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- (71) Applicant: SMITH & NEPHEW, INC. [US/US]; 1450
Brooks Road, Memphis, TN 38116 (US).
- (72) Inventor: ARAI, Tatsuya; 18101 Point Lookout Drive,
Apartment 458, Houston, TX 77058 (US).
- (74) Agents: MARAIA, Joseph, M. et al.; Burns & Levinson
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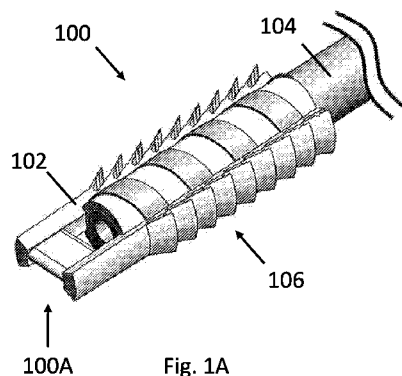


Fig. 1A

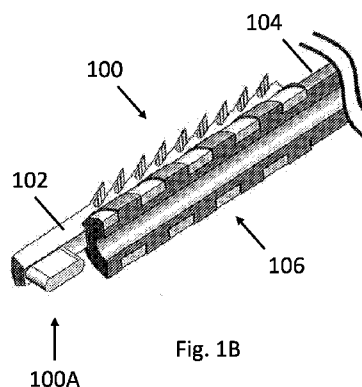


Fig. 1B

(57) **Abstract:** An anchor assembly includes an open-architecture bone anchor and a corresponding anchor inserter. The bone anchor may include a plurality of ribs, an open helical coil, and a suture interfacing member. The helical coil includes a plurality of anchor openings and threads. The anchor inserter includes a body having a plurality of threads and grooves dimensioned to mate with the anchor openings and threads. The anchor inserter provides support (e.g., radial and axial) to the bone anchor during insertion. The anchor inserter may be further removed from the bone anchor after insertion within bone, exposing the internal volume of the bone anchor which provides a scaffold for bony ingrowth and promotes healing.

ROBUST OPEN-ARCHITECTURE BONE ANCHOR

BACKGROUND

[0001] Arthroscopic procedures often require soft tissue to be reattached to bone. To achieve this result, suture anchors may be placed in the bone and sutures attached to the suture anchor. The sutures are passed through the tissue to securely retain the tissue in place.

[0002] Notably, however, insertion of suture anchors into a patient's body may be time consuming. Furthermore, the process of insertion may result in damage to the suture anchor, subsequently impairing its ability to function effectively. Accordingly, a need exists for improved designs that facilitate insertion of suture anchors into a patient.

SUMMARY

[0003] In an embodiment, a suture anchor is provided. The suture anchor includes: a suture interfacing member having a proximal end and a distal end; at least one rib extending, proximally, along a longitudinal axis of the anchor from the distal end of the suture interfacing member; an open helical coil coupled to the at least one rib. The open helical coil extends, proximally, along the longitudinal axis of the anchor from the distal end of the suture interfacing member. The open helical coil includes threads spaced apart by openings, where each thread has a driving surface transmitting a pound-in force delivered in a direction approximately along the longitudinal axis of the anchor. The open helical coil further defines an internal volume communicating with a region exterior to the suture anchor through the openings between the threads of the open helical coil.

[0004] Embodiments of the suture anchor may include one or more of the following, alone or in any combination.

[0005] In an embodiment, the plurality of ribs are a pair of ribs extending parallel to the longitudinal axis.

[0006] In an embodiment, the helical coil is laterally dimensioned to span the distance between the pair of ribs and the helical coil is coupled to each rib at selected positions along the length of the rib.

[0007] In an embodiment, the suture anchor further includes a plurality of wings attached to respective outward facing surfaces of the plurality of ribs and extending outward there-from at a selected angle.

[0008] In an embodiment, the suture interfacing member is a suture bridge extending transverse to the longitudinal axis and coupled to the pair of ribs at about the distal end of the bone anchor.

[0009] In an embodiment, the suture interfacing member is a sharp tip attached to the distal end of each rib, the tip including a passageway extending there through and dimensioned to receive a suture.

[0010] In an embodiment, a suture anchor assembly is provided. The suture anchor assembly includes a suture anchor according to any of the embodiments discussed above and an anchor inserter. The anchor inserter includes: a generally elongate body extending from a proximal end to a distal end along a longitudinal axis of the anchor inserter; and a plurality of threads formed in the inserter body and spaced apart by grooves, where the inserter threads and grooves are dimensioned to mate with the anchor openings and threads.

[0011] Embodiments of the suture anchor assembly may include one or more of the following, alone or in any combination.

[0012] In an embodiment, the suture anchor assembly further includes: a cannula formed through the length of the inserter body; and a suture including a closed end and two limbs extending from the closed end. The suture limbs are positioned within the inserter cannula and the closed end of the suture engages the suture interfacing member.

[0013] In an embodiment, the suture anchor assembly further includes a suture, where the suture includes a closed end and two limbs extending from the closed end. The suture limbs are positioned adjacent to the outer surface of the anchor assembly and the closed end engages the interfacing member.

[0014] In an embodiment of the suture anchor assembly, the suture limbs are crossed proximal to the suture interfacing member.

[0015] In an embodiment, the suture anchor assembly further includes a plurality of grooves formed in the outer surface of the bone anchor, where at least one of the suture limbs is positioned within the plurality of grooves.

[0016] In an embodiment, a method of securing a suture in a bone is provided. The method includes: providing a suture anchor assembly, inserting the suture anchor assembly

within a bone such that at least a portion of the suture is constrained in place by the suture anchor and bone; and removing the suture anchor inserter from the bone such that the suture anchor and at least a portion of the suture remain within the bone. The suture anchor assembly includes a suture anchor and an anchor inserter. The suture anchor includes: a suture interfacing member having a proximal end and a distal end; at least one rib extending, proximally, along a longitudinal axis of the anchor from the distal end of the suture interfacing member; an open helical coil coupled to the at least one rib, the open helical coil extending, proximally, along the longitudinal axis of the anchor from the distal end of the suture interfacing member, the open helical coil having threads spaced apart by openings, each thread having a driving surface transmitting a pound-in force delivered in a direction approximately along the longitudinal axis of the anchor, the open helical coil defining an internal volume communicating with a region exterior to the suture anchor through the openings between the threads of the open helical coil. The suture anchor inserter includes: a generally elongate body extending from a proximal end to a distal end along a longitudinal axis of the anchor inserter; a plurality of threads formed in the inserter body and spaced apart by grooves, where the inserter threads and grooves are dimensioned to mate with the anchor openings and threads; and a suture engaged with the suture anchor.

[0017] Embodiments of the method may include one or more of the following, alone or in any combination.

[0018] In an embodiment of the method, the plurality of ribs are a pair of ribs extending parallel to the longitudinal axis.

[0019] In an embodiment of the method, the helical coil is laterally dimensioned to span the distance between the pair of ribs and where the helical coil is coupled to each rib at selected positions along the length of the rib.

[0020] In an embodiment of the method, the suture anchor further includes a plurality of wings attached to respective outward facing surfaces of the plurality of ribs and extending outward there-from at a selected angle.

[0021] In an embodiment of the method, the suture interfacing member is a suture bridge extending transverse to the longitudinal axis and coupled to the pair of ribs at about the distal end of the bone anchor.

[0022] In an embodiment of the method, the suture interfacing member is a sharp tip attached to the distal end of each rib, the tip including a passageway extending there through and dimensioned to receive a suture.

[0023] In an embodiment of the method, the suture anchor assembly further includes a cannula formed through the length of the inserter body; and a suture including a closed end and two limbs extending from the closed end. The suture limbs are positioned within the inserter cannula and the closed end of the suture engages the suture interfacing member.

[0024] In an embodiment of the method, the suture includes a closed end and two limbs extending from the closed end. The suture limbs are positioned adjacent to the outer surface of the anchor assembly and the closed end engages the interfacing member.

[0025] In an embodiment, the method further includes crossing the suture limbs proximal to the suture interfacing member.

[0026] In an embodiment of the method, the bone anchor further includes a plurality of grooves formed on the outer surface of the bone anchor and at least one of the suture limbs is positioned within the plurality of grooves.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027] The objects, features and advantages of embodiments of the present disclosure will be apparent from the following more particular description, as illustrated in the accompanying drawings, in which like reference characters refer to the same parts throughout the different views. It may be understood that the drawings are not necessarily to scale, with emphasis instead being placed upon illustrating the principles of the embodiments.

[0028] Figures 1A-1B are isometric and cross-sectional views of an anchor assembly in accordance with various embodiments.

[0029] Figure 2 is an isometric view illustrating components of a bone anchor in accordance with various embodiments.

[0030] Figure 3 is an isometric view illustrating components of an anchor inserter in accordance with various embodiments.

[0031] Figure 4 is an isometric view of an alternative bone anchor in accordance with various embodiments.

[0032] Figures 5A-5B are cross-sectional views of the anchor assembly of Figure 2, illustrating forces acting on the bone anchor and inserter during insertion.

[0033] Figures 6A-6C are isometric views of the anchor assembly of Figure 1 in combination with embodiments of different suture configurations.

[0034] Figure 7 is a schematic illustration of a further embodiment of the suture anchor of Figures 1A-1B and Figure 4, in cross-section view, illustrating a plurality of grooves formed within the suture anchor.

[0035] Figures 8A-8C illustrate insertion of embodiments of the bone anchor in a bone to secure a suture.

DETAILED DESCRIPTION

[0036] The following description of embodiments of the disclosure is merely exemplary in nature and is in no way intended to limit the disclosure, its application, or uses.

[0037] Embodiments of the present disclosure relate generally to tissue repair and, more specifically, to an open-architecture bone anchor for securing tissue to bone.

[0038] Open architecture bone anchors for use in tissue repair have received favorable acceptance by surgeons. In general, a bone anchor is mounted to an inserter device and, using the inserter device, the anchor is screwed into a desired location in the patient's bone along a pre-existing pilot hole. The inserter is subsequently removed to leave behind the bone anchor in the bone. Open architecture bone anchors are advantageous, as they promote bony ingrowth that accelerates bone recovery and reduce patient recovery time. Notably, however, some bone anchors, such as open architecture anchors, require a careful insertion technique such as screwing. The screwing operation during insertion is time consuming and lengthens operating time for placement of the bone anchor. Furthermore, during the screwing operation, a bone anchor may experience forces which result in damage to the bone anchor and impair its ability to function.

[0039] Embodiments of the present disclosure provide a bone anchor for use in an anchor assembly which is capable of inserting the bone anchor by pound-in, as opposed to screw-in. The anchor assembly includes an open-architecture bone anchor that is configured to mate with a corresponding anchor inserter. The anchor inserter provides radial and axial support to the bone anchor during insertion (i.e., pound-in) and thereby inhibits damage to the bone anchor (e.g., cracking, fracture, etc.). Advantageously, removal of the anchor inserter leaves behind the open-architecture bone anchor possessing the attendant advantages of rapid healing.

[0040] Reference will now be made to Figure 1, which illustrates isometric and cross-sectional views of an anchor assembly 100 in accordance with various embodiments. The anchor assembly 100 includes a bone anchor 102 and a mating anchor inserter 104. In some embodiments, the anchor assembly 100 may be inserted into a patient's bone by pound-in through a previously formed pilot hole. For example, a surgeon may employ a drill or other device to form a pilot hole of selected size and depth in a bone. In alternative embodiments, the anchor assembly may be adapted for insertion into the patient's bone without a pilot hole, as discussed in greater detail below with respect to Figure 4. In either embodiment, a distal end 100A of the anchor assembly 100 may be positioned to enter the bone first, with a body of the anchor assembly 100 further advanced into the bone to secure the bone anchor 102 within the bone.

[0041] With respect to Figure 2, an isometric view illustrating components of the bone anchor 102 in accordance with various embodiments is shown. The bone anchor 102 extends from a distal end 102A to a proximal end 102B along a longitudinal axis. The bone anchor 102 further includes a plurality of ribs 202, a helical coil or threads 204, a suture bridge 206, and wings 210.

[0042] In an embodiment, the plurality of ribs 202 are generally elongated and spaced apart from one another by a selected distance. For example, in certain embodiments, the ribs 202 may be positioned on opposite sides of the bone anchor 102, as illustrated in Figure 2. The plurality of ribs 202 may further extend from a distal end 102A of the bone anchor 102 towards a proximal end 102B of the bone anchor 102, approximately parallel to one another and the longitudinal axis 200 of the bone anchor 102. While the embodiment of Figure 2 illustrates the presence of two ribs 202, it may be understood that, in alternative embodiments, the bone anchor may possess greater or fewer ribs. Furthermore, the ribs may be configured at a selected angle with respect to one another.

[0043] The suture bridge 206 may be adapted to engage with a suture before, after and/or during insertion of the bone anchor 102 into bone. Engagement may include, but is not limited to, contact with a suture, receiving a suture there-through, and the like. For example, as illustrated in the embodiment of Figure 2, the suture bridge 206 may extend transverse to the longitudinal axis 200 of the bone anchor 102 and be attached to one or more of the plurality of ribs 204 at a location at or near the distal end 102A of the bone anchor 102. For example, as illustrated in the embodiment of Figure 2, lateral faces of the suture bridge

206 are attached to corresponding, opposing lateral faces of the ribs 202. It may be understood, however, in alternative embodiments, that the suture bridge may be engaged with other faces of the ribs (e.g., top face, bottom face, combinations thereof, etc.).

[0044] Further embodiments of the suture bridge (not shown) may also include one or more suture retaining features. For example, the suture bridge may include a notch, protrusion (e.g., hook), passageway or other feature that receives the suture.

[0045] The suture bridge 206 may be further dimensioned to span the distance between the plurality of ribs 204 at about the distal end 102A of the bone anchor 100. For example, in the non-limiting embodiment of Figure 2, the suture bridge 206 may be generally elongated, extending between the plurality of ribs 204 and possessing a width greater than its thickness. However, the geometry of the suture bridge may be varied in alternative embodiments, as necessary, while still being secured to the plurality of ribs.

[0046] The helical coil 204 may extend from about the distal end 102A of the bone anchor 102 towards the proximal end 102B of the bone anchor 102 and include a plurality of helical threads 204A. The helical coil (e.g., helical threads 204A) may be laterally dimensioned to span the distance between the plurality of ribs 202 (e.g., two ribs) and be attached to the ribs 202 at selected positions along the length of the ribs. The helical threads 204A may also include an internal void space or volume 210 and be spaced apart from one another by openings 212. The internal volume 210 of the helical threads 204A may communicate with a region exterior to the bone anchor 102 through the openings 212. As discussed in greater detail below, the internal volume 210 and openings 212 may accommodate at least a portion of the anchor inserter 104 for support of the bone anchor 102 during insertion.

[0047] Each of the threads 204A of the helical coil 204 may further possess a plurality of driving surfaces 214. The driving surfaces 214 may be oriented with at least one face exposed towards the direction of insertion (e.g., the distal end 102A of the bone anchor 102). Thus, the driving surfaces may transmit an applied force delivered in a direction in which the bone anchor is inserted into the bone (e.g., parallel to the longitudinal axis 200). In certain embodiments, the driving surfaces 214 may be surfaces of the helical threads 204A having a surface normal extending generally parallel to the longitudinal axis 200 of the bone anchor. However, in alternative embodiments, the driving surfaces may be angled and/or faceted.

[0048] The bone anchor 102 may also include a plurality wings 216. of thin, elongate wings. The wings 216 may be connected to, and extend outward from, the outward facing surfaces of the ribs 202 . In certain embodiments, the wings 216 may extend outward from the ribs 202 at a selected angle with respect to the longitudinal axis 200 of the bone anchor 102. As discussed in greater detail below, the wings may act to inhibit motion of the bone anchor 102 in a direction opposite of the insertion direction, advantageously facilitating fixation and stable positioning of the bone anchor 102 within the bone. In alternative embodiments, barbs or equivalents may be mounted to the ribs, in lieu of or in addition to the wings, in order to engage with bone.

[0049] Figure 4 illustrates an alternative embodiment of the anchor assembly 400 in which the bone anchor 402 is modified, as compared to the bone anchor 102, to replace the suture bridge 206 with a sharp, pointed distal tip 404. The sharp distal tip 404 may facilitate insertion of the bone anchor assembly 400 into bone without the need to form a bone hole. The sharp distal tip 404 may further include a passageway 406 for securing a suture to the anchor assembly 400 during insertion. Unless otherwise noted, embodiments of the bone anchor assembly 400 and bone anchor 402 may be formed and function in the same manner as discussed with respect to the bone anchor assembly 100 and bone anchor 102, respectively.

[0050] Figure 3 is an isometric view illustrating the anchor inserter 104 in accordance with various embodiments. The anchor inserter 104 may be generally elongated, extending from a distal end 104A to a proximal end 104B along a longitudinal axis 306 of the inserter 104. A suture cannula 302 may be formed within the body of the anchor inserter 104. As discussed in greater detail below with respect to Figure 6, the suture cannula 302 is dimensioned to receive a suture through the interior volume of the anchor inserter 104 for engagement with the bone anchor 102.

[0051] The anchor inserter 104 may also include inserter threads 302, separated by grooves 304. The inserter threads 304 and inserter grooves 304A are configured to engage and mate with the helical threads 204 and openings 204A of the bone anchor 102, as illustrated in the cross-sectional view of the anchor assembly 100 of Figure 1B. So configured, the threads 304 of the anchor inserter 104 may occupy the openings 204A of the bone anchor 102 during insertion. Correspondingly, the helical threads 204 of the bone anchor 102 may be positioned within the inserter grooves 304A. In certain embodiments, the inserter threads 304 and helical coil 204 of the bone anchor 102 may be dimensioned so that

respective adjacent surfaces of the inserter threads 304 and the helical threads 204 are in contact with each other when the bone anchor 102 is mounted upon the inserter 104.

[0052] In use, the anchor assembly may be installed into bone using a driving mechanism (not shown). The driving mechanism may be connected to the proximal end 104B of the anchor inserter 104 and apply a force to the anchor assembly 100 for insertion of the anchor assembly 100 into bone. Examples of anchor drivers may include, but are not limited to, those described in U.S. Patent Application No. 13/838,729 and entitled “Fenestrating Locking Suture Anchor Assembly,” the entirety of which is hereby incorporated by reference in its entirety.

[0053] When inserted into bone, the anchor assembly 100 experiences a plurality of applied forces, as illustrated in Figures 5A and 5B (black arrows). For example, the applied forces may include radial forces 502 normal to the direction of insertion 500 and friction/interfering forces 504 parallel to the direction of insertion 500.

[0054] Advantageously, the mating contact of the inserter threads 304 and helical coil 204 allows the inserter 104 to provide mechanical support to the bone anchor 102 that, at least in part, opposes and counteracts applied forces (e.g., the radial and axial (friction/interfering) forces 502, 504) experienced by the bone anchor 102 during insertion so as to inhibit damage to the bone anchor 102. For example, as illustrated in Figures 5A and 5B, in an embodiment, each of the threads 204A of the helical coil 204 possesses four faces (labeled 1, 2, 3, 4 in Figure 5A) and each inserter groove 304A possesses three faces (labeled A, B, C in Figure 5A). When the inserter 104 is engaged with the bone anchor 102, the threads 204A of the helical coil 204 are placed within a respective inserter groove 304A. So positioned, three of the four faces of each helical thread 204A (e.g., faces 1, 2, and 3) is surrounded by the adjacent faces of its respective inserter groove 304A (faces A, B, C), with the fourth face of each helical thread 204A facing outward from the anchor assembly 100. As further illustrated in Figures 5A and 5B, the anchor inserter 104A provides radial support 502' (white vertical arrows) to the helical coil 204A in opposition to the radial forces 502 applied during insertion, as well as axial support 504' (white horizontal arrow) to the bone anchor 102 in opposition to the friction/interfering forces 504 applied during insertion.

[0055] In certain embodiments, the geometry of the helical coil of the bone anchor and the inserter thread may be varied. For example, in one embodiment, the spatial extent of the helical coil parallel to the longitudinal axis of the bone anchor (i.e., length) may be

changed. This spatial extent may be changed by adding/removing threads, increasing/decreasing the width of the threads, increasing/decreasing the width of the openings between the helical threads, etc. Accordingly, geometry of the corresponding anchor inserter (e.g., the inserter grooves and inserter threads) may be simultaneously adjusted to maintain mating contact with the bone anchor.

[0056] In another embodiment, the spatial extent of the helical coils in the direction normal to the longitudinal axis of the bone anchor (e.g., thickness) and the depth of the inserter grooves may be varied with respect to one another. For example, the thickness of the coils may be selected as less than, approximately equal to, and greater than the corresponding depth of the groove in which it mates. Advantageously, with one or more of these geometric changes in the helical coil and inserter thread, the degree of axial and radial support provided to the bone anchor during insertion may be varied.

[0057] In an embodiment, the bone anchor and inserter may be independently constructed from materials including, but not limited to, one or more of polymers (e.g., PEEK), osteo-conductive, angiogenetic, bioabsorbable materials, composites, ceramics, metals (e.g., surgical grade steel, titanium, etc.), and/or any other suitable biocompatible material.

[0058] Although bioabsorbable materials are understood as generally being weaker than polymers or metals, the enhanced support provided to the bone anchor by embodiments of the disclosed anchor assembly may allow expanded use of bone anchors formed from bioabsorbable materials. Advantageously, more patients may benefit from bioabsorbable bone anchors due to their gradual breakdown/absorption by the body, as opposed to permanent metal or polymer bone anchors.

[0059] Reference will now be made to Figures 6A-6C, which present isometric views of the anchor assembly 100 of Figures 1A-1B in combination with a suture 600. Figures 6A-6C illustrate embodiments of different suture routing configurations. The suture 600 may include a closed end 602 and two limbs 600A, 600B extending from the closed end 602 and is engaged with the suture interfacing member 206 prior to, during, or after insertion of the bone anchor 100 into bone. For example, as discussed below, engagement of the closed end of the suture 602 with the suture interfacing member 206 may include, but is not limited to, one or more of the following, alone or in combination: routing the suture 600 around the suture interfacing member 206 such that the closed end of the suture 602 is adjacent to and/or

contacting the suture interfacing member 206, looping the closed end of the suture 206 about the suture interfacing member 206, inserting the suture 600 within the suture interfacing member 206 such that the closed end of the suture 602 is positioned within the suture interfacing member 206, and equivalents thereof. Embodiments of the anchor assembly 100 may be further combined with plug systems where the proximal end of the anchor assembly has a plug and threads to secure sutures (e.g., the FOOTPRINT[®] series or HELICOIL[®] series (Smith & Nephew, Andover, Massachusetts)).

[0060] As illustrated in Figure 6A, a suture 600 may be drawn through the suture cannula 302 of the anchor inserter 104, from the proximal to the distal end of the anchor inserter 104, looped around the suture bridge 206, and drawn back through the suture cannula 206 to the proximal end 100B of the anchor assembly 100.

[0061] In an alternative embodiment, as illustrated in Figure 6B, a suture 600 may be drawn from the proximal 100B to the distal end 100A of the anchor assembly 100, around the exterior of the anchor assembly 100, looped around the suture bridge 206, and drawn back to the proximal end 100B of the anchor assembly 100.

[0062] In a further alternative embodiment, as illustrated in Figure 6C, a suture 600 may be drawn from the proximal 100B to the distal end 100A of the anchor assembly 100, around the exterior of the anchor assembly 100, looped around the suture bridge 206, crossing from one side of the anchor assembly 100 to the other, and drawn back to the proximal end 100B of the anchor assembly 100.

[0063] In a further alternative embodiment, illustrated in Figure 7 the bone anchor 102 may include a plurality of grooves dimensioned to receive the suture. For example, grooves 700 may be positioned on the outer surface of the helical coil 204. Thus, a suture may be drawn from the proximal to the distal end of the anchor assembly along the outer surface of the anchor assembly 100, as discussed above with respect to Figures 6B, 6C within the inserter grooves 700.

[0064] It may be understood that the embodiments discussed with respect to Figures 6A-6C and Figure 7 may be employed in combination with the bone anchor 400 of Figure 4. For example, engagement of the suture with the bone anchor may include passing at least one limb through the passageway of the distal tip such that the closed end of the suture is positioned within the passageway. In other respects, the suture routing of Figures 6A-6C may be unchanged with respect to the discussion presented above.

[0065] In a further alternative embodiment, not shown, one or more sutures may be drawn from other implants or tissues and passed through the suture bridge before insertion of the anchor.

[0066] Figures 8A-8C illustrate an embodiment of a method of securing a suture 600 in a bone 800 employing embodiments of the suture anchor assembly and bone anchors discussed above. As illustrated in Figure 8A, a suture anchor assembly 100 is provided, including suture anchor 102 and suture anchor inserter 104. It may be understood, however, that embodiments of the method may also be employed with suture anchor 400 of Figure 4.

[0067] As further illustrated in Figure 8A, the suture 600 is further engaged with the anchor assembly 100. The engagement of the suture with the anchor assembly 100 may be achieved by suture routing according to any of the embodiments of Figures 6A-6C and 7. Furthermore, while the suture 600 is illustrated in Figures 8A-8C as being engaged with the anchor assembly 100 prior to insertion, in further embodiments, the suture may be engaged with the anchor assembly during or after insertion of the anchor assembly into the bone.

[0068] With reference to Figure 8B, the suture anchor assembly 100 is inserted into the bone 800. For example, the suture anchor assembly 100 is inserted by pounding the anchor assembly 100 into the bone 800. The pound-in force may be applied to the anchor assembly 100 until the entire length of the bone anchor 102 is embedded within the bone 800.

[0069] It may be further observed in Figure 8B that the relative positions of the bone anchor 102, the suture 600, and the bone 800 constrain the suture 600 in place once the bone anchor 102 is inserted within the bone. For example, in one embodiment, at least the closed end 602 of the suture 600 is interposed between the bone 800 and the suture bridge 206. Alternatively or additionally, the suture limbs extending from the closed end of the suture 602 may be further interposed between the bone and the helical coil of the bone anchor 102.

[0070] With reference to Figure 8C, the inserter 104 is removed from the bone 800. For example, the inserter 104 may be rotated so as to proximally advance the anchor inserter 104 with respect to the bone anchor 102. Notably, this rotation does not cause movement of the bone anchor 102 with respect to the bone 800, allowing the bone anchor 102 to be maintained in position.

[0071] Once the inserter 104 is fully disengaged from the bone anchor 102, at least a portion of the suture 600 remains within the bone 800. For example, the closed end of the suture 602 and a distal portion of the suture limbs 802A may remain within the bone 800. A

proximal portion of the suture limbs 802B may extend out from the bone 800 for further use by a surgeon in further repair operations.

[0072] The terms comprise, include, and/or plural forms of each are open ended and include the listed parts and can include additional parts that are not listed. And/or is open ended and includes one or more of the listed parts and combinations of the listed parts.

[0073] The terms about, approximately, substantially, and their equivalents may be understood to include their ordinary and customary meaning. In addition, these terms may be understood to represent values close to, but not equal to, a specified value. For example, 1%, 0.9%, 0.8%, 0.7%, 0.6%, 0.5%, 0.4%, 0.3%, 0.2%, 0.1%, etc., of a specified value.

[0074] One skilled in the art will realize the invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The foregoing embodiments are therefore to be considered in all respects illustrative rather than limiting of the invention described herein. Scope of the invention is thus indicated by the appended claims, rather than by the foregoing description, and all changes that come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

CLAIMS

What is claimed is:

1. A suture anchor, comprising:
 - a suture interfacing member having a proximal end and a distal end;
 - at least one rib extending, proximally, along a longitudinal axis of the anchor from the distal end of the suture interfacing member;
 - an open helical coil coupled to the at least one rib, the open helical coil extending, proximally, along the longitudinal axis of the anchor from the distal end of the suture interfacing member, the open helical coil having threads spaced apart by openings, each thread having a driving surface transmitting a pound-in force delivered in a direction approximately along the longitudinal axis of the anchor, the open helical coil defining an internal volume communicating with a region exterior to the suture anchor through the openings between the threads of the open helical coil.
2. The suture anchor of Claim 1, wherein the plurality of ribs are a pair of ribs extending parallel to the longitudinal axis.
3. The suture anchor of Claim 2, wherein the helical coil is laterally dimensioned to span the distance between the pair of ribs and wherein the helical coil is coupled to each rib at selected positions along the length of the rib.
4. The suture anchor of any of Claims 1-3, further comprising a plurality of wings attached to respective outward facing surfaces of the plurality of ribs and extending outward there-from at a selected angle.
5. The suture anchor of any of Claims 1-4, wherein the suture interfacing member is a suture bridge extending transverse to the longitudinal axis and coupled to the pair of ribs at about the distal end of the bone anchor.
6. The suture anchor of any of Claims 1-4, wherein the suture interfacing member is a sharp tip attached to the distal end of each rib, the tip including a passageway extending there through and dimensioned to receive a suture.
7. A suture anchor assembly, the anchor assembly comprising:

a suture anchor according to any of Claims 1-6;

an anchor inserter comprising:

a generally elongate body extending from a proximal end to a distal end along a longitudinal axis of the anchor inserter; and

a plurality of threads formed in the inserter body and spaced apart by grooves, wherein the inserter threads and grooves are dimensioned to mate with the anchor openings and threads.

8. The suture anchor assembly of Claim 7, further comprising:
 - a cannula formed through the length of the inserter body; and
 - a suture including a closed end and two limbs extending from the closed end; wherein the suture limbs are positioned within the inserter cannula and wherein the closed end of the suture engages the suture interfacing member.
9. The suture anchor assembly of Claim 7, further comprising a suture, wherein the suture includes a closed end and two limbs extending from the closed end, wherein the suture limbs are positioned adjacent to the outer surface of the anchor assembly and wherein the closed end engages the interfacing member.
10. The suture anchor assembly of Claim 9, wherein the suture limbs are crossed proximal to the suture interfacing member.
11. The suture anchor assembly of Claim 9, further comprising a plurality of grooves formed in the outer surface of the bone anchor, wherein at least one of the suture limbs is positioned within the plurality of grooves.
12. A method of securing a suture, comprising:
 - providing a suture anchor assembly comprising:
 - a suture anchor comprising:
 - a suture interfacing member having a proximal end and a distal end;
 - at least one rib extending, proximally, along a longitudinal axis of the anchor from the distal end of the suture interfacing member;

an open helical coil coupled to the at least one rib, the open helical coil extending, proximally, along the longitudinal axis of the anchor from the distal end of the suture interfacing member, the open helical coil having threads spaced apart by openings, each thread having a driving surface transmitting a pound-in force delivered in a direction approximately along the longitudinal axis of the anchor, the open helical coil defining an internal volume communicating with a region exterior to the suture anchor through the openings between the threads of the open helical coil;
a suture anchor inserter, comprising:

a generally elongate body extending from a proximal end to a distal end along a longitudinal axis of the anchor inserter;

a plurality of threads formed in the inserter body and spaced apart by grooves, wherein the inserter threads and grooves are dimensioned to mate with the anchor openings and threads; and

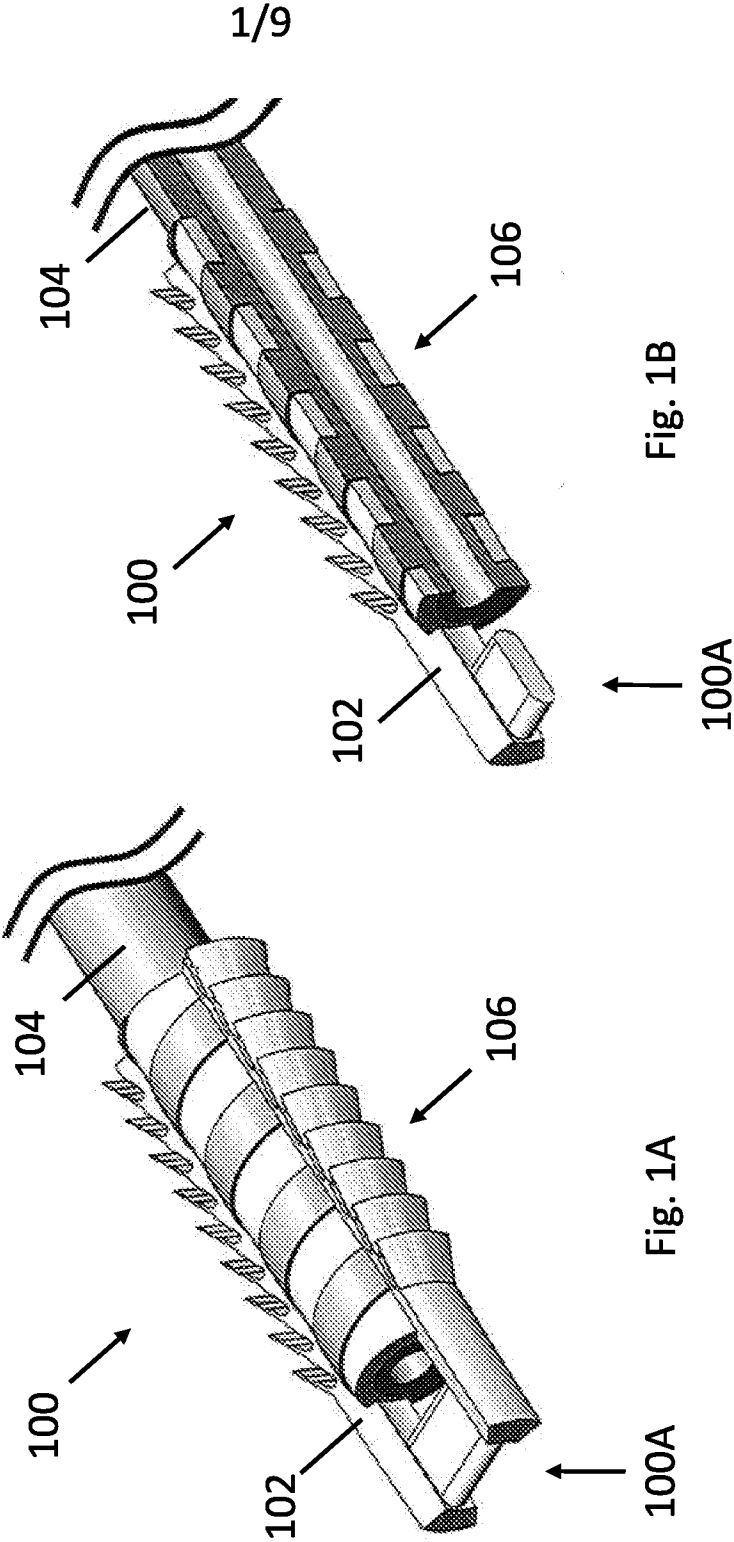
a suture engaged with the suture anchor;

inserting the suture anchor assembly within a bone such that at least a portion of the suture is constrained in place by the suture anchor and bone; and

removing the suture anchor inserter from the bone such that the suture anchor and at least a portion of the suture remain within the bone.

13. The method of Claim 12, wherein the plurality of ribs are a pair of ribs extending parallel to the longitudinal axis.
14. The method of Claim 13, wherein the helical coil is laterally dimensioned to span the distance between the pair of ribs and wherein the helical coil is coupled to each rib at selected positions along the length of the rib.
15. The method of any of Claims 12-14, wherein the suture anchor further comprises a plurality of wings attached to respective outward facing surfaces of the plurality of ribs and extending outward there-from at a selected angle.

16. The method of any of Claims 12-15, wherein the suture interfacing member is a suture bridge extending transverse to the longitudinal axis and coupled to the pair of ribs at about the distal end of the bone anchor.
17. The method of any of Claims 12-15, wherein the suture interfacing member is a sharp tip attached to the distal end of each rib, the tip including a passageway extending there through and dimensioned to receive a suture.
18. The method of any of Claims 12-17, wherein the suture anchor assembly further comprises:
 - a cannula formed through the length of the inserter body; and
 - a suture including a closed end and two limbs extending from the closed end; wherein the suture limbs are positioned within the inserter cannula and wherein the closed end of the suture engages the suture interfacing member.
19. The method of any of Claims 12-17, wherein the suture includes a closed end and two limbs extending from the closed end, wherein the suture limbs are positioned adjacent to the outer surface of the anchor assembly and wherein the closed end engages the interfacing member.
20. The method of Claim 19, further comprising crossing the suture limbs proximal to the suture interfacing member.
21. The method of Claim 19, wherein the bone anchor further comprises a plurality of grooves formed on the outer surface of the bone anchor and wherein at least one of the suture limbs is positioned within the plurality of grooves.



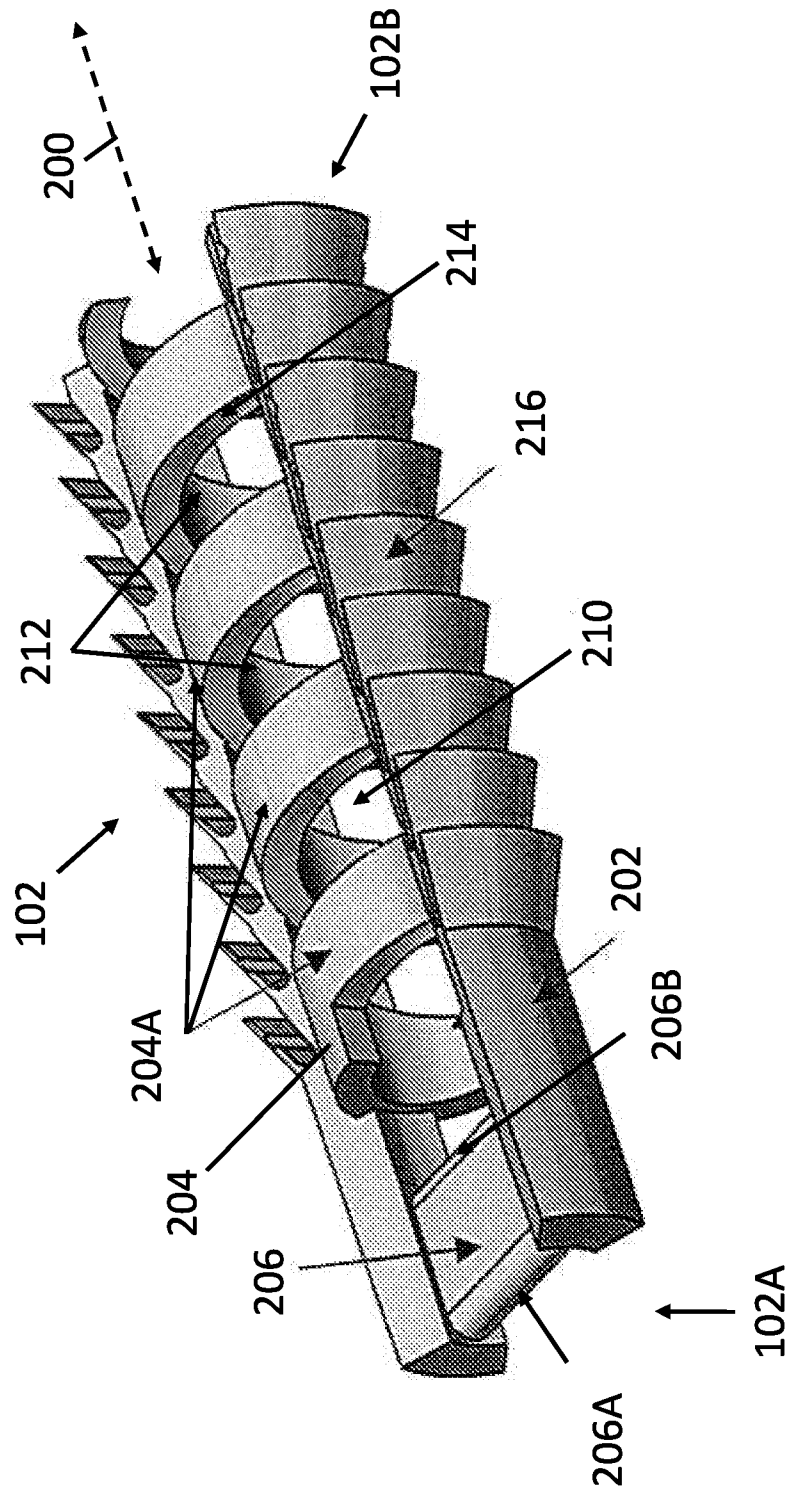


Fig. 2

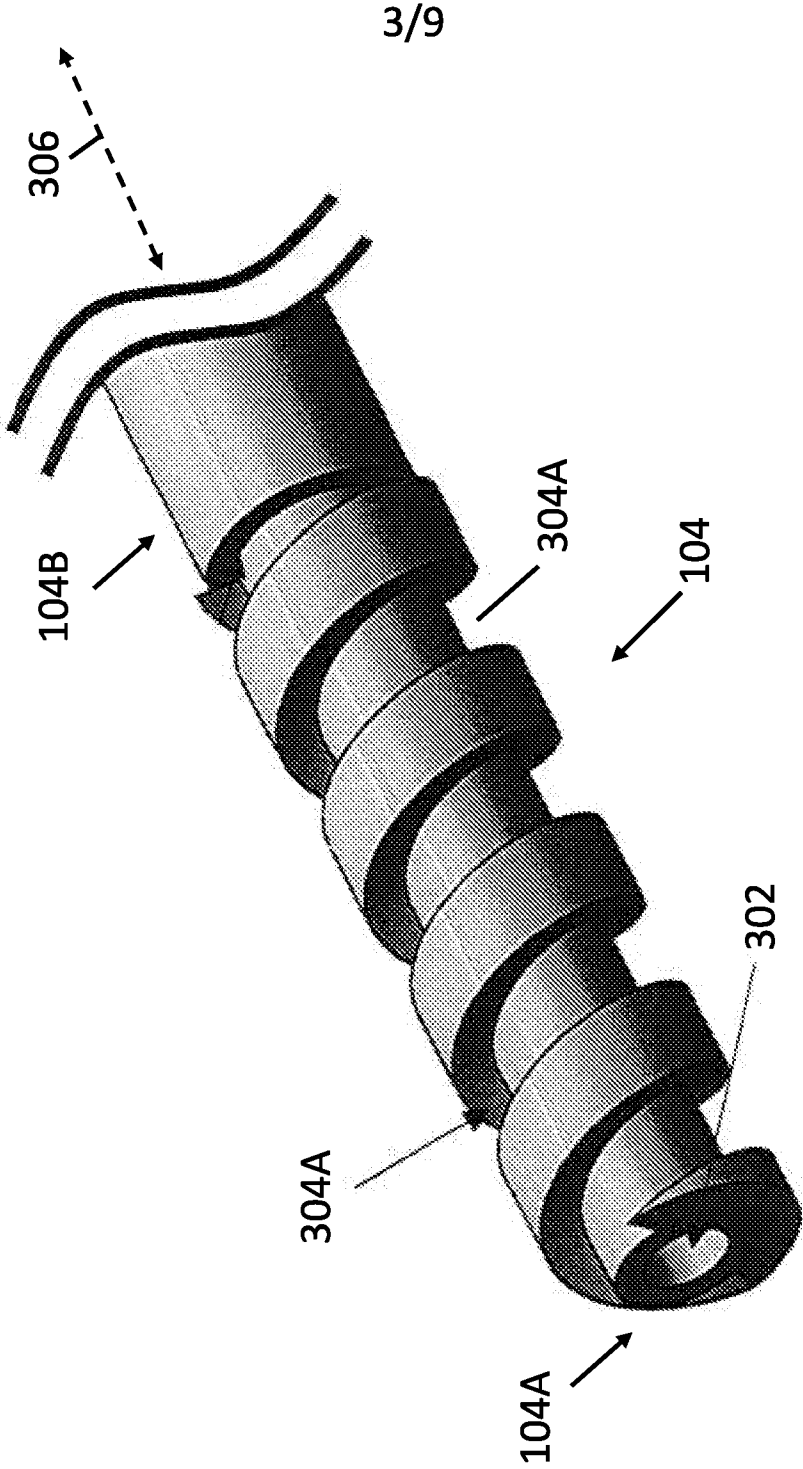


Fig. 3

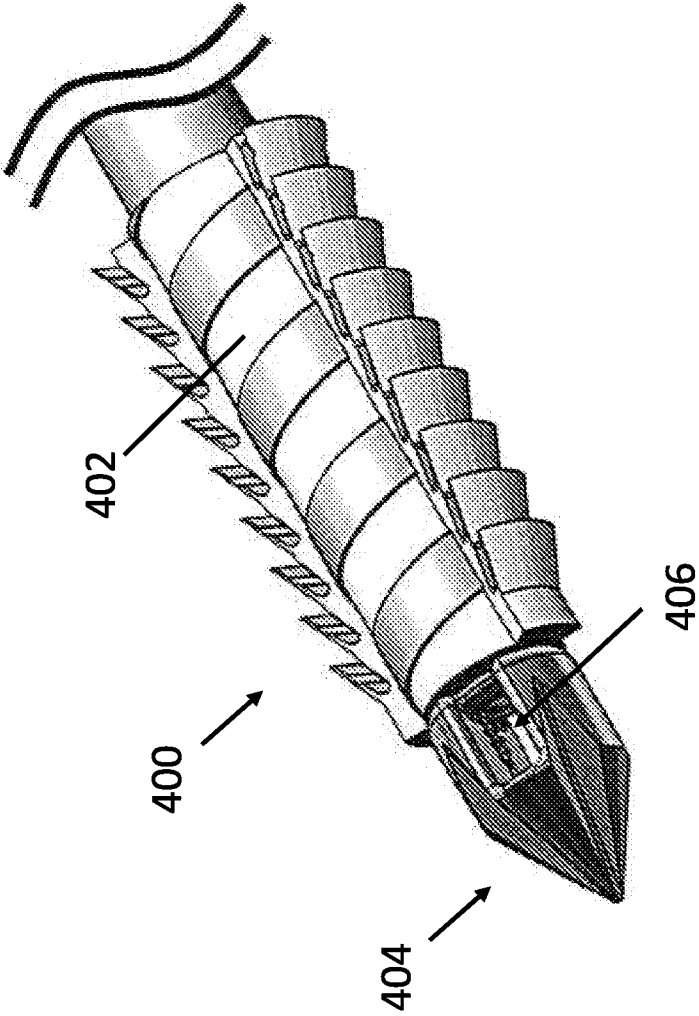


Fig. 4

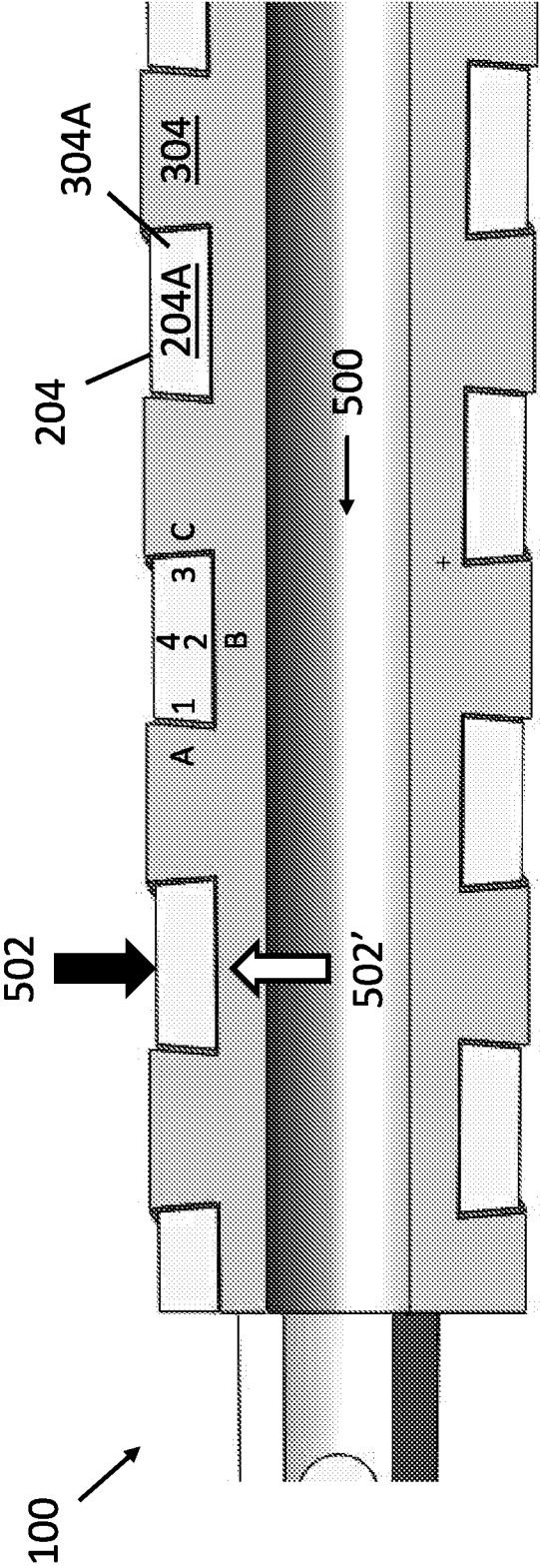


Fig. 5A

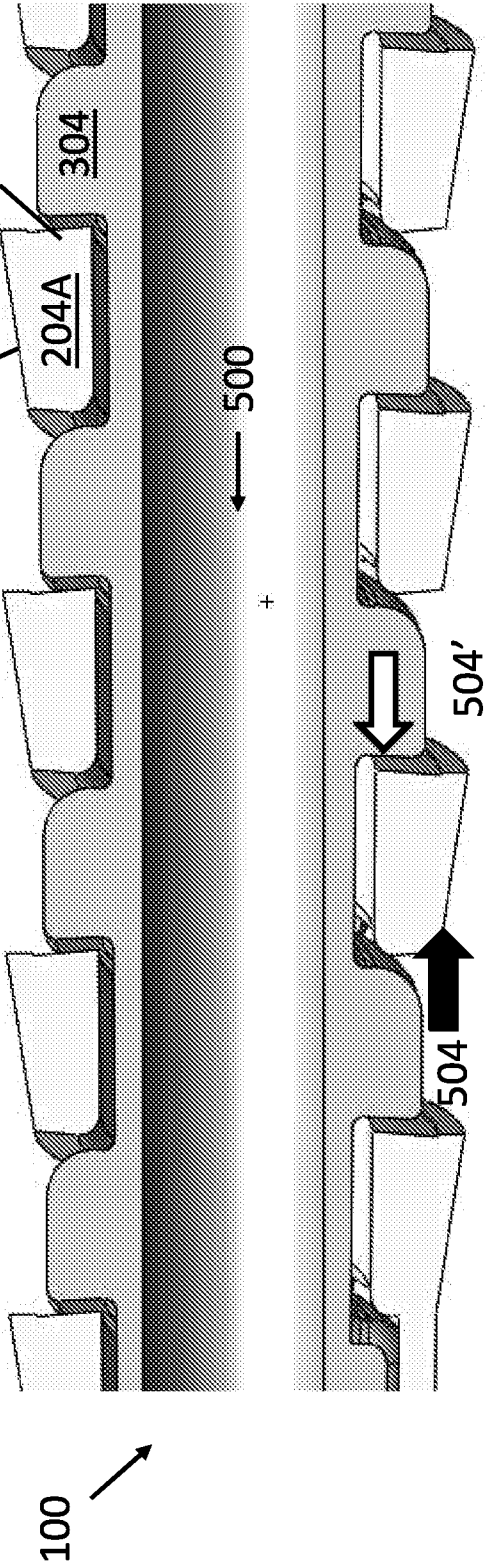
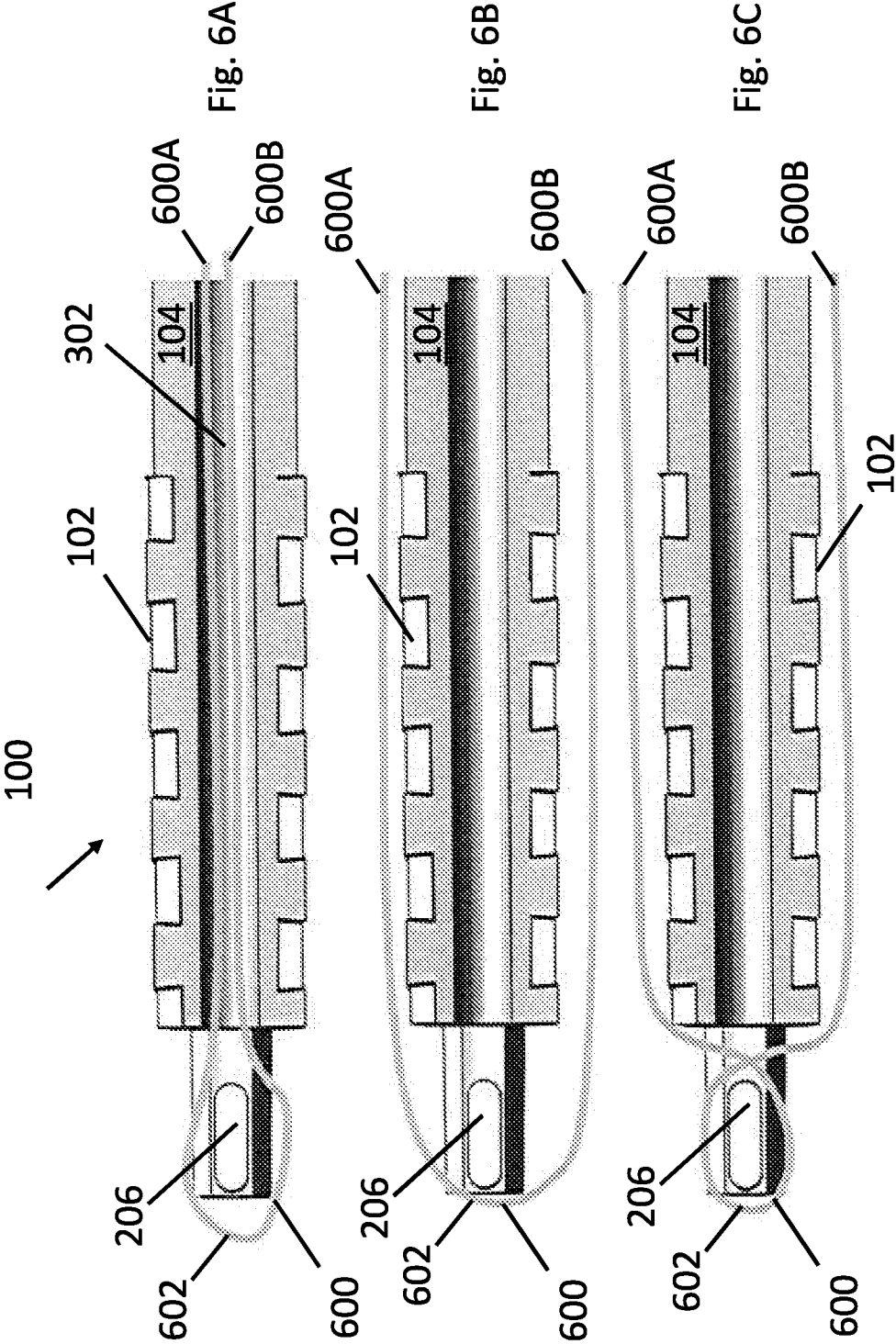


Fig. 5B



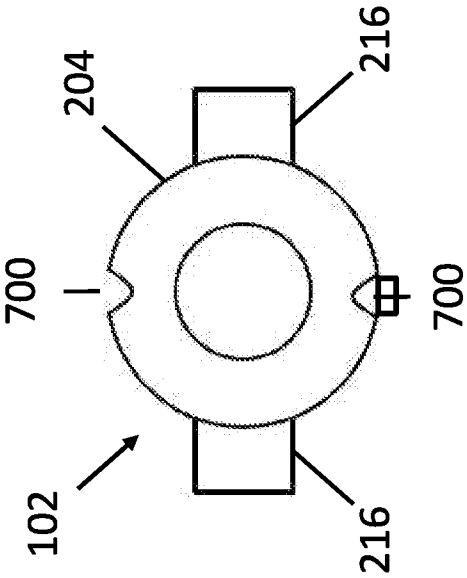


Fig. 7

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Fig. 8B

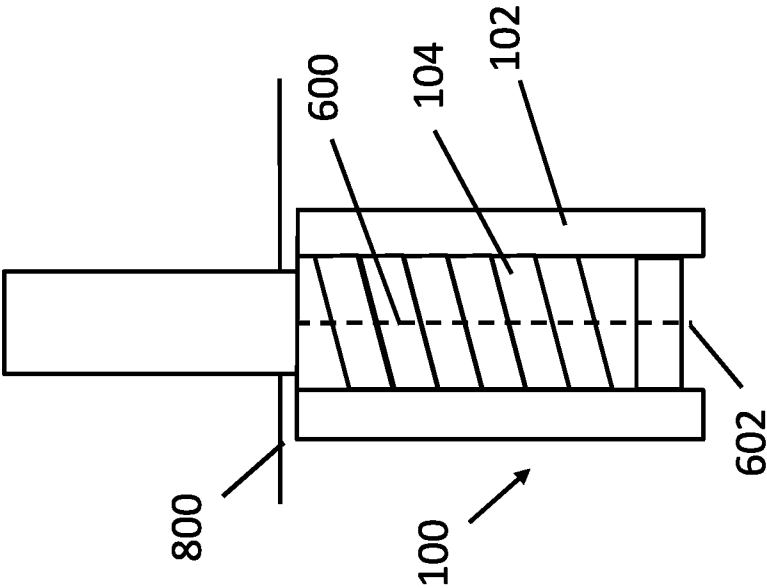
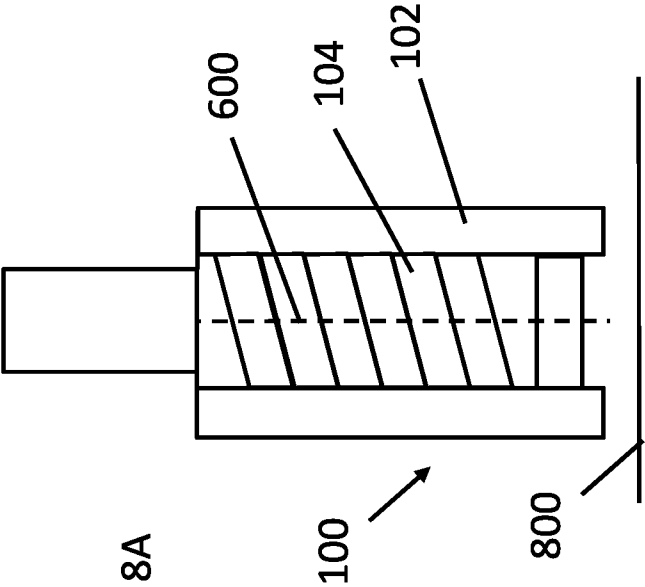
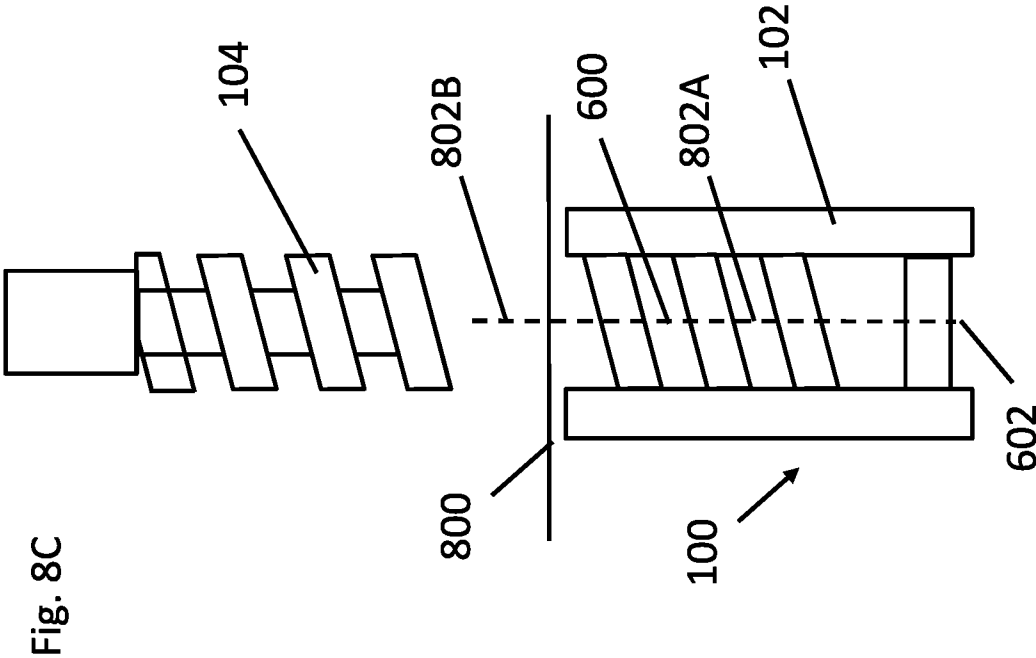


Fig. 8A





INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2014/041931

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☒ Claims Nos.: 12-21
because they relate to subject matter not required to be searched by this Authority, namely:
Rule 39.1(iv) PCT - Method for treatment of the human or animal body by surgery
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2014/041931

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B17/04
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A61B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2011/112576 A1 (NGUYEN LINH TUONG [US] ET AL) 12 May 2011 (2011-05-12) paragraph [0076] - paragraph [0079]; figures	1-11
A	----- US 2009/076545 A1 (DIMATTEO KRISTIAN [US] ET AL) 19 March 2009 (2009-03-19) figures	1-11
A	----- WO 2009/055800 A1 (SMITH & NEPHEW INC [US]; LUNN RICHARD M [US]; PAULK DAVID A [US]; MAY) 30 April 2009 (2009-04-30) figures	1-11



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

13 November 2014

Date of mailing of the international search report

24/11/2014

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Held, Günter

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2014/041931

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