region of the reservoir. The central core element has a wall surrounding a lumen, an inlet to the lumen, an outlet from the lumen, and one or more openings extending through the wall of the central core element between the inlet and the outlet. The lumen is in fluid communication with the volume of the reservoir via the one or

Claims:

1. A drug delivery device configured to be at least partially implanted in an eye, the device comprising:

a retention structure positioned near a proximal end region of the device;

a penetrable element coupled to and extending within at least a portion of the retention structure;

a porous drug release element positioned in fluid communication with an outlet of the device;

an elongated core element having a longitudinal axis; and

a reservoir positioned around the elongated core element, the reservoir having a volume configured to contain one or more therapeutic agents and to be in fluid communication with the outlet through the porous drug release element,

wherein the device is configured to be at least partially inserted into the eye, and

wherein the reservoir is configured to enlarge from an insertion configuration having a first three-dimensional shape to a deployed configuration having a second three-dimensional shape, wherein the second three-dimensional shape is eccentrically positioned relative to the longitudinal axis of the elongated core element.

2. The device of claim 1, wherein a first portion of the volume of the reservoir in the deployed configuration unfolds away from the lens of the eye and is greater than a remaining portion of the volume.

3. The device of claim 2, wherein the first portion and the remaining portion each remain outside the visual axis of the eye.

4. The device of claim 1, wherein the reservoir is formed of a non-compliant material that enlarges in a non-distensible manner to the deployed configuration.

5. The device of claim 4, wherein the non-compliant material of the reservoir deploys from the first three-dimensional shape to the second three-dimensional shape, but does not stretch beyond the second three-dimensional shape.

6. The device of claim 1, wherein a proximal end of the reservoir is separated a distance from one or more internal tissue surfaces surrounding penetration site of the eye when in the deployed configuration.

7. The device of claim 1, wherein the device remains outside the visual axis in the deployed configuration.

8. The device of claim 1, wherein the elongated core element extends from the proximal end region of the device to a distal end region of the device.

9. The device of claim 8, wherein the drug release element is coupled to the elongated core element near the distal end region of the device and the retention structure is coupled to the elongated core element near the proximal end region of the device.

10. The device of claim 8, wherein the elongated core element comprises an inner lumen and one or more openings extending through a wall of the elongated core element.

11. The device of claim 10, wherein the inner lumen of the elongated core element is in fluid communication with the reservoir volume through the one or more openings.

12. The device of claim 11, wherein the one or more openings direct flow of material injected into the device into the reservoir volume and allow diffusion of material from the reservoir volume through the porous drug release element.

13. The device of claim 11, wherein the elongated core element comprises a cylindrical geometry and further comprises a flow director to direct flow through the one more openings.

14. The device of claim 13, wherein the flow director comprises a first cylindrical region coupled to a second cylindrical region by a funnel shaped region, wherein the first cylindrical region has a larger cross-sectional diameter than the second cylindrical region.

15. The device of claim 13, wherein the flow director comprises a penetrable barrier positioned within the inner lumen of the elongated core element, wherein the penetrable barrier seals the inner lumen.

16. The device of claim 8, wherein the retention structure comprises a proximal flange element configured to extend outside a sclera of the eye and a neck, the neck having a

proximal region configured to extend through a penetration site in the sclera of the eye and a distal extension extending inside the vitreal cavity of the eye.

17. The device of claim 16, wherein the distal extension of the neck surrounds a portion of the elongated core element near the proximal end of the device providing stabilization of the neck to maintain a position of the reservoir.

18. The device of claim 17, wherein the distal extension of the neck prevents contact between the reservoir and internal surfaces of the eye adjacent the penetration site.

19. The device of claim 17, wherein an upper surface of the proximal flange element indicates orientation of the reservoir in the deployed configuration.

20. The device of claim 19, wherein the upper surface of the flange element comprises an orientation indicator visible to a user from outside the eye.

21. The device of claim 20, wherein the orientation indicator is a shape of the flange element or a mark on the upper surface of the flange element.

22. The device of claim 20, wherein the distal extension of the neck provides stabilization of the neck to maintain a position of the reservoir as indicated by the orientation indicator.

23. The device of claim 20, wherein the orientation indicator indicates to the user a direction of eccentricity of the second three-dimensional shape.

24. The device of claim 23, wherein the direction of eccentricity of the second three-dimensional shape is relative to the longitudinal axis of the elongated core element.

25. The device of claim 1, wherein the elongate core element is substantially rigid relative to a wall of the reservoir.

26. A drug delivery device, the device comprising:

a proximal end region of the device comprising a retention structure and a penetrable element coupled to and extending within at least a portion of the retention structure; and

a distal end region of the device configured to be at least partially implanted into an eye, the distal end region comprising:

a porous drug release element positioned in fluid communication with an outlet of the device;

an elongated core element; and

a reservoir positioned around the elongated core element, the reservoir having a volume configured to contain one or more therapeutic agents and to be in fluid communication with the outlet through the porous drug release element, wherein the reservoir is configured to enlarge from an insertion configuration to a deployed configuration,

wherein after at least partial implantation in the eye along an axis of insertion, a wall of the reservoir is configured to unfold asymmetrically relative to the elongated core element towards the deployed configuration.

27. The device of claim 26, further comprising a flow director positioned within a lumen of the elongated core element, the flow director configured to facilitate filling of the reservoir volume.

28. The device of claim 27, wherein the flow director comprises a first cylindrical region coupled to a second cylindrical region by a funnel-shaped region to direct flow through one or more openings in the elongated core element, wherein the first cylindrical region has a larger cross-sectional diameter than the second cylindrical region.

29. The device of claim 26, wherein the wall of the reservoir configured to unfold asymmetrically formed a major portion of the reservoir relative to the elongated core element and a minor portion relative to the elongated core element.

30. The device of claim 29, wherein after expansion of the reservoir into the deployed configuration inside the eye, the major portion is directed away from anterior tissue of a vitreal cavity of the eye.

31. The device of claim 26, wherein the elongate core element is substantially rigid relative to the wall of the reservoir.

32. The device of claim 26, wherein the elongated core element extends from the proximal end region of the device to the distal end region of the device.

33. The device of claim 32, wherein the retention structure comprises a proximal flange element configured to extend outside a sclera of the eye and a neck, the neck having a proximal region configured to extend through a penetration site in the sclera of the eye and a distal extension extending inside the sclera of the eye.

34. The device of claim 33, wherein the distal extension of the neck surrounds a portion of the elongated core element near the proximal end of the device providing stabilization of the neck to maintain a position of the reservoir.

35. The device of claim 34, wherein the distal extension of the neck prevents contact between the reservoir and internal surfaces of the eye adjacent the penetration site.

36. The device of claim 34, wherein an upper surface of the proximal flange element indicates orientation of the reservoir in the deployed configuration.

37. The device of claim 36, wherein the upper surface of the flange element comprises an orientation indicator visible to a user from outside the eye.

38. The device of claim 37, wherein the orientation indicator indicates to an observer a direction of eccentricity of the second three-dimensional shape.

39. The device of claim 37, wherein the orientation indicator indicates to an observer a direction of eccentricity of the second three-dimensional shape relative to the longitudinal axis of the elongated core element.

40. A drug delivery device configured to be at least partially implanted in an eye, the device comprising:

a reservoir formed of non-compliant material, the reservoir forming a volume configured to contain one or more therapeutic agents;

an elongated core element extending through the volume between a proximal end region of the reservoir and a distal end region of the reservoir, the elongated core element having a wall surrounding a lumen, an inlet to the lumen, an outlet from the lumen, and one or more openings extending through the wall of the elongated core element between the inlet and the outlet, wherein the lumen is in fluid communication with the volume of the reservoir via the one or more openings; and

a porous drug release element positioned within the outlet and configured to release the one or more therapeutic agents from the volume through the porous drug release element,

wherein the non-compliant material of the reservoir is configured to collapse around the elongated core element forming a first three-dimensional shape prior to filling the volume with the one or more therapeutic agents when the device is in an insertion configuration, and

wherein the non-compliant material of the reservoir is configured to eccentrically enlarge away from the elongated core element to form a second three-dimensional shape upon filling the volume with the one or more therapeutic agents when the device is in a deployed configuration.

41. The device of claim 40, further comprising a retention structure positioned near a proximal end region of the device and a penetrable element coupled to and extending within at least a portion of the retention structure.

42. The device of claim 40, further comprising a flow director positioned within the lumen of the elongated core element, the flow director configured to facilitate filling of the reservoir volume.

43. The device of claim 42, wherein the flow director comprises a first cylindrical region coupled to a second cylindrical region by a funnel-shaped region to direct flow through the one or more openings in the elongated core element, wherein the first cylindrical region has a larger cross-sectional diameter than the second cylindrical region.

44. The device of claim 40, wherein the second three-dimensional shape has a major portion relative to the elongated core element and a minor portion relative to the elongated core element.

45. The device of claim 44, wherein after expansion of the reservoir into the deployed configuration inside the eye, the major portion is directed away from anterior tissue of a vitreal cavity of the eye.

46. The device of claim 40, wherein the one or more openings direct flow of material injected into the device into the reservoir volume and allow diffusion of material from the reservoir volume through the porous drug release element positioned within the outlet.

47. The device of claim 40, wherein the non-compliant material of the reservoir is configured to collapse from the deployed configuration towards the insertion configuration upon application of aspiration within the reservoir volume.