(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
22 September 2016 (22.09.2016)

WIPO | PCT

(10) International Publication Number
WO 2016/148941 A1

(51) International Patent Classification:
A61B 17/04 (2006.01) *A61B 17/06* (2006.01)

(21) International Application Number:
PCT/US2016/020846

(22) International Filing Date:
4 March 2016 (04.03.2016)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
62/132,994 13 March 2015 (13.03.2015) US

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

(54) Title: MICROANCHORS FOR KNOTLESS TISSUE REPAIR

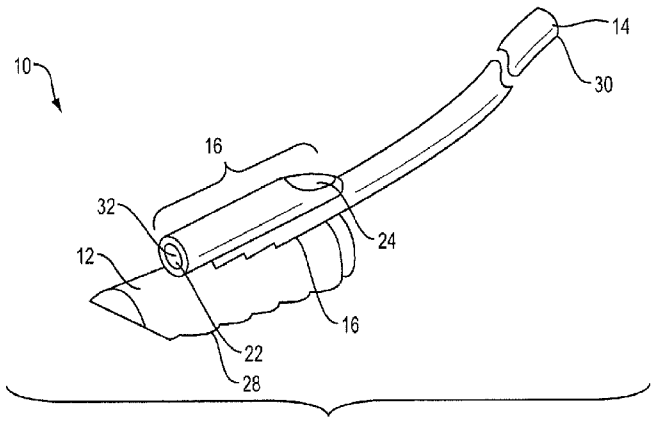

FIG. 1A

(57) Abstract: A knotless anchor for attachment of tissue to bone includes a rigid anchor body and a suture extending there from. The suture is hollow and includes a fixed limb portion secured to the rigid anchor body. A soft suture tunnel extends in a longitudinal direction through the fixed limb portion of the suture. A free suture limb is passed through the tissue, back to the anchor, and through the soft suture tunnel, thereby creating a closable suture loop around the tissue. Tension applied to the free suture limb closes the suture loop, and approximates the tissue to the anchor body. When the anchor is deployed in a bone hole, external features of the anchor body grip the walls of the bone hole and simultaneously compress the suture, thereby preventing tissue pull-out. Anchor assemblies and methods of tissue fixation are also disclosed.

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MICROANCHORS FOR KNOTLESS TISSUE REPAIR

FIELD

The present disclosure is generally directed to anchors for approximating a tissue to bone and, more particularly to microanchors for knotless tissue repair.

BACKGROUND

There is an increasing demand for more types of minimally invasive surgical techniques. Because endoscopic and arthroscopic surgery tends to result in lower morbidity than open surgery, the minimally invasive surgical techniques are very appealing to both patients and physicians. These technologically-advanced procedures include many forms of soft tissue to soft tissue repairs and soft tissue to bone repair. Examples of these procedures in orthopedic surgery include rotator cuff repair, labral repair, biceps tenodesis, and anterior cruciate ligament reconstruction. Other examples in other surgical subspecialties include, but are not limited to, hernia repair, hysterectomies, and laparoscopic gastric bypass.

Many of the above mentioned tissue repair procedures involve approximating the tissue to a bone by deploying an anchor into the bone, and tying the tissue to the anchor with a suture. In a number of suture anchors, the suture is passed through an eyelet located on the proximal end of the anchor and passed through the tissue. (See, for example, U.S. Patent Publication No. 2002/0052629 and U.S. Pat. No. 5,370,662, where a suture is passed through an eyelet located on the proximal end of the anchor.) In order to use these suture anchors, however, the diameter of the hole drilled into the bone is generally in excess of 2.5 mm due to the need to manage four or more suture limbs, the anchor body, and the eyelet structure. While this may be acceptable in certain procedures, there are a number of procedures that would benefit from a smaller bone hole. For example, the procedure for reattaching the labrum to the acetabular rim in a hip repair would benefit by use of a smaller bone hole. It is therefore desirable to reduce the diameter of both the anchoring structure and the bone hole. Reducing the size of the bone hole and the anchor tends to make the tissue repair less traumatic and leads to a shorter patient recovery time.

SUMMARY OF THE DISCLOSURE

Described herein is a knotless anchor for securing a tissue to a bone in a human or animal including a rigid anchor body and a suture secured thereto. As described further herein, the parallel direction or orientation of a suture tunnel reduces the number of suture limbs required to fixate a tissue to bone. The reduction in the number of suture limbs arises because the suture itself forms the eyelet, eliminating the need of a separate laterally-disposed eyelet structure. It is estimated that the effective diameter is reduced by an amount equal to at least the cross sectional area of one suture plus the cross sectional area of the eyelet mechanism. Additionally, the bone fixation features compress the suture between the bone wall and an exterior surface of the rigid anchor body when the anchor body is deployed in a bone hole. Embodiments described herein bind the suture and prevent tissue pull out. Advantageously, the anchor operates without the need to tie a knot, without adding blocking protrusions or obstacles along the suture, and without use of multiple actuatable/moving internal components for clamping the suture.

In embodiments, the suture and the rigid anchor body are securely connected by bonding, heat staking, ultrasonic welding or staking, ultrasonic molding, or injection molding.

In embodiments, the fixed limb portion of the suture includes a suture tunnel. The suture tunnel commences at a suture entry port and terminates at a suture exit port.

In embodiments, the rigid anchor body comprises at least one bone locking feature such as but not limited to an exterior barb, ridge, thread, or rib.

In embodiments, the suture is locked by compressing the suture between an exterior surface of the anchor body and the interior surface of the bone hole.

In embodiments, an anchor assembly comprises an anchor as described above and a snare extending through the suture eyelet. The snare is configured to draw the free end of the suture through the eyelet. The anchor assembly may also include an inserter tube for supporting and manipulating the anchor into the bone hole.

In embodiments, the anchor assembly may also include an advancer (or die) tube abutting the proximal end of the anchor body and for holding the anchor body in the bone hole as the inserter tube is retracted.

In embodiments, a method of anchoring a tissue to a bone of a human or an animal without tying a knot comprises passing a free suture limb through the tissue. The fixed suture

limb is secured to a rigid anchor body. The free suture limb is drawn through a suture tunnel formed in the fixed suture limb thereby defining a closable suture loop around the tissue. The tissue is approximated towards the anchor body by closing the suture loop. The anchor body is inserted into a bone hole whereby the suture is compressed between an internal wall of the bone hole and an exterior feature of the anchor body thereby locking the suture and affixing the tissue to the bone.

In embodiments, the method further comprises providing the fixed suture limb on an exterior of the anchor body.

In embodiments, a multi-row tissue fixation method for anchoring a tissue to a bone without tying a knot comprises providing a first and a second rigid anchor body. A fixed suture limb is joined to each of the rigid anchor bodies. A free suture limb extends from each of the anchor bodies. The method further comprises deploying the first and second anchor bodies in first and second bone holes respectively. The free suture limbs are passed through the tissue. The tissue is approximated to the bone by applying tension to the free suture limbs of the first and second sutures until the tissue is positioned as desired.

In embodiments, the multi-row tissue fixation method further comprises threading the first and second free suture limbs through at least a third anchor body.

In embodiments, the multi-row tissue fixation method further comprises threading the first and second free suture limbs through third and fourth anchor bodies respectively.

In embodiments, the multi-row tissue fixation method further comprises deploying the third and fourth anchor bodies in third and fourth bone holes respectively.

In embodiments, the multi-row tissue fixation method further comprises creating the third and fourth bone holes in lateral locations relative to the first and second bone holes, the first and second bone holes being medially disposed.

In embodiments, a multi-row tissue fixation method further comprises a first suture having a non-hollow or tape-like shape.

Aspects of the present disclosure advantageously improve upon some of the previous anchor designs by, amongst other things, reducing the footprint of the bone hole.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other features will be apparent from the following description of particular embodiments disclosed herein, as illustrated in the accompanying drawings.

Fig. 1a is a perspective view of an anchor comprising a soft suture tunnel secured to an exterior surface of the anchor body;

Figs. 1b-c are details of the interface between the soft suture tunnel and the anchor body of Fig. 1a;

Fig. 2 is a perspective view of another anchor comprising a soft suture tunnel partially incorporated into the anchor body;

Fig. 3 is a cross sectional view of the anchor shown in Fig. 2, taken along line 3-3;

Fig. 4 is a perspective view of another anchor including a hard suture tunnel extending through the anchor body;

Fig. 5a is a perspective view of another anchor including a suture tunnel extending through the anchor body;

Fig. 5b is a cross sectional view of the anchor shown in Fig. 5a, taken along line 5b-5b;

Figs. 6-10 are illustrations of a method for approximating a tissue to bone;

Fig. 11 is a perspective view of another anchor for approximating a tissue to bone; and

Figs. 12-13 are illustrations of multi-row tissue fixation methods for approximating tissue to a bone.

DETAILED DESCRIPTION

Before the present disclosure is described in detail, it is to be understood that this disclosure is not limited to particular variations set forth herein as various changes or modifications may be made to the disclosure described and equivalents may be substituted without departing from the spirit and scope of the disclosure. As will be apparent to those of skill in the art upon reading this disclosure, each of the individual embodiments described and illustrated herein has discrete components and features which may be readily separated from or combined with the features of any of the other several embodiments without departing from the scope or spirit of the present disclosure. In addition, many modifications may be made to adapt a particular situation, material, composition of matter, process, process act(s) or

step(s) to the objective(s), spirit or scope of the present disclosure. All such modifications are intended to be within the scope of the claims made herein.

Methods recited herein may be carried out in any order of the recited events which is logically possible, as well as the recited order of events. Furthermore, where a range of values is provided, it is understood that every intervening value, between the upper and lower limit of that range and any other stated or intervening value in that stated range is encompassed within the disclosure. Also, it is contemplated that any optional feature of the inventive variations described may be set forth and claimed independently, or in combination with any one or more of the features described herein.

All existing subject matter mentioned herein (*e.g.*, publications, patents, patent applications and hardware) is incorporated by reference herein in its entirety except insofar as the subject matter may conflict with that of the present disclosure (in which case what is present herein shall prevail). The referenced items are provided solely for their disclosure prior to the filing date of the present application. Nothing herein is to be construed as an admission that the present disclosure is not entitled to antedate such material by virtue of prior disclosure.

Reference to a singular item, includes the possibility that there are plural of the same items present. More specifically, as used herein and in the appended claims, the singular forms "a," "an," "said" and "the" include plural referents unless the context clearly dictates otherwise. It is further noted that the claims may be drafted to exclude any optional element. As such, this statement is intended to serve as antecedent basis for use of such exclusive terminology as "solely," "only" and the like in connection with the recitation of claim elements, or use of a "negative" limitation. Last, it is to be appreciated that unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this disclosure belongs.

With reference to Fig. 1a, for example, a knotless anchor 10 for securing soft tissue to bone is shown. In embodiments, the anchor 10 comprises a rigid anchor body 12, and a length of suture 14 secured to an external surface of the anchor body 12. The anchor body 12 may comprise a single or unitary rigid body. A fixed end 16 of the suture 14 is secured along the exterior of the anchor body 12. The fixed end 16 is shown affixed between the proximal and distal end of the anchor body 12. As described further herein, the other end of the suture

14 is a free end 30 and is threaded through the tissue to be approximated to the bone. Exemplary materials for the suture 14 are PGA, PGLA, or Ultra-high-molecular-weight polyethylene (namely, UHMWPE). The suture 14 is preferably hollow and braided. The suture 14 may have a variable pitch of the yarn. In embodiments, the suture 14 has a low pitch, permitting the hollow braid to more easily expand over the anchor body 12 than a high pitch braid. In embodiments, a section of flat tape (not shown) is incorporated into the suture 14 in order to spread tension load where the tape/suture is to contact the tissue.

In the embodiment shown in Fig. 1a, the suture 14 is a soft hollow member (e.g., a hollow braid). It is secured in a predominantly parallel orientation to the longitudinal axis of the anchor body 12. The fixed end 16 of the suture 14 operates as an eyelet for passage of the free end 30. A first port 22 and a second port 24 are shown in the hollow braided suture 14. The first port 22 and the second port 24 can be used be as a suture entry port and suture exit port respectively. Alternatively, the first port 22 could be used as an exit port and the second port 24 could be used as an entry port. A suture lumen or tunnel 32 extends parallel to the axis of the anchor body 12 and connects the first port 22 to the second port 24. The free end 30 of the suture 14 is passed through tissue, then through tunnel 32, resulting in only three limbs extending from the bone hole (rather than four limbs), advantageously providing a reduced diameter when compared to other anchor designs.

With reference again to Fig. 1a, the length of the tunnel 32 may range from about 1 mm to about 12 mm. The diameter of the tunnel 32 may range from about 0.2 mm to about 2 mm. The tunnel 32 and suture 14 are preferably unitary continuous components of the knotless anchor 10, and not separate members or assemblies which can undesirably make the anchor footprint larger and more complex. The cross section of the knotless anchor 10 (i.e., suture 14 plus anchor body 12) is about the same diameter as the suture 14 itself, or maybe slightly larger (e.g., 10-15%, or up to 25% larger) to accommodate the diameter of the anchor body 12. Bone fixation features, such as ridges 28, are shown on the anchor body 12. However, the bone fixation features may vary widely. Screw threads, barbs, ribs, protrusions, or a smooth shell can be utilized to secure the anchor body 12 in bone. The bone fixation features serve to grip internal walls of the bone hole when the anchor body 12 is installed.

As detailed in Fig. 1b, the suture 14 and the anchor body 12 may be connected in various ways. For example, the suture 14 can be connected to the anchor body 12 via

bonding, ultrasonic welding or staking, or heat staking. Mechanical interlocking features 13 incorporated into the anchor body 12 that pierce or engage the suture 14 may aid the assembly process. The materials and size of the anchor body 12 and suture 14 may be selected such that the melt temperature of the anchor body 12 is lower or equal to the melt temperature of the suture 14 for ease of assembly. Alternatively, if the melt temperature of the anchor body 12 is higher than the melt temperature of the suture 14, the attachment can still be formed because the actual polymer melt profile can be a lower temperature at the suture interface and managed to limit damage to the suture 14. As shown in Fig. 1c, displacement and or deformation 17 of mechanical interlocking features 13 (Fig. 1b) on the anchor body 12 that engage the suture 14 via ultrasonic welding or staking, or heat staking is a suitable assembly process to limit damage to the suture 14. Suitable materials for the anchor body 12 include without limitation PEEK, PLLA, REGENESORB™ (manufactured by Smith & Nephew plc, London England), and other biocompatible or bioabsorbable materials. Insert molding the anchor body 12 to the suture 14 via ultrasonic molding or injection molding are also viable assembly methods. In embodiments, the suture 14 is connected to the anchor body 12 without a knot.

Fig. 2 illustrates an alternative embodiment of a knotless anchor 40 for attaching tissue to bone. Anchor 40 is similar to the anchor 10 shown in Fig. 1a except that the suture 44 is partially integrated into (insert molded, bonded, or staked to) the anchor body 42. The fixed end 46 of the suture 44 can be joined to the anchor body 42 via heat staking or molding. A suture tunnel 56 extends from the first port 52 to the second port 54. The suture tunnel 56 acts as an eyelet running parallel to the longitudinal axis of the anchor body 42. As described herein, incorporating the suture tunnel 56 along the longitudinal axis of the anchor body 42 reduces the diameter of the anchor 40 compared to anchors having a tunnel (or eyelet) perpendicular to the anchor body. Fig. 3 shows a cross-sectional view of the anchor 40 shown in Fig. 2, taken along line 3-3

Fig. 4 shows another knotless anchor 60 for attaching tissue to bone. The anchor 60 shown in Fig. 4 is similar to the anchor 10 shown in Fig. 1a except that both the anchor body 62 and the suture 64 have a suture tunnel 68 extending in the longitudinal direction. The fixed end 66 circumferentially or radially surrounds the hard anchor body 62. The anchor 60 shown in Fig. 4 thus comprises a hard tunnel coaxially arranged within a soft tunnel.

Fig. 5a shows another knotless anchor 80 for attaching tissue to bone. The anchor 80 shown in Fig. 5a is similar to that shown in Fig. 4 except the fixed end 84 is secure internally to the anchor body 88. More specifically, the fixed end 84 is secure within hard lumen 86 of the anchor body 88. The fixed end 84 includes a first port 94 and a second port 96. Therefore, in anchor 80, the axially or longitudinally disposed soft tunnel is coaxially arranged within the hard tunnel.

With reference to Fig. 5b, a cross-sectional view of the anchor 80 is shown, taken along line 5b-5b. A preferred range for the internal diameter D_1 of the lumen 86 is about 0.5 mm to about 8 mm. A preferred range for the outer diameter D_2 of anchor body 88 is about 1.2 mm to about 2.5 mm. However, it is to be understood that the anchor 80 may have other dimensions.

Figs. 6-10 illustrate a method of deploying an anchor 116 and approximating tissue 104 to bone 110. Although the anchor 116 shown in Figs. 6-10 is similar to anchors described above in connection with Figs. 5a-5b, other anchor configurations may be utilized in accordance with methods described herein.

Fig. 6 shows an anchor 116 comprising a fixed suture end 101 secured to the anchor 116 and a free suture end 102 which has been passed through tissue 104. A non-limiting example of a suture passer to deliver the suture free end through the tissue is the ACCU-PASS device manufactured by Smith & Nephew Corporation, Austin Texas, U.S.A. Fig. 6 also shows the free suture end 102 fed into a snare loop 106 having snare handle 108.

Next, and with reference to Fig. 7, snare handle 108 (Fig. 6) is pulled, drawing the free suture end 102 through the anchor 116. Free suture end 102 is drawn through the longitudinally disposed soft eyelet 112 formed by the suture 120. Stated alternatively, the suture 120 is drawn through (or fed into) itself. As free suture end 102 is further pulled, a closable loop 119 is formed and drawn over a portion of the tissue 104. Thus, a suture path commences at the fixed suture end 101 on the anchor 116, extends through the tissue 104, and returns to the anchor 116, continues through the soft eyelet 112 of the suture 120, and terminates at the free suture end 102. Free suture end 102 may be pulled by the physician to the desired tensional force. With reference to Fig. 8, tension (T) is applied to the free suture end 102 until a desired level of force or resistance is achieved. Tissue 104 is now shown in close proximity or adjacent anchor body 116.

With reference to Fig. 9, an inserter 114 is shown mating with a proximal surface of the anchor body 116. The inserter 114, as described herein, assists with positioning the anchor 116 in the bone hole 118. Additionally, in embodiments, the inserter 114 may comprise an internal, axially slidable die member 115 to cooperate with an internal key hole (not shown) of the anchor 116. The inserter 114 holds the anchor 116 in place as the internal die member 115 is retracted. The components of the inserter 114 cooperate together to place, hold, and deploy the anchor 116 in the bone hole. Non-limiting examples of inserter members, dies, and handles are described in, for example, U.S. Patent No. 6,780,198 to Gregoire et al.

Fig. 9 also illustrates the anchor 116 being inserted into a pre-drilled bone hole 118. However, in embodiments, the anchor 116 may be pounded directly into a bone, creating the bone hole 118 as it is pounded into the bone. In embodiments, the distal end of the anchor 116 includes a hard, pointed edge to facilitate cutting through the bone. The anchor 116 may also include self-tapping threads to dig and grip the bone. In the assembly shown in Fig. 9, the suture 120 is compressed between the interior wall of the bone hole 118 and the rigid exterior surface of the anchor 116. Ridges on the surface of the anchor (Fig. 1) make contact with the suture 120 and securely hold the suture 120 in place. The suture 120 is compressed and locked. The anchor 116 may be adjusted to a depth, as shown, safely below the relatively hard cortical bone layer indicated by reference numeral 122.

Fig. 10 shows the tissue 104 secured to the bone. The inserter 114 removed, and the free suture end 102 trimmed. Notably, the embodiment shown in Fig. 10 includes only three suture limbs 102, 134, 136 extending from the anchor 116. This reduction in the number of suture limbs arises from the soft eyelet 112 present along the longitudinal axis. Consequently, a larger laterally-disposed eyelet (or other type of suture loop/connector) is not necessary for tissue fixation.

Fig. 11 shows another anchor 202 including a rigid anchor body 204 and a suture 206 secure thereto. The embodiment shown in Fig. 11, however, differs from the previous described embodiments in that the anchor 202 does not feature a suture tunnel or eyelet. The fixed suture end 210 is preferably a suture tape or non-hollow suture. The free suture end 208 is directly affixed to a lateral aspect of the rigid anchor body 204. Alternatively, the free suture end 208 may be bonded, staked, or joined internally to anchor body 204. The tape or

non-hollow suture is preferred in this embodiment so as to reduce the diameter or footprint of the bone hole. As described herein, anchor 202 can be useful in double or multi-row tissue fixation procedures. In another embodiment, the rigid anchor body 204 may include a hole (not shown) traversing the longitudinal axis to serve as an eyelet or insertion aid.

Fig. 12 is an illustration of a multi-row tissue fixation technique comprising a first set of anchors 210a, 210b and a second set of anchors 212a, 212b. The second or additional set 212a, 212b are intended to provide better purchase on the tissue 214. In a double row procedure, medial anchors 210a, 212a (an example of which is shown in Fig. 11) may be pounded or installed into the medial bone holes. Free suture ends 216a, 216b are passed through the tissue 214 (e.g., a labrum or tendon). Free suture ends 216a, 216b are snared or otherwise threaded through suture eyelets of the lateral anchors 210b, 212b. Lateral anchors 210b, 212b may include the self-contained suture tunnels as described above. Tension is applied to free suture ends 216a, 216b until a desired force across the tissue 214 is achieved. The lateral anchors 210b, 212b are then deployed in the bone holes 218, 220, thereby locking the suture and anchors in the bone holes. The free suture ends 216a, 216b are trimmed.

The above-described double row technique utilizes smaller-diameter implants, and consequently reduces the size of the bone hole. In particular, in embodiments, less than four suture limbs (or in some embodiments less than three suture limbs) are necessary to carry out the tissue fixation procedure. The medial anchors 210a, 212a, for example, have only one suture limb extending therefrom, the suture being non-hollow or flat. Additionally, the lateral anchors 210b, 212b show only two suture limbs extending from the proximal end of the anchor. Smaller diameter bone holes and hardware are therefore enabled by the anchors and procedure described in connection with Figs. 11-12.

Fig. 13 is an illustration of another multi-row tissue fixation technique comprising a first set of medial anchors 230a, 230b and a second anchor 232. The technique shown in Fig. 13 is similar to that shown in Fig. 12 except that the two suture free ends 240, 242 are shown threaded through sole lateral anchor 232. Lateral anchor 232 has an internal lumen to accommodate both suture free ends 240, 242, and features a suture lock wholly independent of the bone lock mechanisms. For example, the anchor may be deployed in the bone hole, and after the anchor is properly seated in the bone hole, the suture may be tensioned and then locked within the anchor. A non-limiting example of an anchor similar to the anchor 232

shown in Fig. 13 is the SpeedScrew Knotless Fixation Device (Manufactured by Arthrocare Corporation, Austin, Texas). The sutures are then trimmed.

Although Figs. 11-13 illustrate double row configurations, the disclosure is not so limited. In embodiments, at least three rows of anchors may be deployed to achieve better tissue purchase and stability. Additionally, a number of non-limiting examples of multi- or double row techniques may be combined with aspects described herein including, without limitation, the multi-row fixation techniques described in connection with the Speedscrew™ , Labralock™, and Speedlock™ -brand knotless implants manufactured by ArthroCare Corporation, Austin Texas, U.S.A., and the suture described in U.S. Patent No. 8,818,326 to Gagliano.

Although the present disclosure is suitable for attaching the labrum to the acetabular rim in a hip surgery, it is also applicable to other tissue fixation procedures including attachment of the rotator cuff tendon to the humeral head, or other tissue to bone and tissue to tissue procedures. Indeed, the present disclosure is suitable for hip, shoulder, and small joint repair. It is particularly desirable for repairs requiring a relatively small footprint.

While preferred embodiments of this disclosure have been shown and described, modifications thereof can be made by one skilled in the art without departing from the scope or teaching herein. The embodiments described herein are exemplary only and are not intended to be limiting. Because many varying and different embodiments may be made within the scope of the present inventive concept, including equivalent structures, materials, or methods hereafter thought of, and because many modifications may be made in the embodiments herein detailed in accordance with the descriptive requirements of the law, it is to be understood that the details herein are to be interpreted as illustrative and not in a limiting sense.

What is claimed is:

CLAIMS

1. A knotless anchor for attaching a tissue to a bone, the knotless anchor comprising:

a rigid anchor body comprising a proximal end, a distal end, and at least one bone locking feature for engaging an internal wall of a bone hole; and

a hollow suture comprising a suture fixed limb secure to the anchor body, a suture free limb, and a length of suture extending there between wherein the suture fixed limb comprises a suture entry port, a suture exit port, and a longitudinally-disposed suture tunnel extending from the suture entry port to the suture exit port.

2. The knotless anchor of claim 1 wherein the at least one bone locking feature is selected from the group consisting of a barb, ridge, thread, and rib.

3. The knotless anchor of claim 1 wherein the suture fixed limb is secure to the anchor body via bonding, ultrasonic welding, ultrasonic staking, heat staking, ultrasonic molding, or injection molding the anchor body to the hollow suture.

4. The knotless anchor of claim 1 comprising a maximum number of suture limbs extending from the bone hole, wherein the maximum number of suture limbs is three.

5. The knotless anchor of claim 1 wherein the suture tunnel has a length ranging from about 1 mm to about 12 mm.

6. The knotless anchor of claim 1 wherein the rigid anchor body comprises a rigid longitudinally disposed eyelet, and the free limb of the suture is passed through both the eyelet and the suture tunnel.

7. The knotless anchor of claim 6 wherein the suture tunnel is disposed in a coaxial arrangement with the longitudinally disposed eyelet.

8. The knotless anchor of claim 6 wherein the suture tunnel is disposed inside the longitudinally disposed eyelet.

9. The knotless anchor of claim 6 wherein the suture tunnel is disposed outside the longitudinally disposed eyelet.

10. The knotless anchor of claim 1 wherein the suture tunnel is disposed at least partially on an exterior surface of the rigid anchor body.

11. The knotless anchor of claim 1 wherein the rigid anchor body is comprised of PEEK or REGENESORB.

12. The knotless anchor of claim 1 wherein the suture is comprised of UHMWPE .

13. The knotless anchor of claim 1 wherein at least a portion of the suture fixed limb is positioned intermediate the proximal end and the distal end of the anchor body.

14. The knotless anchor of claim 1 wherein the suture is a soft braid.

15. The knotless anchor of claim 1 wherein the anchor and suture are sized to be secured in a bone hole having a diameter less than or equal to the diameter of the suture.

16. The knotless anchor of claim 1 wherein the suture includes a section of flat tape where the tape/suture is to contact the tissue.

17. A knotless anchor assembly for attaching tissue to bone, the knotless anchor assembly comprising:

an anchor having an anchor body;

a suture having a free end and a fixed end secured to the anchor body, and a suture tunnel extending through the suture in the vicinity of the fixed end;

a snare extending through the suture tunnel, and configured to draw the free end of the suture through the suture tunnel;

a die member for engaging a proximal portion of the anchor body and manipulating the anchor body into the bone hole; and

an inserter member movable relative to the die member, and having a distal surface abutting the proximal end of the anchor body and for holding the anchor body in the bone hole as the die member is disconnected from the anchor body.

18. A method of anchoring a tissue to a bone of a human or an animal without tying a knot, the method comprising:

passing a free suture limb through the tissue, the free suture limb extending from a fixed suture limb that has been secured to a rigid anchor body;

drawing the free suture limb through a suture tunnel formed in the fixed suture limb thereby defining a closable suture loop around the tissue;

closing the suture loop thereby approximating the tissue towards the anchor body;

inserting the anchor body into a bone hole whereby the suture is compressed between an internal wall of the bone hole and an exterior feature of the anchor body thereby preventing tissue pull-out.

19. The method of claim 18 further comprising drawing the tissue towards the deployed anchor by pulling on the free suture limb.

20. The method of claim 18 wherein the fixed suture limb is secured to an exterior of the anchor body.

21. A multi-row tissue fixation method to anchor a tissue to a bone of a human or an animal without tying a knot, the method comprising:

providing a first rigid anchor body and a first suture, the first suture comprising a fixed suture limb secured to the first rigid anchor body, and a free suture limb extending there from;

providing a second rigid anchor body and a second suture, the second suture comprising a fixed suture limb secured to the second rigid anchor body, and a free suture limb extending there from;

deploying the first and second anchor bodies in first and second bone holes respectively;

passing the free suture limb of the first suture through the tissue at a first location;

passing the free suture limb of the second suture through the tissue at a second location; and

approximating the tissue to the bone by applying tension to the free suture limb of the first and second sutures.

22. The method of claim 21 further comprising threading the first and second free suture limbs through at least a third anchor body.

23. The method of claim 21 further comprising threading the first and second free suture limbs through third and fourth anchor bodies respectively.

24. The method of claim 23 further comprising deploying the third and fourth anchor bodies in third and fourth bone holes respectively.

25. The method of claim 21 further comprising creating the third and fourth bone holes in lateral locations relative to the first and second bone holes, the first and second holes being medially disposed.

26. The method of claim 21 wherein the first suture is non-hollow or a tape.

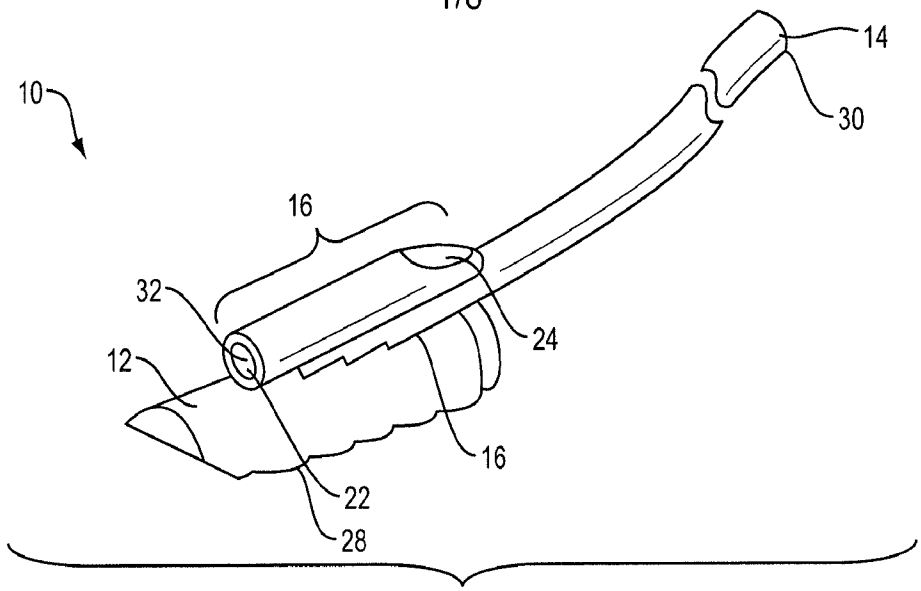

FIG. 1A

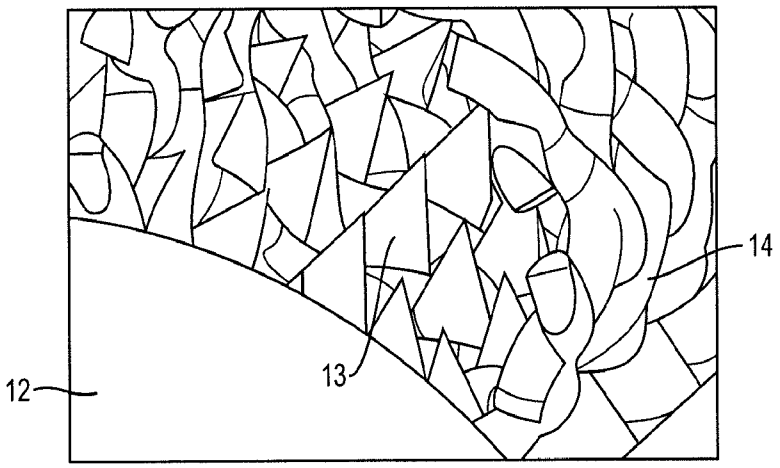

FIG. 1B

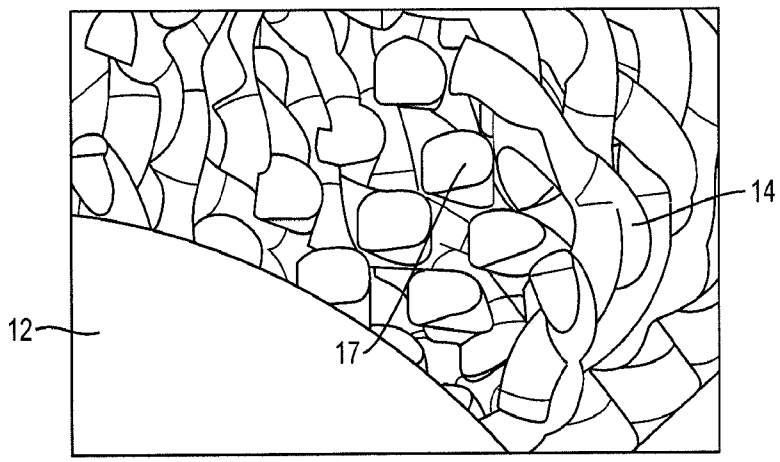

FIG. 1C

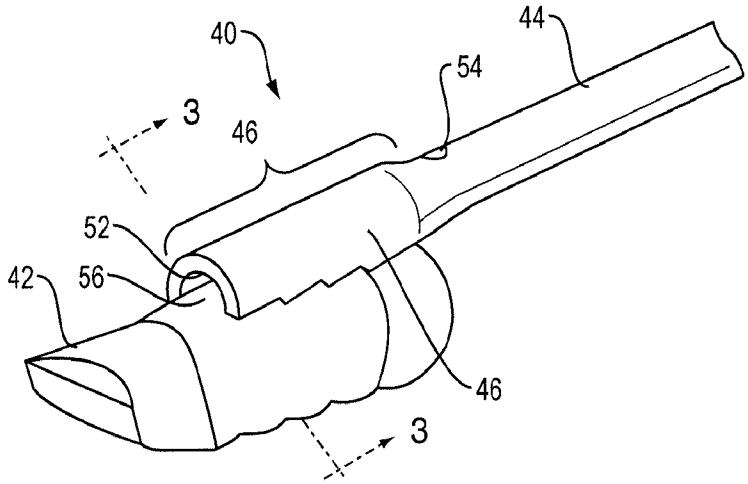

FIG. 2

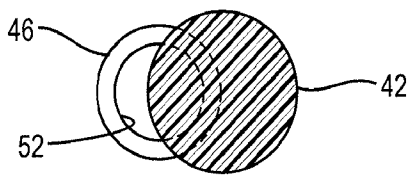

FIG. 3

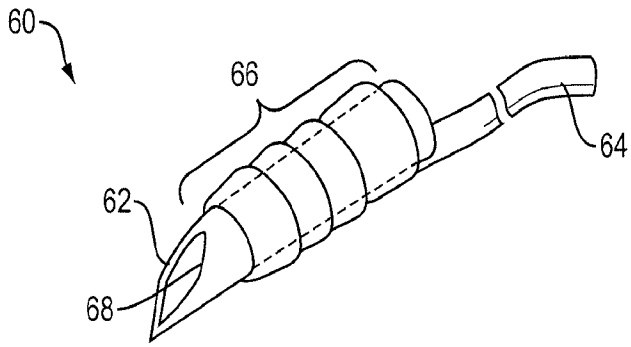

FIG. 4

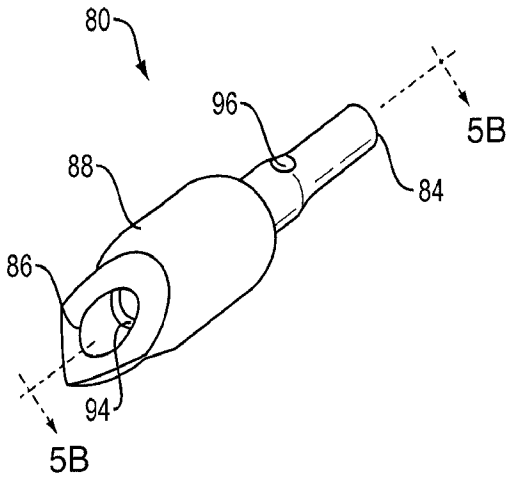

FIG. 5A

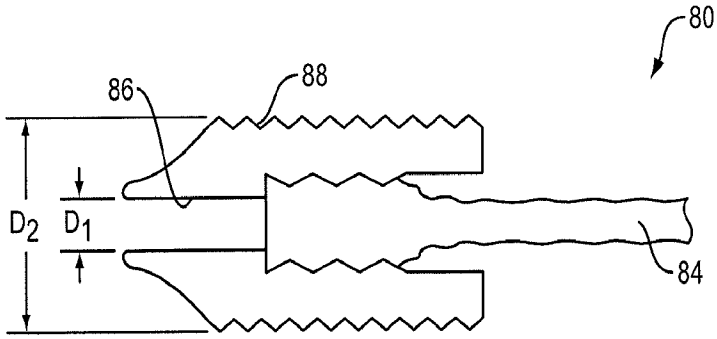

FIG. 5B

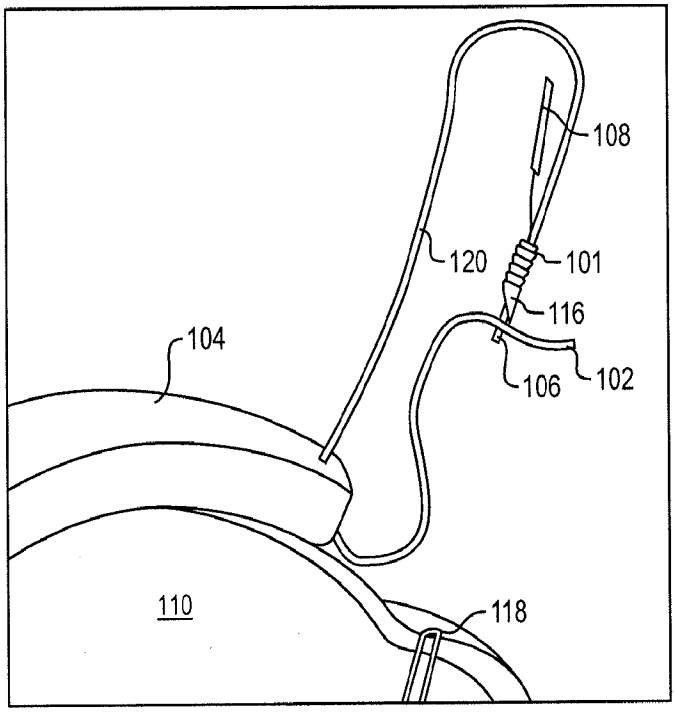
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FIG. 6

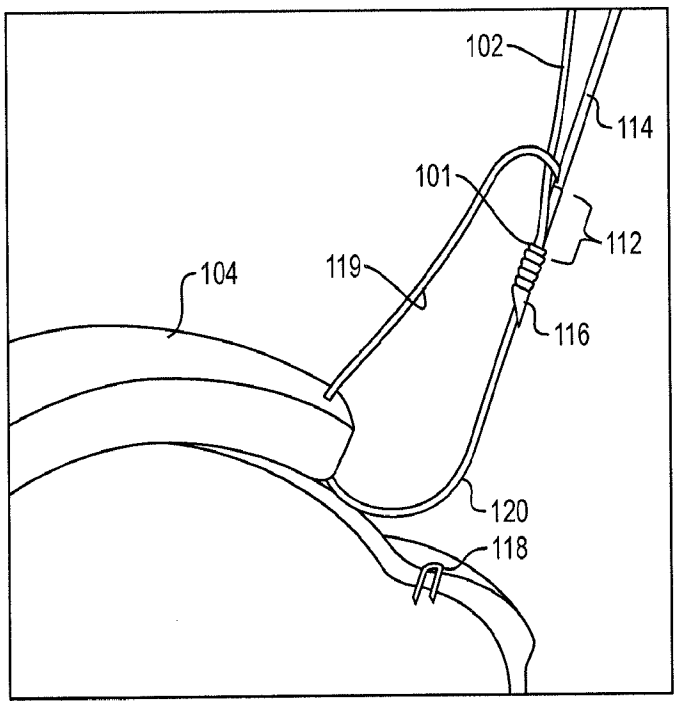
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FIG. 7

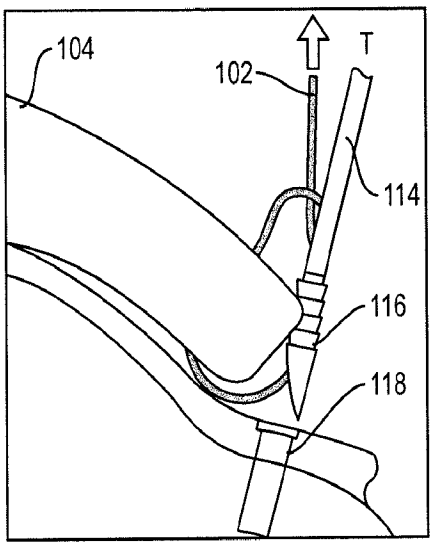

FIG. 8

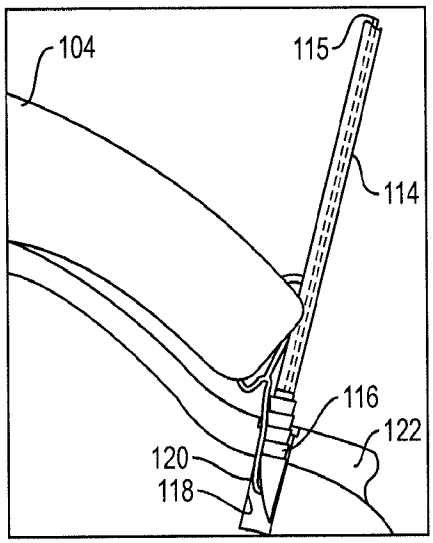

FIG. 9

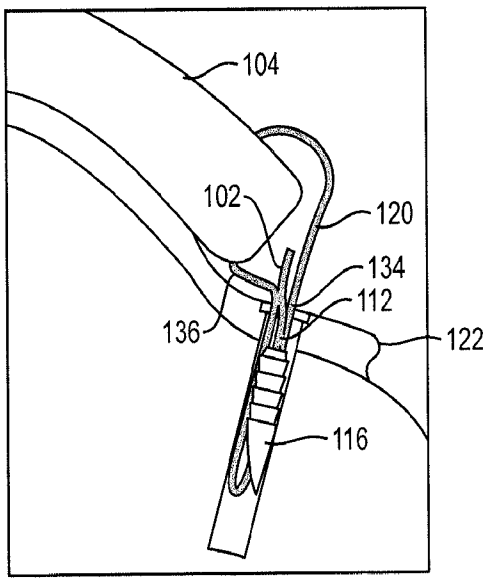

FIG. 10

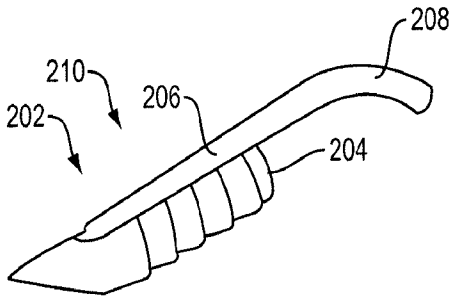

FIG. 11

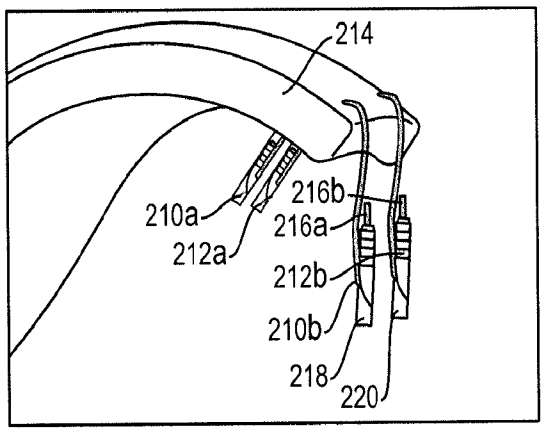

FIG. 12

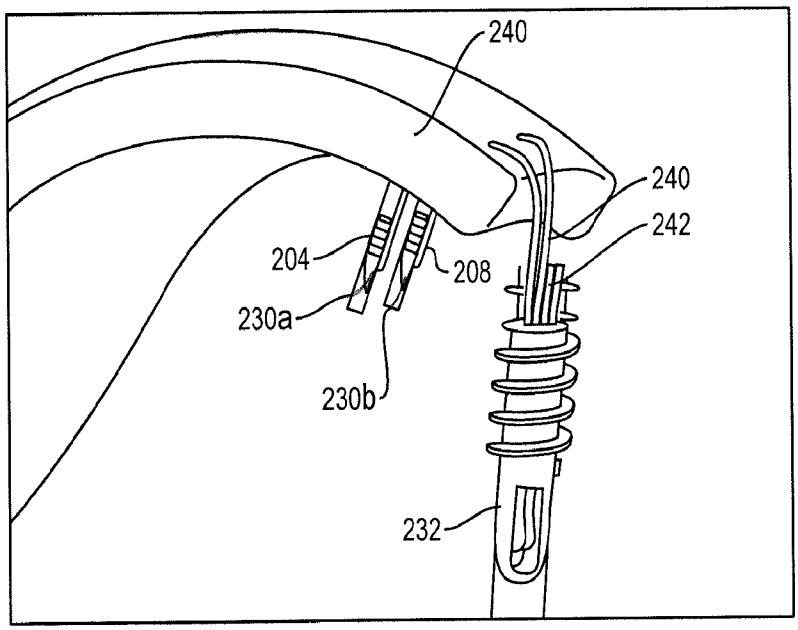

FIG. 13

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/020846

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B17/04 A61B17/06
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	EP 2 572 648 A1 (ARTHREX INC [US]) 27 March 2013 (2013-03-27) figures 1-5, 35, 73-78 paragraph [0034] - paragraph [0035] paragraph [0041] - paragraph [0042] paragraph [0046] paragraph [0062] - paragraph [0063] paragraph [0067] paragraph [0105] - paragraph [0114] paragraph [0116] ----- -/--	1-17

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"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	Date of mailing of the international search report
3 May 2016	17/05/2016

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Etienne, Nicolas

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Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/020846

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 2 676 612 A2 (ARTHREX INC [US]) 25 December 2013 (2013-12-25) figures 1-4, 12, 20 paragraph [0019] - paragraph [0026] paragraph [0031] - paragraph [0037] paragraph [0042] paragraph [0045] paragraph [0057] - paragraph [0060] -----	1-17
X	US 2013/345749 A1 (SULLIVAN DEREK C [US] ET AL) 26 December 2013 (2013-12-26) figures 99, 102, 103 paragraph [0239] - paragraph [0241] -----	1,2,4-8, 11-14, 16,17

1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2016/020846

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. [X] Claims Nos.: 18-26
because they relate to subject matter not required to be searched by this Authority, namely:

see FURTHER INFORMATION sheet PCT/ISA/210

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.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box II.1

Claims Nos.: 18-26

Pursuant to Article 17(2)(a)(i) PCT, this Authority is not required to search the subject-matter of claims 18-26, since it relates to methods for treatment of the human or animal body by surgery (Rule 39.1(iv) and Rule 43bis PCT). Indeed, both independent claims 18 and 21 comprise, inter alia, the step of inserting/deploying an anchor body into a bone hole, which is a surgical step. The same reasoning applies for claims 19-20 and 22-26 which are dependent on claims 18 and 21, respectively.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2016/020846

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 2572648 A1	27-03-2013	EP 2572648 A1	27-03-2013
		US 2013096611 A1	18-04-2013
		US 2015245831 A1	03-09-2015
EP 2676612 A2	25-12-2013	EP 2676612 A2	25-12-2013
		US 2013345750 A1	26-12-2013
US 2013345749 A1	26-12-2013	NONE	