CLAIMS

What is claimed is:

1. A device to deliver fluid to an ear, the device comprising:
a handle portion comprising a proximal end and a distal end;
a needle sub-assembly coupled to the distal end of the handle portion, the needle sub-assembly comprising a bent needle; and
tubing coupled to the proximal end of the handle portion,
wherein the bent needle extends through the handle portion and fluidly connects directly to the tubing.

2. The device of claim 1, further comprising a telescoping support coupled to a proximal end of the needle sub-assembly.

3. The device of claim 1 and 2, wherein the distal end of the handle is coupled to a proximal end of the telescoping support.

4. The device of claim 2 or 3, wherein the telescoping support comprises multiple nested hypotubes.

5. The device of any one of the preceding claims, wherein the bent needle comprises:
an angled tip for piercing at least one membrane; and
a bent portion.

6. The device of any one of the preceding claims, comprising:
a strain relief feature coupled to the proximal end of the handle portion.

7. The device of any one of the preceding claims, comprising a camera (e.g., a distal tip camera, wherein the distal tip camera is positioned within the needle sub-assembly).

~~8. The device of any one of the preceding claims, wherein the tubing couples to the bent needle within a hollow interior of the handle portion.~~

~~9. The device of claim 8, wherein the tubing comprises an inner diameter from about 0.005 inches to about 0.01 inches.~~

~~10. The device of any one of the preceding claims, wherein the bent portion has a length from about 0.5 mm to about 5 mm (e.g., from about 1 mm to about 3 mm, e.g., about 1.4 mm).~~

~~11. The device of any one of the preceding claims, wherein the angle is from about 20 degree to about 70 degrees (e.g., from about 20 degrees to about 60 degrees, e.g., from about 20 degrees to about 50 degrees, e.g., from about 20 degrees to about 40 degrees, e.g., about 30 degrees, e.g., from about 30 degrees to about 70 degrees, e.g., from about 40 degrees to about 60 degrees, e.g., about 55 degrees).~~

~~12. The device of any one of the preceding claims, wherein the angle is about 30 degrees.~~
~~13. The device of any one of the preceding claims, wherein the angle is about 55 degrees.~~

~~14. The device of any one of the preceding claims, wherein the bent needle comprises a gauge within a range from about 10 to about 35, e.g., from about 20 to about 35, e.g., from about 30 to about 35, e.g., a 33 gauge.~~

~~15. The device of any one of the preceding claims, wherein the bent needle comprises stainless steel.~~

~~16. The device of any one of the preceding claims, comprising an adhesive disposed on the proximal end and distal end of the handle portion.~~

~~17. The device of any one of the preceding claims, comprising a stopper coupled to the bent needle, wherein the stopper is shaped and sized for positioning within the inner ear and controlling a distance that the angled tip projects into a cochlea.~~

~~18. The device of any one of the preceding claims, wherein the stopper comprises a cylinder-disk shape.~~

~~19. The device of any one of the preceding claims, wherein the stopper is molded in place onto the bent needle, and~~
~~wherein the stopper prevents the bent needle from being inserted into at least one membrane beyond a desired amount.~~

~~20. The device of any one of the preceding claims, wherein the stopper is positioned at a distance of about 0.2 mm to about 1.2 mm (e.g., from about 0.4 mm to about 1.0 mm, e.g., from about 0.6 mm to about 0.9 mm, e.g., about 0.85 mm) from a distal end of the angled tip.~~

~~21. The device of any one of the preceding claims, wherein the stopper comprises a diameter from about 0.2 mm to about 1.2 mm (e.g., from about 0.4 mm to about 1.0 mm, e.g., from about 0.6 mm to about 0.9 mm, e.g., about 0.85 mm).~~

~~22. The device of any one of the preceding claims, wherein the stopper comprises a height from about 0.2 mm to about 1.0 mm (e.g., from about 0.3 mm to about 0.7 mm, e.g., from about 0.4 mm to about 0.6 mm, e.g., about 0.5 mm).~~

~~23. The device of claim 4, wherein each hyptotube of the multiple nested hypotubes comprises a gauge from about 10 to about 30. (e.g., 14XH, 20TW, 23XTW, and/or 27TW).~~

~~24. The device of claim 4, wherein each hyptotube of the multiple nested hypotubes comprises stainless steel.~~

~~25. The device of any one of the preceding claims, the handle portion further comprising a tapered portion disposed at the distal end of the handle, the telescoping support coupling to the tapered portion wherein the handle tapers down to the first distal end (e.g., such that the second proximal end of the telescoping support is coupled to the first distal end).~~

~~26. The device of any one of the preceding claims, wherein the telescoping support tapers from an outer diameter of about 0.2 inches or less at a proximal end to an outer diameter of about 0.01 inches or more at a distal end.~~

~~27. The device of any one of the preceding claims, wherein the handle portion comprises machined grooves for tactility and control.~~

~~28. The device of any one of the preceding claims, wherein the handle portion is shaped and sized to facilitate placement into the inner ear.~~

~~29. The device of any one of the preceding claims, wherein the strain relief feature comprises layered extrusions (e.g., layered Pebax extrusions).~~

~~30. The device of any one of claims 6 to 29, wherein the strain relief feature prevents kinking and/or deformation of the tubing.~~

~~31. The device of any one of claims 8 to 30, wherein the tubing is coupled to the bent needle via compression fit.~~

~~32. The device of any one of claims 8 to 31, wherein the tubing comprises polyether ether ketone (PEEK).~~

~~33. The device of any one of claims 8 to 32, wherein the tubing comprises an inner diameter from about 0.003 inches to about 0.01 inches (e.g., about 0.007 inches).~~

~~34. The device of any one of claims 8 to 33, wherein the tubing comprises an outer diameter from about 1/64 inches to about 1/16 inches (e.g., about 1/32 inches).~~

~~35. The device from any one of claims 8 to 34, wherein the tubing comprises a length greater than 20 inches, e.g., greater than 30 inches, e.g., greater than 40 inches, e.g., greater than 50 inches, e.g., greater than 60 inches, e.g., about 60 inches.~~

~~36. The device of any one of the preceding claims, wherein the device is sterile and/or biocompatible.~~

~~37. The device of any one of the preceding claims, wherein the angled tip projects from the bent portion of the bent needle to form an outlet for dispensing fluid.~~

~~38. A system comprising the device of any one of the preceding claims and a sterilized syringe fluidly coupled to the tubing.~~

~~39. The system of claim 38, comprising a pump.~~

~~40. The system of claim 39, wherein the pump controls a flow rate of a fluid through any one of the devices (e.g., at a rate from about 10 μL/min to about 60 μL/min, e.g., from about 15 μL/min to about 55 μL/min, e.g., from about 20 μL/min to about 50 μL/min, e.g., from about 25 μL/min to about 45 μL/min, e.g., from about 25 μL/min to about 40 μL/min, e.g., from about 20 μL/min to about 35 μL/min, e.g., about 30 μL/min) (e.g., at a rate from about 10 μL/min to about 200 μL/min, e.g., from about 20 μL/min to about 180 μL/min, e.g., from about 30 μL/min to about 180 μL/min, e.g., from about 40 μL/min to about 150 μL/min, e.g., from about 50 μL/min to about 150 μL/min, e.g., from about 60 μL/min to about 140 μL/min, e.g., from about 70 μL/min to about 130 μL/min, e.g., from about 80 μL/min to about 120 μL/min, e.g., from about 90 μL/min to about 110 μL/min, e.g., about 100 μL/min).~~

~~41. A delivery system comprising:~~
~~a delivery device, the delivery device comprising:~~
~~a distal end; and~~
~~a stopper disposed at the distal end of the delivery device;~~

~~a distal tip camera disposed at the distal end of the delivery device, the distal tip camera comprising an image sensor; and~~

~~a monitor operatively coupled to the distal tip camera, wherein the monitor displays information received from the distal tip camera.~~

~~42. The system of claim 41, wherein the stopper is transparent.~~

~~43. The system of claim 41, wherein the stopper comprises a transparent portion for the distal tip camera to see through the stopper.~~

~~44. The system of claim 41, wherein the distal tip camera is disposed above the front surface of the stopper, the front surface of the stopper facing toward a target.~~

~~45. The system of claim 44, wherein the target is a part of an ear.~~

~~46. The system of claim 43, wherein the distal tip camera is embedded (e.g. integrated) within the stopper.~~

~~47. The system of claim 43, wherein the distal tip camera is disposed behind the stopper.~~

~~48. The system of claim 41, further comprising a wire that is operatively coupled between the distal tip camera and the monitor.~~

~~49. The system of claim 41, wherein the distal tip camera comprises autofocus features.~~

~~50. The system of claim 41, wherein the distal tip camera comprises at least one of a cuboid shape, a chip shape, a cylindrical shape, and combinations thereof.~~

~~51. The system of claim 41, wherein the image sensor comprises a field of view from about 90^{e} to about 150^{e}.~~

~~52. The system of claim 41, wherein the image sensor comprises at least one of a cuboid shape with dimensions of up to 10 mm x 10 mm with a height of up to 100 mm, and a cylindrical shape comprising an outer diameter of up to 10 mm with a length of up to 100 mm.~~

~~53. The system of claim 41, wherein the image sensor comprises an image array capable of capturing at least 10 x 10 pixels resolution video at a frame rate of at least 5 frames per second (fps).~~

~~54. The system of claim 41, wherein the image sensor comprises an image area of at most 10 mm x 10 mm.~~

~~55. The system of claim 41, wherein the image sensor comprises an optical format of up to 10 mm, and a pixel size of up to 10 µm.~~

~~56. The system of claim 41, comprising a processor operatively coupled to the image sensor.~~

~~57. The system of claim 41, comprising driver packages and/or software packages.~~

~~58. The system of claim 41, comprising at least one light source.~~

~~59. The system of claim 41, comprising an optical fiber.~~

~~60. A distal tip camera system, comprising:~~

~~an image sensor disposed at a distal end of a needle, the distal end of the needle comprising a stopper;~~

~~a wire operatively coupled to the image sensor;~~

~~a processor operatively coupled to the image sensor; and~~

~~a monitor operatively coupled to the processor to display information captured by the image sensor and processed by the processor.~~

~~61. A surgical procedure for delivering a therapeutic fluid to a portion of the inner ear (e.g., using any one of the devices of claims 1-37 or 83 or any one of the systems of claims 38-60) comprising:~~
~~developing a posterior tympanomeatal flap;~~
~~creating an opening in the stapes footplate;~~
~~piercing the round window with a needle positioned at the distal end of a fluid delivery device;~~
~~positioning the fluid delivery device at a desired insertion depth within the round window; and~~
~~flowing the therapeutic fluid through the fluid delivery device to the inner ear.~~

~~62. The procedure of claim 61, further comprising:~~
~~activating at least one of a distal tip camera, an endoscope, and an operating microscope prior to piercing the round window; and~~
~~monitoring at least one of the flow rate of therapeutic fluid and the distribution of therapeutic fluid across the inner ear via at least one of the distal tip camera, the endoscope, and the operating microscope prior to piercing the round window.~~

~~63. The procedure of claim 62, comprising activating a distal tip camera prior to piercing the round window, wherein the distal tip camera is communicatively coupled to at least one monitor viewable by a surgeon during the procedure.~~

~~64. The procedure of claim 61, wherein developing a posterior tympanomeatal flap comprises cutting the posterior tympanomeatal using at least one of a micro curette and a drill.~~

~~65. The procedure of claim 61, further comprising:~~
~~prepping and draping the ear prior to developing the posterior tympanomeatal flap;~~
~~positioning the patient prior to prepping and draping the ear;~~
~~inducing anesthesia prior to positioning the patient; and~~
~~marking the ear prior to inducing anesthesia.~~

~~66. The procedure of claim 61 further comprising:~~
~~connecting tubing between the fluid delivery device and an upstream pump prior to developing the posterior tympanomeatal flap;~~

~~sterilizing the fluid delivery device prior to developing the posterior tympanomeatal flap; and~~

~~priming the system prior to developing the posterior tympanomeatal flap.~~

~~67. The procedure of claim 61, wherein the therapeutic fluid comprises at least one viral gene therapy.~~

~~68. The procedure of claim 61, further comprising:~~

~~removing the fluid delivery device from the inner ear after flowing the therapeutic fluid through the fluid delivery device; and~~

~~applying at least one skin treatment to at least one of the round window membrane and the stapes footplate after removing the fluid delivery device.~~

~~69. The procedure of claim 68, further comprising returning the posterior tympanomeatal flap back to the original position after applying at least one skin treatment.~~

~~70. The procedure of claim 61, further comprising removing bone from the junction of the bony canal and the tympanic membrane, and/or pseudomembrane overhanging bone, after developing the posterior tympanomeatal flap.~~

~~71. The procedure of claim 70, further comprising using at least one of a diamond drill and an otologic drill to remove bone.~~

~~72. The procedure of claim 61, wherein creating an opening in the stapes footplate comprises creating an opening in the stapes footplate using a laser.~~

~~73. The procedure of claim 62, wherein the laser comprises an otologic laser.~~

~~74. The procedure of claim 61, further comprising applying at least one of an anesthetic and an adrenaline to the ear canal of the patient prior to developing the posterior tympanomeatal flap.~~

~~75. The procedure of claim 61, wherein prepping the ear further comprises applying at least one antiseptic to the ear.~~

~~76. The procedure of claim 75, wherein the at least one antiseptic comprises at least one of povidone-iodine, iodopovidone, betadine, wokadine, and pyodine.~~

~~77. The procedure of claim 68, wherein the at least one skin treatment comprises at least one of sodium hyaluronate and hyaluronic acid.~~

~~78. A method for delivering a therapeutic fluid to a portion of the inner ear (e.g., using any one of the devices of claims 1-37 or 83 or any one of the systems of claims 38-60) comprising:~~
~~creating an opening in the stapes footplate;~~
~~piercing the round window with a needle positioned at the distal end of a fluid delivery device;~~
~~positioning the fluid delivery device at a desired insertion depth within the round window; and~~
~~flowing the therapeutic fluid through the fluid delivery device to the inner ear,~~
~~wherein the therapeutic fluid comprises at least one viral gene therapy.~~

~~79. A method for delivering a therapeutic fluid to a portion of the inner ear (e.g., using any one of the devices of claims 1-37 or 83 or any one of the systems of claims 38-60) comprising:~~
~~creating an opening in the stapes footplate;~~
~~piercing the round window with a needle positioned at the distal end of a fluid delivery device;~~
~~positioning the fluid delivery device at a desired insertion depth within the round window; and~~
~~flowing the therapeutic fluid through the fluid delivery device to the inner ear,~~
~~wherein the desired insertion depth comprises a depth from about 0.7 mm to about 1.0 mm.~~

~~80. The method of claim 79, wherein flowing the therapeutic fluid through the fluid delivery device to the inner ear comprises flowing the therapeutic fluid at a flow rate from about 20 µL/min to about 100 µL/min.~~

~~81. The method of claim 79, wherein flowing the therapeutic fluid through the fluid delivery device to the inner ear comprises flowing a total volume of therapeutic fluid in a range from about 0.07 mL to about 0.11 mL.~~

~~82. The method of claim 79, wherein flowing the therapeutic fluid through the fluid delivery device to the inner ear comprises flowing therapeutic fluid for a time duration in a range from about 0.5 minutes to about 5 minutes.~~

~~83. A device to deliver fluid to an ear, the device comprising:~~
~~a handle portion comprising a proximal end and a distal end;~~
~~a telescoping support coupled to the distal end of the handle portion;~~
~~a needle sub-assembly coupled to the distal end of the telescoping support, the needle sub-assembly comprising a bent needle; and~~
~~tubing coupled to the proximal end of the handle portion.~~

~~84. A packaging system for holding a delivery device comprising a distal end and a stopper disposed at the distal end of the delivery device, the packaging system comprising:~~
~~a mounting surface; and~~
~~a device nesting for holding the delivery device,~~
~~wherein the device nesting is mounted on the mounting surface.~~

~~85. A packaging system for holding a delivery device, the packaging system comprising:~~
~~a mounting surface; and~~
~~a device nesting for holding the delivery device,~~
~~wherein the device nesting is mounted on the mounting surface.~~

~~86. The system of claim 85, comprising at least one pair of oppositely-oriented slits disposed within the mounting surface.~~

~~87. The system of claim 86, wherein the at least one pair of oppositely-oriented slits holds tubing fluidly coupled to a proximal end of the delivery device.~~

~~88. The system of claim 85, comprising a plurality of nesting notches disposed within the device nesting, the nesting notches holding at least one of a proximal end, a distal end, and a body portion of the delivery device.~~

~~89. The system of claim 85, comprising:~~
~~at least one attachment slit disposed within the mounting surface; and~~
~~at least one locking portion extending across the device nesting and attaching to the at least one attachment slit.~~

~~90. The system of claim 85, wherein in the device nesting is fiddle-shaped.~~

~~91. The system of claim 85, further comprising at least one twist tie for securing the delivery device to the device nesting.~~

~~92. The system of claim 86, wherein the at least one pair of oppositely-oriented slits comprise a pair of curved ends at either end to prevent the at least one pair of oppositely-oriented slits from causing damage to the mounting surface.~~

~~93. The system of claim 85, wherein the delivery device comprises:~~
~~a device body comprising a distal tip and a proximal end; and~~
~~tubing fluidly coupled to the proximal end.~~

~~94. A packaging system for holding a delivery device used to deliver therapeutic fluid to the inner ear, the packaging system comprising:~~
~~a mounting surface; and~~
~~a device nesting for holding the delivery device,~~
~~wherein the device nesting is mounted to the mounting surface.~~

~~95. The system of claim 94, further comprising:~~
~~PEEK tubing fluidly coupled upstream of the delivery device; and~~

~~a sleeve disposed around the PEEK tubing.~~

~~96. The system of claim 93, further comprising a sleeve disposed concentrically around the tubing to prevent kinking of the tubing.~~

~~97. The system of claim 96, wherein the sleeve is composed of a polymer material.~~

~~98. A surgical procedure for delivering a therapeutic fluid to a portion of the inner ear of a patient comprising:~~

~~injecting the therapeutic fluid via a delivery device as described herein into the inner ear.~~

~~99. The procedure of claim 98, further comprising:~~

~~performing a transcanal tympanotomy; and~~

~~performing a laser-assisted micro-stapedotomy.~~

~~100. A surgical procedure comprising:~~

~~performing a transcanal tympanotomy;~~

~~performing a laser-assisted micro-stapedotomy;~~

~~injecting therapeutic fluid via a delivery device as described herein into an inner ear of a patient;~~

~~applying sealant around at least one of a round window and an oval window of the patient; and~~

~~lowering a tympanomeatal flap of the patient to the anatomical position.~~

~~101. A surgical procedure for delivering a therapeutic fluid to a portion of the inner ear of a patient comprising:~~

~~performing a transcanal tympanotomy;~~

~~preparing a round window of the patient;~~

~~performing a laser-assisted micro-stapedotomy;~~

~~preparing both a delivery device and the therapeutic fluid for delivery to the inner ear;~~

injecting the therapeutic fluid via the delivery device to the inner ear;

applying sealant around at least one of the round window and an oval window of the patient; and

lowering a tympanomeatal flap of the patient to the anatomical position.

102. The procedure of claim 101, wherein performing a laser-assisted micro-stapedotomy comprises using at least one of a KTP otologic laser and a CO_2 otologic laser.

103. The procedure of claim 99, wherein the therapeutic fluid comprises an AAV vector.

104. The procedure of claim 103, wherein the AAV vector comprises an Anc80 AAV vector.

105. The procedure of claim 103, wherein the AAV vector comprises a coding region encoding hOTOF.

106. The device of claim 17, wherein the stopper is seated around a stopper anchoring groove disposed within the bent needle.

107. The device of claim 2, further comprising an annular brace disposed at an interface between the telescoping support and the handle portion.

108. The device of claim 6, further comprising at least one machined barb disposed at the proximal end of the handle portion, wherein the at least one machined barb interfaces with the strain relief feature and prevents axial movement between the handle portion and the strain relief feature.

CLAIMS

What is claimed is:

1. A device to deliver fluid to an ear, the device comprising:

a handle portion comprising a proximal end and a distal end;

a telescoping support coupled to the distal end of the handle portion;

a needle sub-assembly coupled to the distal end of the handle portion and coupled to the distal end of the telescoping support, the needle sub-assembly comprising a bent needle, the bent needle comprising:

an angled tip for piercing at least one membrane; and

a bent portion; and

tubing coupled to the proximal end of the handle portion,

wherein the bent needle extends through a hollow interior of the handle portion and fluidly connects directly to the tubing.

2. The device of claim 1, wherein the telescoping support comprises multiple nested hypotubes, each of the nested hypotubes comprising a gauge from 10 to 30, and each of the nested hypotubes comprising stainless steel.

3. The device of any one of the preceding claims, comprising:

a strain relief feature coupled to the proximal end of the handle portion,

wherein the strain relief feature prevents kinking and/or deformation of the tubing, and

wherein the strain relief feature comprises layered extrusions.

4. The device of any one of the preceding claims, comprising a distal tip camera positioned within the needle sub-assembly.

5. The device of any one of the preceding claims, wherein the bent portion of the bent needle has a length from 0.5 mm to 5 mm,

wherein the angle of the angled tip is from 20 degrees to 70 degrees, and

wherein the angled tip projects from the bent portion of the bent needle to form an outlet for dispensing fluid.

6. The device of any one of the preceding claims, the device comprising a stopper coupled to the bent needle, wherein the stopper is shaped and sized for positioning within the inner ear and controlling a distance that the angled tip projects into a cochlea.

7. The device of any one of the preceding claims, wherein the stopper comprises a cylindrical disk shape with a diameter from 0.2 mm to 1.2 mm and a height from 0.2 mm to 1.0 mm,

wherein the stopper is molded in place onto the bent needle at a distance of 0.2 mm to 1.2 mm from a distal end of the angled tip,

wherein the stopper prevents the bent needle from being inserted into at least one membrane beyond a desired amount, and

wherein the stopper is seated around a stopper anchoring groove disposed within the bent needle.

8. The device of any one of the preceding claims, wherein the handle portion further comprises:

machined grooves for tactility and control; and

a tapered portion disposed at the distal end of the handle, the telescoping support coupling to the tapered portion wherein the handle tapers down to the distal end such that the proximal end of the telescoping support is coupled to first distal end,

wherein the telescoping support tapers from an outer diameter of 0.2 inches or less at a proximal end to an outer diameter of 0.01 inches or more at a distal end.

9. The device of any one of the preceding claims, wherein the tubing is coupled to the bent needle via a compression fit,

wherein the tubing comprises polyether ether ketone (PEEK),

wherein the tubing comprises an inner diameter from 0.0003 inches to 0.01 inches,

wherein the tubing comprises an outer diameter from 1/64 inches to 1/16 inches, and

wherein the tubing comprises a length greater than 20 inches.

10. The device of claim 3, further comprising:

at least one machined barb disposed at the proximal end of the handle portion, wherein the at least one machined barb interfaces with the strain relief feature and prevents axial movement between the handle portion and the strain relief feature; and

an annular brace disposed at an interface between the telescoping support and the handle portion.

11. A system comprising:

the device of any one of the preceding claims;

a sterilized syringe fluidly coupled to the tubing; and

a pump fluidly coupled to the tubing,

wherein the pump controls flow of a fluid through the device at a flow rate from 10 μL/min to 200 μL/min.

12. A system for delivering a therapeutic fluid to a portion of an inner ear of a patient comprising:

means for developing a posterior tympanomeatal flap;

means for creating an opening in a stapes footplate of the inner ear; and

a fluid delivery device comprising a needle positioned at a distal end of the fluid delivery device, wherein the needle is configured to pierce a round window of the inner ear,

wherein the fluid delivery device is configured to be positioned at a desired insertion depth within the round window;

wherein the fluid delivery device is configured to deliver the therapeutic fluid to the inner ear, and

wherein the therapeutic fluid comprises at least one viral gene therapy.

13. The system of claim 12, further comprising:

an imaging device; and

a monitor communicatively coupled to the imaging device, the monitor viewable by a surgeon;

wherein the imaging device is activated prior to piercing the round window;

wherein the imaging device is configured to monitor at least one of a flow rate of therapeutic fluid and a distribution of therapeutic fluid across the inner ear , and

wherein the imaging device comprises at least one of a distal tip camera, an endoscope, and an operating microscope.

14. The system of claim 12, wherein the means for developing a posterior tympanomeatal flap comprises at least one of a micro curette and a drill for cutting the posterior tympanomeatal.

15. The system of claim 12, further comprising:

means for preparing and draping the ear prior to developing the posterior tympanomeatal flap, wherein the patient is positioned prior to preparing and draping the ear;

means for inducing anesthesia prior to positioning the patient; and

means for marking the ear prior to inducing anesthesia.

16. The system of claim 12, further comprising:

an upstream pump;

tubing for connecting the fluid delivery device to the upstream pump, wherein the tubing is connected prior to developing the posterior tympanomeatal flap; and

means for sterilizing the fluid delivery device prior to developing the posterior tympanomeatal flap,

wherein the system is primed prior to developing the posterior tympanomeatal flap.

17. The system of claim 12, wherein the fluid delivery device is removed from the inner ear after delivery of the therapeutic fluid; and

wherein at least one skin treatment is applied to at least one of the round window membrane and the stapes footplate after removal of the fluid delivery device; and

the system further comprising means for returning the posterior tympanomeatal flap back to an original position after application of the at least one skin treatment,

wherein the at least one skin treatment comprises at least one of sodium hyaluronate and hyaluronic acid.

18. The system of claim 12, further comprising means for removing bone from the junction of the bony canal and the tympanic membrane, and/or pseudomembrane overhanging bone, after developing the posterior tympanomeatal flap, wherein the means for removing bone comprises at least one of a diamond drill and an otologic drill.

19. The system of claim 12, wherein the means for creating an opening in the stapes footplate comprises an otologic laser.

20. The system of claim 12, further comprising means for applying at least one of an anesthetic and an adrenaline to the ear canal of the patient prior to developing the posterior tympanomeatal flap.

21. The system of claim 15, wherein the means for preparing the ear comprises means for applying at least one antiseptic to the ear, wherein the at least one antiseptic comprises at least one of povidone-iodine, iodopovidone, betadine, wokadine, and pyodine.

22. The system of claim 12, wherein the desired insertion depth comprises a depth from 0.7 mm to 1.0 mm.

23. The system of claim 12,

wherein the fluid delivery device is configured to deliver the therapeutic fluid to the inner ear at a flow rate from 20 µL/min to 100 µL/min,

wherein the fluid delivery device is configured to deliver to the inner ear a total volume of therapeutic fluid in a range from 0.07 mL to 0.11 mL, and

wherein the fluid delivery device is configured to deliver the therapeutic fluid for a time duration in a range from 0.5 min to 5 min.

24. A system for delivering a therapeutic fluid to a portion of an inner ear of a patient comprising:

means for performing a transcanal tympanotomy;

means for preparing a round window of the patient;

means for performing a laser-assisted micro-stapedotomy;

a delivery device configured to inject the therapeutic fluid to the inner ear;

means for applying sealant around at least one of the round window and an oval window of the patient; and

means for lowering a tympanomeatal flap of the patient to an anatomical position,

wherein the means for performing the laser-assisted micro-stapedotomy comprises at least one of a KTP otologic laser and a CO_2 otologic laser, and

wherein the therapeutic fluid comprises adeno-associated virus (AAV) vector that comprises an Anc80 AAV vector or a coding region encoding hOTOF.