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(54) **SOFT TISSUE CONDUIT DEVICE**

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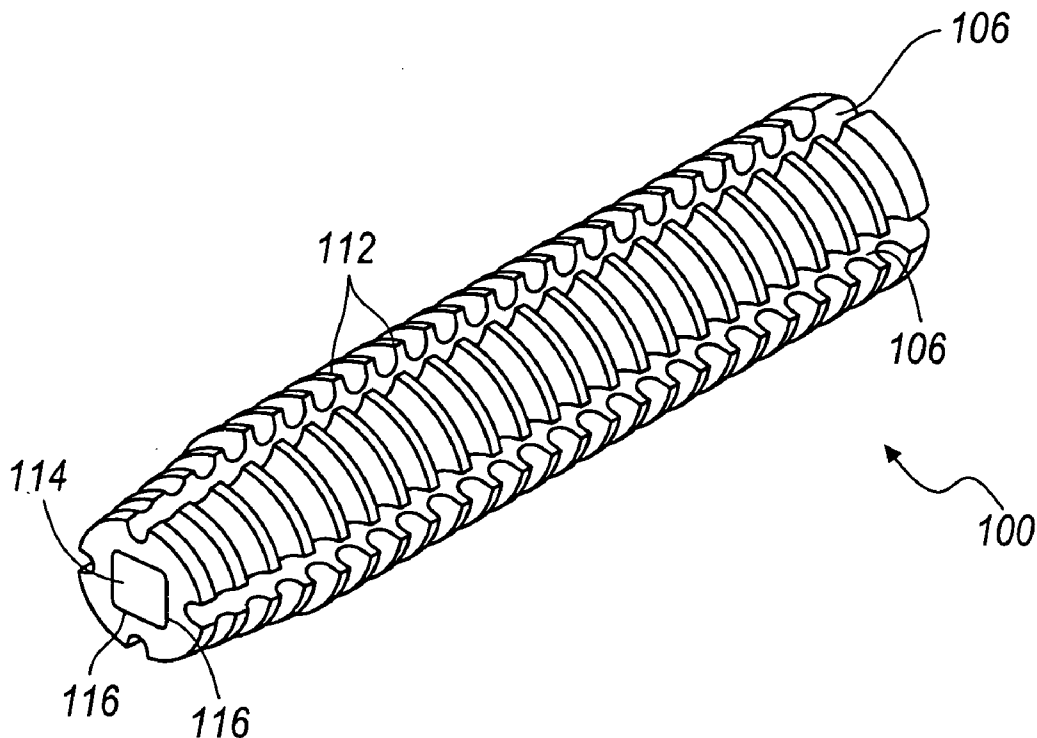
(51) **Int. Cl.**

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(52) **U.S. Cl.** **606/73**

(57) **ABSTRACT**

A soft tissue conduit device. The device includes an elongated body having an outer surface, the elongated body defining a plurality of longitudinal external channels, each longitudinal channel defining a conduit open to the outer surface of the elongated body, each conduit operable to conduct a biological material in soft tissue.



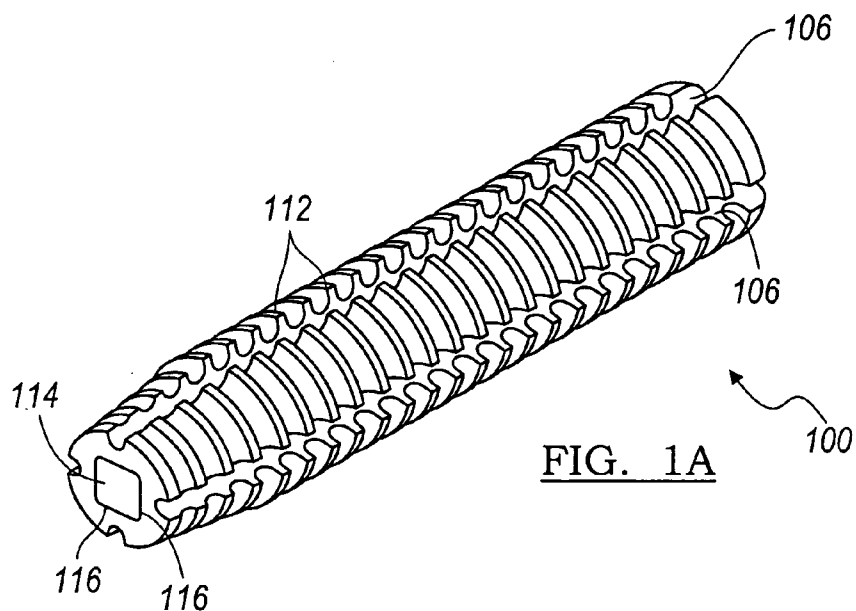


FIG. 1A

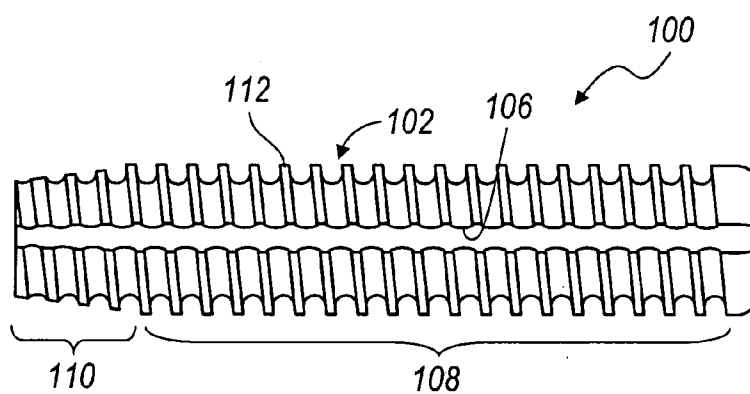


FIG. 1B

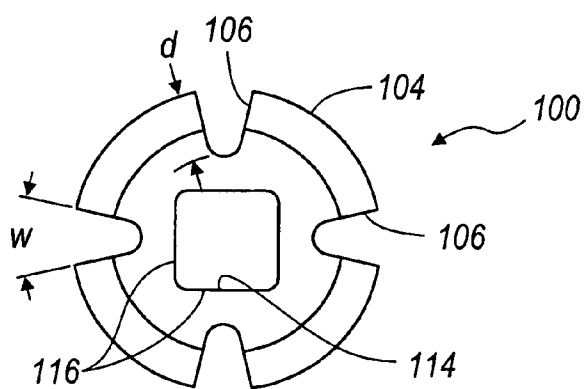


FIG. 1C

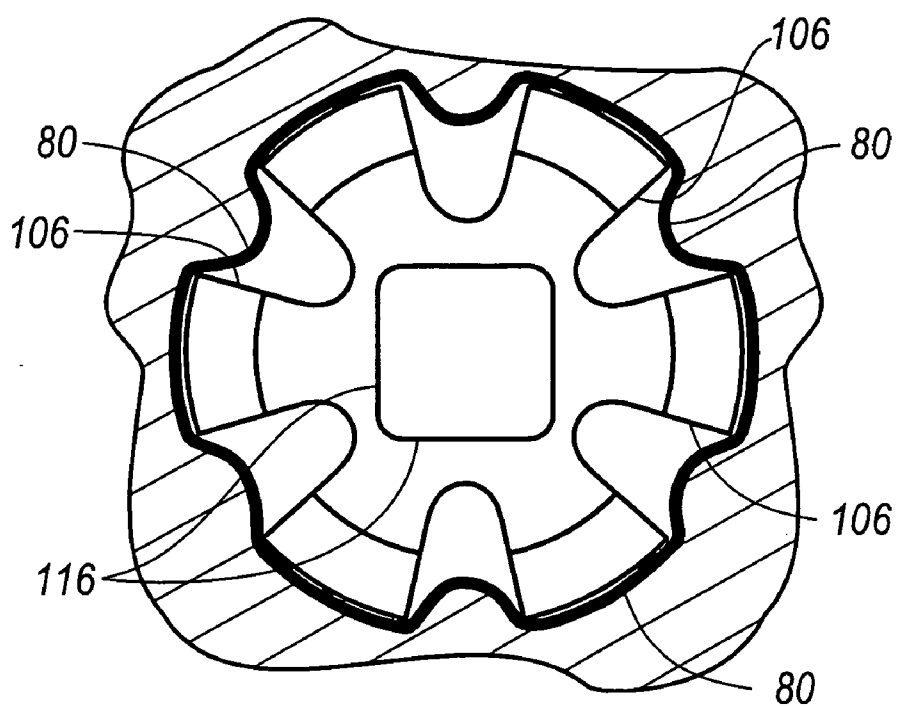


FIG. 1D

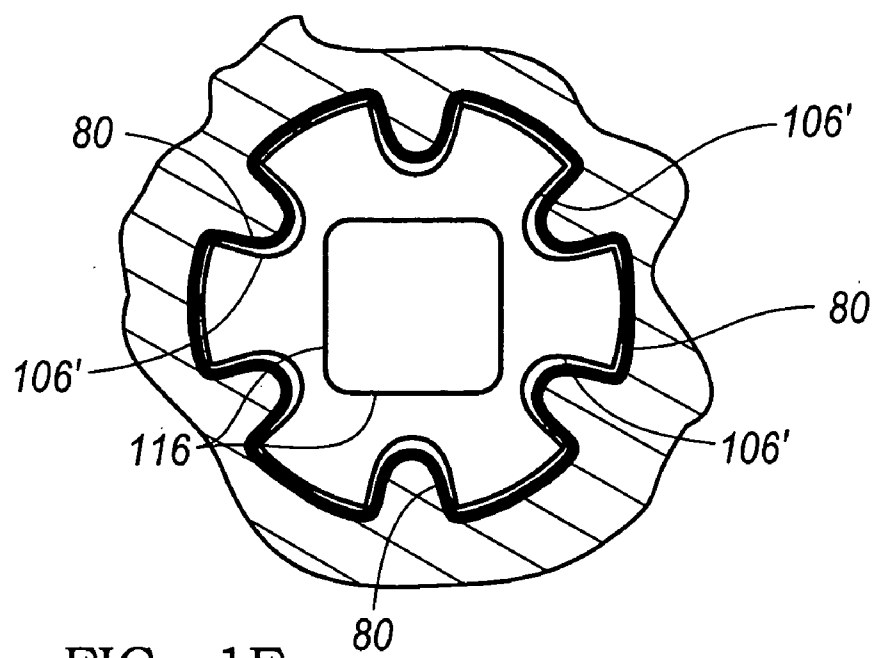


FIG. 1E

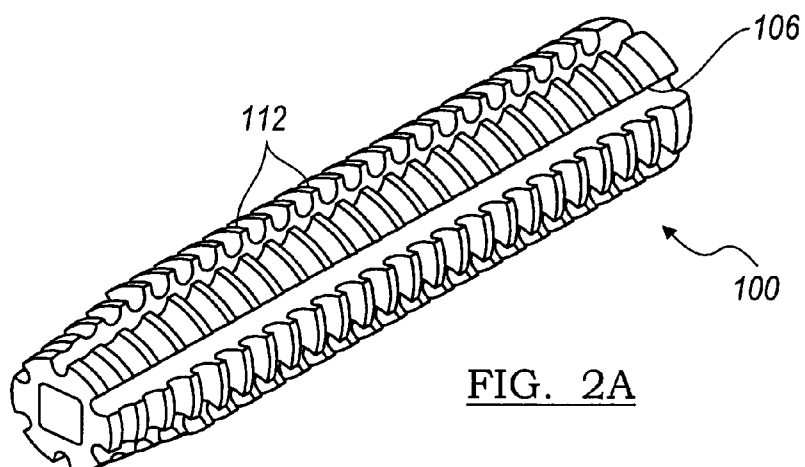


FIG. 2A

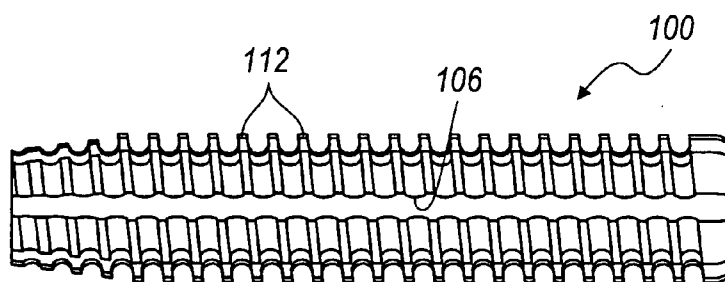


FIG. 2B

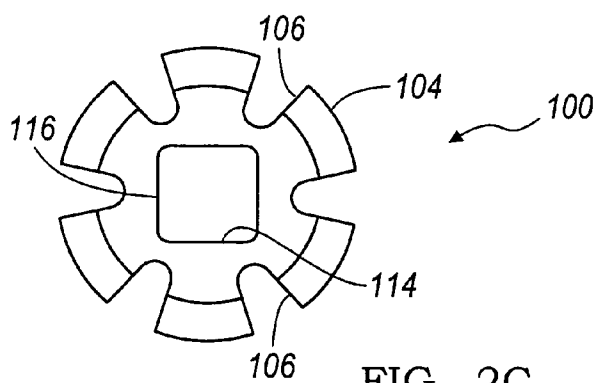


FIG. 2C

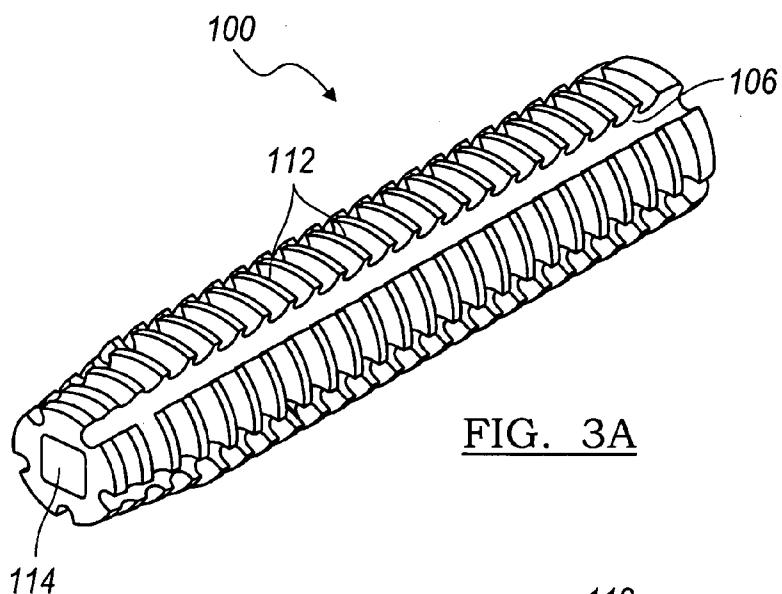


FIG. 3A

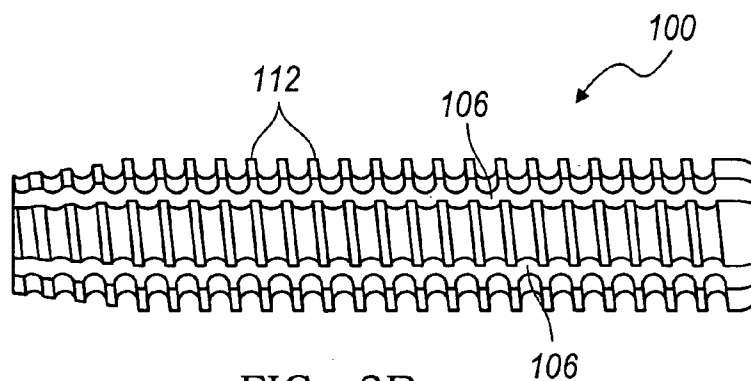


FIG. 3B

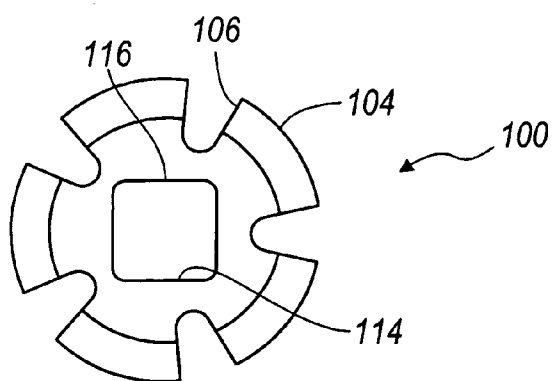


FIG. 3C

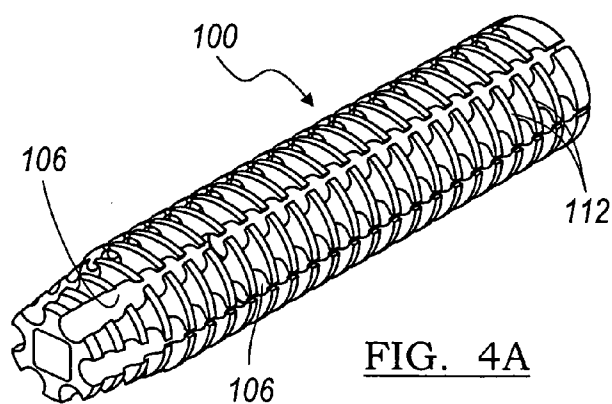


FIG. 4A

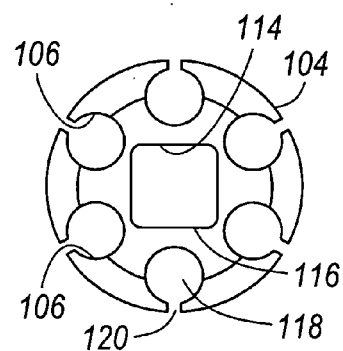


FIG. 4C

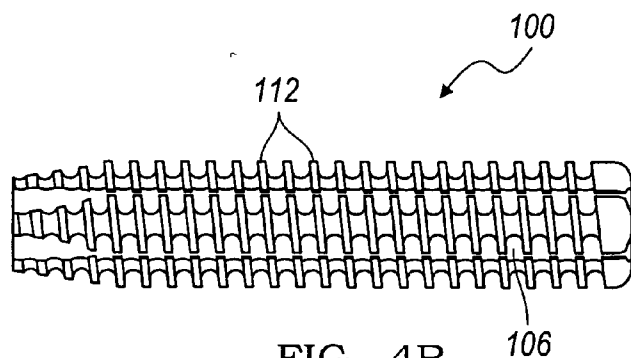


FIG. 4B

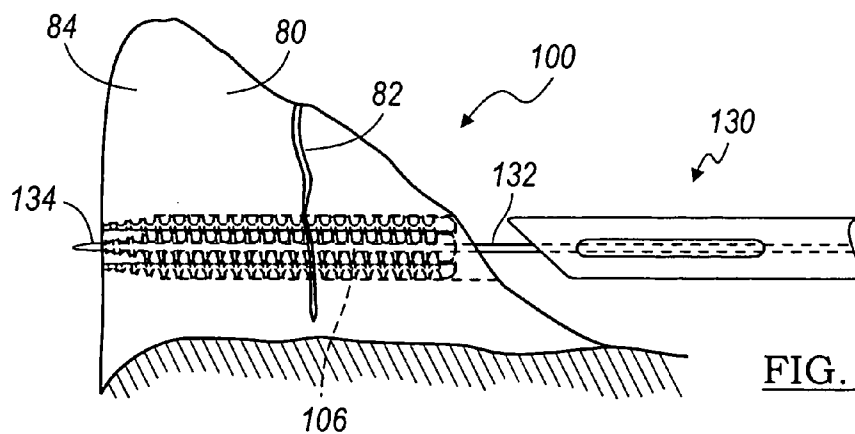


FIG. 5

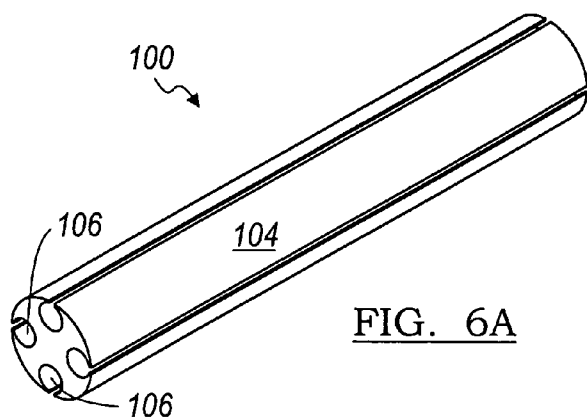


FIG. 6A

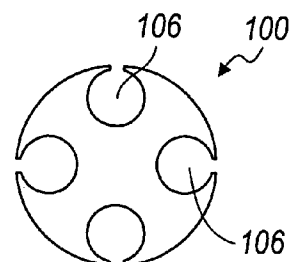


FIG. 6C

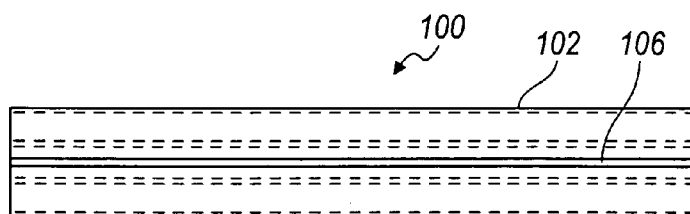


FIG. 6B

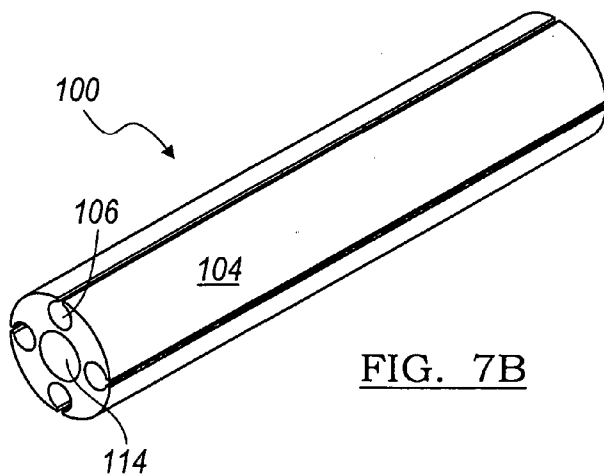


FIG. 7B

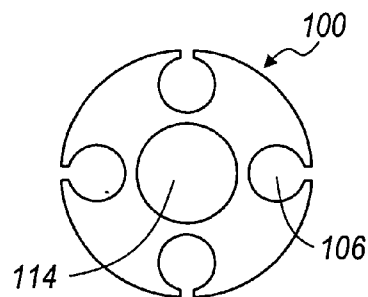


FIG. 7C

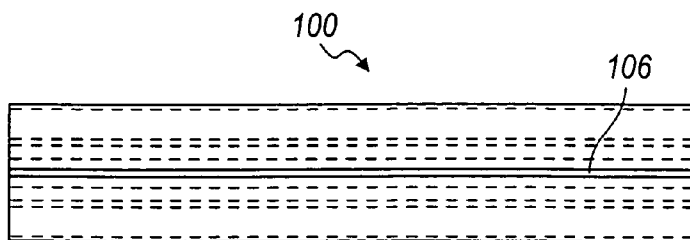
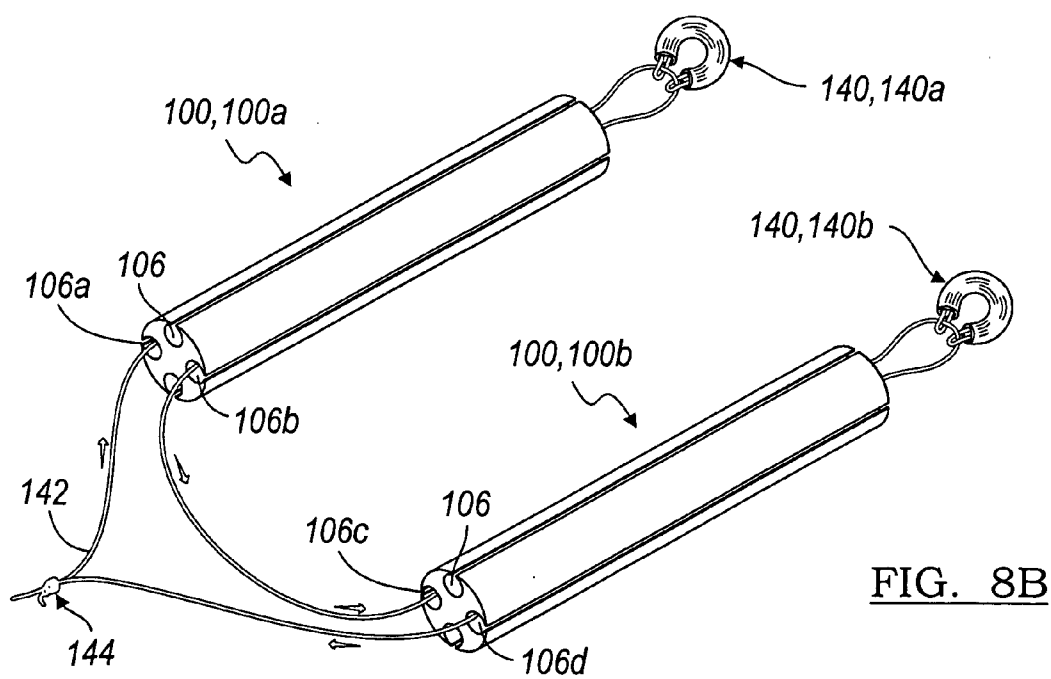
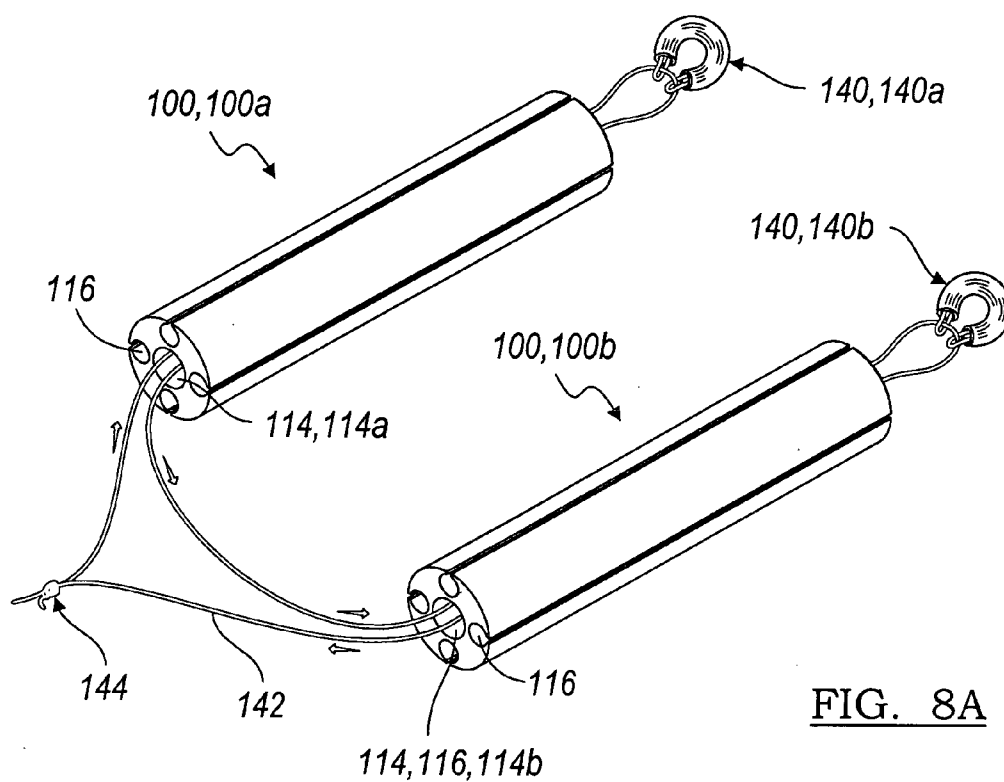


FIG. 7A



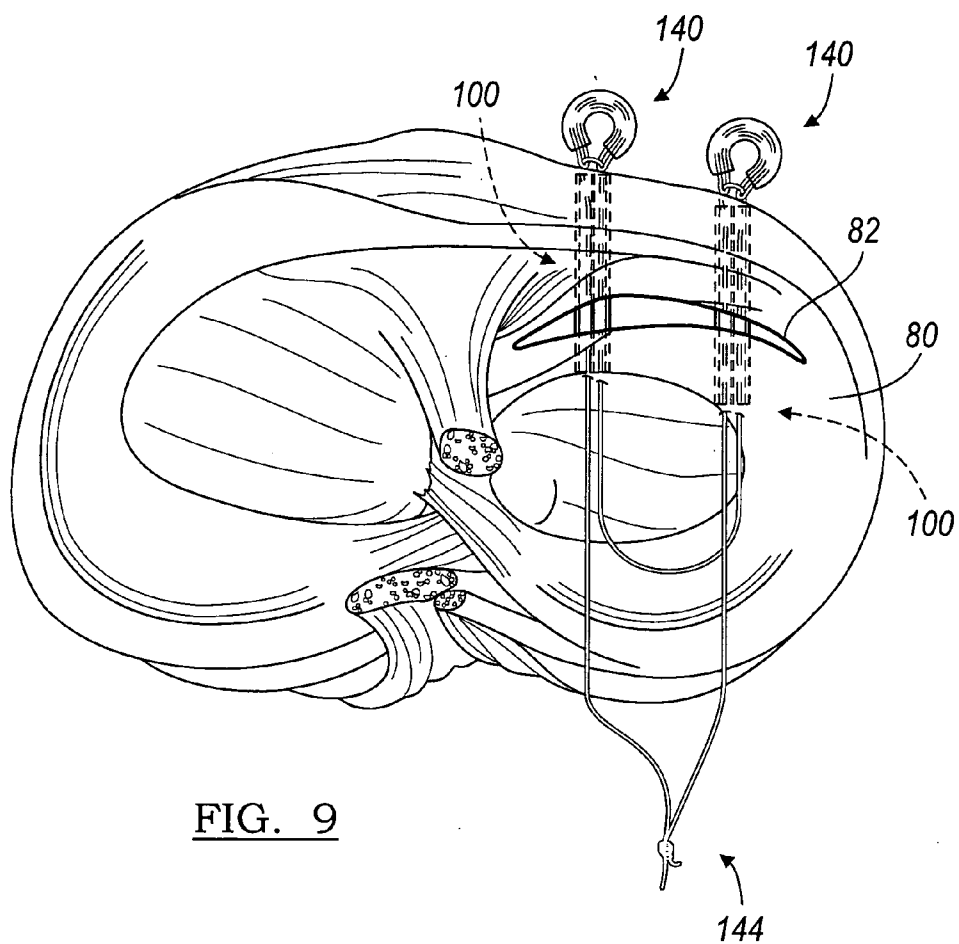


FIG. 9

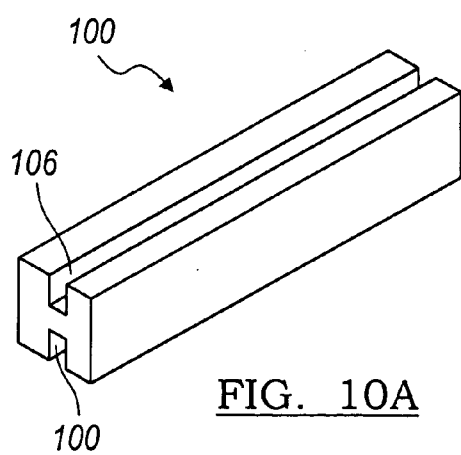


FIG. 10A

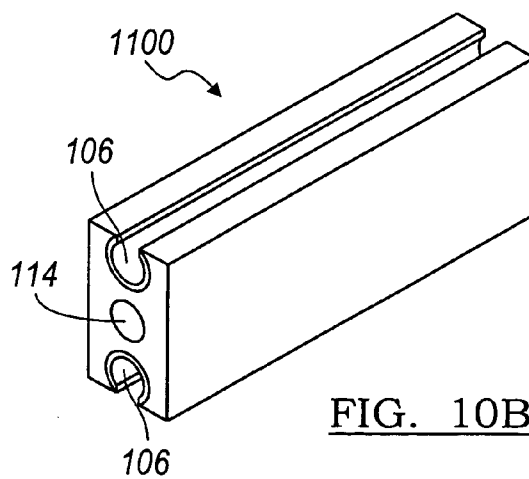


FIG. 10B

SOFT TISSUE CONDUIT DEVICE**CROSS-REFERENCE TO RELATED APPLICATIONS**

[0001] This application is a continuation-in-part of U.S. patent application Ser. No. 11/347,661 filed on Feb. 3, 2006. This application is also a continuation-in-part of U.S. patent application Ser. No. 11/294,694 filed Dec. 5, 2005, which is a continuation-in-part of U.S. patent application Ser. No. 10/984,624 filed Nov. 9, 2004. The disclosures of the above applications are incorporated herein by reference.

INTRODUCTION

[0002] Tears caused by trauma or disease in soft tissue, such as cartilage, ligament, or muscle, can be repaired by suturing and/or use of various fixation devices. Various tissue fixation devices have been developed for facilitating suturing and are effective for their intended purposes.

[0003] Although the existing soft tissue fixation devices can be satisfactory for their intended purposes, there is still a need for new devices that provide conduits for facilitating healing and promoting soft tissue vascularity.

SUMMARY

[0004] The present teachings provide a soft tissue conduit device. The device includes an elongated body having an outer surface, the elongated body defining a plurality of longitudinal external channels, each longitudinal channel defining a conduit open to the outer surface of the elongated body, each conduit operable to conduct a biological material in soft tissue.

[0005] The present teachings also provide a method of conducting biological materials to a defect in soft tissue. The method includes inserting a conduit device into the soft tissue and through the defect in the soft tissue, and conducting biological materials along at least one longitudinal channel defined on an outer surface of the conduit device into the soft tissue.

[0006] The present teachings further provide a method of conducting biological materials between first and second areas of different vascularity of a meniscus. The method includes inserting an elongated body in the meniscus such that at least one longitudinal channel of the elongated body extends between the first and second areas and defines a conduit for biological materials, wherein the channel is open to an outer surface of the elongated body.

[0007] Further areas of applicability of the present invention will become apparent from the description provided hereinafter. It should be understood that the description and specific examples are intended for purposes of illustration only and are not intended to limit the scope of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The present invention will become more fully understood from the detailed description and the accompanying drawings, wherein:

[0009] **FIG. 1A** is an isometric view of a conduit device according to the present teachings;

[0010] **FIG. 1B** is a side view of the conduit device of **FIG. 1A**;

[0011] **FIG. 1C** is an end view of the conduit device of **FIG. 1A**;

[0012] **FIG. 1D** is an end view of a conduit device illustrating adequate tenting of soft tissue according to the present teachings;

[0013] **FIG. 1E** is an end view of a conduit device illustrating inadequate tenting of soft tissue;

[0014] **FIG. 2A** is an isometric view of a conduit device according to the present teachings;

[0015] **FIG. 2B** is a side view of the conduit device of **FIG. 2A**;

[0016] **FIG. 2C** is an end view of the conduit device of **FIG. 2A**;

[0017] **FIG. 3A** is an isometric view of a conduit device according to the present teachings;

[0018] **FIG. 3B** is a side view of the conduit device of **FIG. 3A**;

[0019] **FIG. 3C** is an end view of the conduit device of **FIG. 3A**;

[0020] **FIG. 4A** is an isometric view of a conduit device according to the present teachings;

[0021] **FIG. 4B** is a side view of the conduit device of **FIG. 4A**;

[0022] **FIG. 4C** is an end view of the conduit device of **FIG. 4A**;

[0023] **FIG. 5** illustrates a method of inserting a conduit device in soft tissue according to the present teachings;

[0024] **FIG. 6A** is an isometric view of a conduit device according to the present teachings;

[0025] **FIG. 6B** is a side view of the conduit device of **FIG. 6A**;

[0026] **FIG. 6C** is an end view of the conduit device of **FIG. 6A**;

[0027] **FIG. 7A** is an isometric view of a conduit device according to the present teachings;

[0028] **FIG. 7B** is a side view of the conduit device of **FIG. 7A**;

[0029] **FIG. 7C** is an end view of the conduit device of **FIG. 7A**;

[0030] **FIG. 8A** illustrates a method of connecting two conduit devices with two fixation devices according to the present teachings;

[0031] **FIG. 8B** illustrates a method of connecting two conduit devices with two fixation devices according to the present teachings;

[0032] **FIG. 9** illustrates a method of repairing a meniscal tear according to the present teachings;

[0033] **FIG. 10A** is an isometric view of a conduit device according to the present teachings; and

[0034] **FIG. 10B** is an isometric view of a conduit device according to the present teachings.

DESCRIPTION OF VARIOUS ASPECTS

[0035] The following description is merely exemplary in nature and is in no way intended to limit the invention, its application, or uses. For example, although the present teachings are illustrated for repairing meniscal defects in knee surgery, the present teachings can be used to repair and facilitate healing or regeneration of any injured soft tissue.

[0036] Referring to FIGS. 1A-C, an exemplary soft tissue conduit device 100 according to the present teachings includes an elongated body 102 having an outer surface 104 and a plurality of longitudinal external channels 106 extending along the entire length of the body 102. The channels 106 are shaped such that when the conduit device 100 is inserted into soft tissue, the channels 106 can serve as conduits for conducting biological materials, such as nutrients, into the tissue from outside the tissue or between first and second areas of the tissue, such as, for example, between healthy tissue and injured or torn tissue, or between areas of different vascularity, such as between red-red (vascular), red-white (semi-vascular) and white (avascular) tissue areas of a meniscus. The channels 106 can provide a vascularity path in the tissue for facilitating healing or repair. As such, each channel 106 can have a width "w" and a depth "d" that allows the tissue to envelope or form a "tent" over the channel 106 without blocking the channel 106. Referring to FIG. 1D, deep channels 106 exemplify a shape that provides satisfactory "tenting" or draping of tissue 80 over the channels 106. Referring to FIG. 1E, shallow channels 106' illustrate inadequate tenting of tissue 80 over the channels 106', with the tissue at least partially entering the channels 106'. Satisfactory tenting of tissue 80 allows unobstructed or relatively unrestricted flow of nutrients or other biological materials along the channels 106. Typical aspect ratios d/w are less than 1, such as, for example, 0.5, 0.8, etc.

[0037] Various biological materials can be delivered through the channels 106 by external cannulas or other pumping devices during or after implantation. Such biological materials can be in the form of autologous cells derived from blood or bone marrow aspirate, for example, or other appropriate exogenous biological materials. Native or endogenous biological materials can also be carried after implantation from a vascular region of the soft tissue 80 to the injured site by inserting the conduit device 100 such that the conduit device 100 extends from a vascular region of the soft tissue to the injured site. Additionally or alternatively, biological materials in the form of platelet gels can be deposited in the channels 106 before implantation, as another mechanism of biological material delivery, including nutrient, delivery.

[0038] Referring to FIGS. 1A-1C, the body 102 of the conduit device 100 can include a cylindrical portion 108 of constant dimensions and a tapered portion 110. The body 102 can also include a plurality of blunt, rounded, and generally non-cutting ridges or threads 112 that are interrupted by the channels 106. The body 102 can be cannulated with an internal longitudinal bore 114. The longitudinal bore 114 can include a plurality of facets 116 for engaging a driver or other inserter for inserting the conduit device 100 in the soft tissue 80. The bore 114 can have, for example, a square, triangular, hexagonal or other shape configured to engage the driver non-rotatably.

[0039] Referring to FIGS. 1A-1C, 2A-2C, and 3A-3C, exemplary conduit devices 100 having channels 106 with

rounded V-shaped cross-sections are illustrated. FIGS. 1A-1C illustrate an aspect of the conduit device 100 with four channels 106 arranged, for example, symmetrically relative to the four sides 116 of a square bore 114, although asymmetrical arrangements can also be used. FIGS. 2A-2C illustrate an aspect of the conduit device 100 with six channels 106 arranged symmetrically relative to the four sides 116 of the square bore 114. FIGS. 3A-3C illustrate an aspect of the conduit device 100 with five channels 106 arranged asymmetrically relative to the four sides 116 of a square bore 114.

[0040] Referring to FIGS. 4A-4C, an exemplary conduit device 100 having channels 106 with keyhole-shaped cross-sections is illustrated. The keyhole shape can include a substantially circular portion 118 and a narrow slot-like opening 120 to the outer surface 104 of the body 102. The keyhole shape can be used to provide a path for substantial volume of biological materials or nutrients with good tenting of tissue 80 over the channels 106. It will be appreciated, however, that a different number of channels 106 and a variety of different channel shapes can be used as conduits for the conduit device 100.

[0041] Referring to FIG. 5, an exemplary method of using the conduit device 100 is illustrated. A driver 130 can be used to insert the conduit device 100 through a tear or other defect or injury 82 in the soft tissue or meniscus 80. The driver 130 can have a shaft 132 configured to engage the bore 114 of the body 102 of the conduit device 100 to facilitate inserting and guiding the conduit device 100 into the tissue 80. The shaft 132 of the driver 130 can also include a sharp tip 134 for facilitating the insertion of the conduit device 100 into tissue 80. The driver 100 can be used to rotate the conduit device 100 such that the blunt threads 112 push the tissue 80 aside during the insertion of the conduit device 100. The conduit device 100 can be used to connect areas of good vascularity 84 of the soft tissue 80, such as, for example, the outer surface of a meniscus, with the site of the defect 82 or other areas of low or no vascularity, and can also serve as a fixation device that can bridge the defect 82 and or bring closer together opposite sites of torn or damaged tissue at the defect 82.

[0042] Referring to FIGS. 6A-6C and 7A-AC, the conduit device 100 can have a body 102 with a substantially cylindrical shape of constant diameter without external threads or ridges, and having an outer surface 104 interrupted by a plurality of longitudinal channels 106. The body 102 can be otherwise solid (non-cannulated) as illustrated in FIGS. 6A-6C, or cannulated with an internal longitudinal bore 114, as shown in FIGS. 7A-7C. The channels 106 can have different cross-sectional shapes, including the illustrated keyhole shapes for improved tissue tenting. The non-threaded conduit devices 100 of FIGS. 6A-6C and 7A-AC can be used with various anchors, buttons, toggles or other fixation devices 140, as illustrated in FIGS. 8A-B and 9.

[0043] Referring to FIGS. 10A and 10B, exemplary conduit devices 100 having flat or parallelepiped bodies are illustrated. The channels 104 can be square or V-shaped or U-shaped or key-hole shaped, for example. The conduit devices 100 can include central bores 114 or can be solid. It will be appreciated that conduit devices 100 of various other shapes can be used, such as oval, square, rectangular, circular, or other shapes, and having channels 106 of dif-

ferent shapes. The conduit devices can be coupled with fixation devices **140** using sutures or flexible strands **142** passing through the central bore **114** or through two channels **104**, as discussed below in reference to FIGS. **8A-B**.

[0044] Referring to FIG. **8A**, two cannulated conduit devices **100a**, **100b** can be coupled with corresponding fixation devices **140a**, **140b** using a suture or other elongated flexible strand **142**. The flexible strand **142** can define a loop that passes through the first bore **114a**, connects to the corresponding fixation device **140a**, returns through the same bore **114a**, passes through the second bore **114b**, connects to the second fixation device **140b**, returns through the second bore **114b**, and closes the loop with a knot, button or other retainer **144**.

[0045] Similarly, two non-cannulated conduit devices **100a**, **100b** can be coupled with corresponding fixation devices **140a**, **140b** using the flexible strand **142**, as shown in FIG. **8B**. The flexible strand **142** can define a loop that passes through a first external channel **106a** of the first conduit device **100a**, connects to the corresponding fixation device **140a** and returns through a second channel **106b** of the first conduit device **100a**. The flexible strand **142** then passes through a third channel **106c** of the second conduit device **100b**, connects to the second fixation device **140b**, returns through a fourth channel **106d** of the second conduit device **100b**, and closes the loop with a retainer **144**.

[0046] Referring to FIG. **9**, two conduit devices **100** are shown coupled with two fixation devices **140**, which are inserted through a tear **82** in a meniscus and secured by tightening the loop defined by the flexible strand **142**. The implantation of the conduit devices **100** and the fixation devices **140** for reducing or closing the tear **82** can be performed according to the methods described in co-pending parent patent application Ser. No. 11/347,661 filed Feb. 3, 2006, and incorporated herein by reference.

[0047] It will be appreciated from the above description that the conduit devices **100** can be used for many applications in which biological materials or nutrients are needed to be delivered to a soft tissue site or transferred from one tissue site to another. The longitudinal channels **106** of the devices coupled with dimensions that facilitate tenting of tissue provide unobstructed and continuous paths for the flow or delivery of such biological materials and nutrients.

[0048] The foregoing discussion discloses and describes merely exemplary arrangements of the present invention. One skilled in the art will readily recognize from such discussion, and from the accompanying drawings and claims, that various changes, modifications and variations can be made therein without departing from the spirit and scope of the invention as defined in the following claims.

What is claimed is:

1. A soft tissue conduit device comprising:

an elongated body having an outer surface, the elongated body defining a plurality of longitudinal external channels, each longitudinal channel defining a conduit open to the outer surface of the elongated body, each conduit operable to conduct a biological material in soft tissue.

2. The conduit device of claim 1, wherein the conduit is operable to provide a vascularity path in soft tissue.

3. The conduit device of claim 1, wherein the elongated body is threaded and the longitudinal channels interrupt the threads.

4. The conduit device of claim 3, wherein the threads are non-cutting.

5. The conduit device of claim 4, wherein the body comprises a cylindrical portion and a tapered tip portion.

6. The conduit device of claim 1, wherein the body is cannulated and defines a longitudinal bore, the longitudinal bore being isolated from the longitudinal channels.

7. The conduit device of claim 6, wherein the longitudinal bore has a cross-section configured to receive a driver.

8. The conduit device of claim 7, wherein the cross-section of the longitudinal bore is substantially square.

9. The conduit device of claim 1, wherein the longitudinal channels have a cross-section substantially in the shape selected from a rounded V or a keyhole.

10. The conduit device of claim 6, wherein the longitudinal channels are selectively arranged symmetrically or non-symmetrically relative to a cross-section of the longitudinal bore.

11. The conduit device of claim 1, wherein the longitudinal body is unthreaded and substantially cylindrical with a substantially circular cross-section.

12. The conduit device of claim 11, wherein each longitudinal channel has a substantially keyhole-shaped cross-section.

13. The conduit device of claim 13, wherein the longitudinal body is cannulated defining an elongated bore having a substantially circular cross-section not in communication with the elongated channels.

14. The conduit device of claim 1, wherein each channel is shaped such that, upon insertion in soft tissue, the conduit is enveloped but not obstructed by the soft tissue.

15. The conduit of claim 1, wherein the biological material comprises autologous cells, exogenous materials, endogenous nutrients, or platelet gels.

16. A method of conducting biological materials to a defect in soft tissue, the method comprising:

inserting a conduit device into the soft tissue and through the defect in the soft tissue; and

conducting biological materials along at least one longitudinal channel defined on an outer surface of the conduit device into the soft tissue.

17. The method of claim 16, further comprising positioning the conduit device to connect areas of tissue having different vascularities.

18. The method of claim 16, wherein conducting biological materials includes delivering biological materials externally into the channel during or after implantation.

19. The method of claim 16, wherein conducting biological materials includes attaching biological gels in the channels before implantation.

20. The method of claim 16, wherein delivering biological materials includes providing a nutrient path from the tissue to the defect through the channels.

21. The method of claim 16, further comprising coupling the conduit device to a fixation device.

22. The method of claim 21, wherein coupling the conduit device to a fixation device includes forming a flexible strand loop between the conduit device and the fixation device.

23. The method of claim 21, wherein the loop passes through an internal bore of the conduit device.

24. The method of claim 21, wherein the loop passes through the channel of the conduit device.

25. A method of conducting biological materials between first and second areas of different vascularity of a meniscus, the method comprising:

inserting an elongated body in the meniscus such that at least one longitudinal channel of the elongated body extends between the first and second areas and defines a conduit for biological materials, wherein the channel is open to an outer surface of the elongated body.

26. The method of claim 25, further comprising:

delivering biological materials to the channel during or after implantation.

27. The method of claim 25, further comprising:

attaching biological materials to the channel before implantation.

* * * * *