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(57) Abstract:



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METHOD AND SYSTEM FOR PROVIDING A SUTURE WRAP CERCLAGE**BACKGROUND**

[0001] This disclosure relates to a method and system for providing a bone cerclage.

[0002] Cerclages are used to maintain the relative position of fractured bone fragments to promote healing. While cerclages can be used relative to any fractured bone, they are commonly used to promote healing of femoral fractures. Femoral fractures are sometimes caused, for example, by traumatic injuries or as the result of an orthopedic procedure such as a hip replacement. A cerclage is used to fix fractured bone fragments relative to one another, which, again, promotes healing.

[0003] Known cerclages include materials such as cable (i.e., wire) or fabric, and are provided by wrapping the cable or fabric around a fractured bone a single time. After wrapping, the cable or fabric is then locked into place relative to the bone, such as with a plug or clip.

SUMMARY

[0004] This disclosure details a method and system for providing a bone cerclage. The disclosed method includes wrapping a piece of material around a bone, and securing that material relative to the bone. The wrapped material provides a bone cerclage, which maintains the relative position of fractured bone fragments to promote healing.

[0005] A method for providing a fractured bone with a bone cerclage according to an exemplary aspect of the present disclosure includes wrapping suture around bone a first time using a suture passer, wrapping the suture around bone a second time using a shuttling suture, and securing the suture to the bone.

[0006] In a further non-limiting embodiment of the foregoing method, the suture is wrapped around the bone the first time by wrapping the suture and the shuttling suture around the bone by moving the suture carrier in a first direction, and the suture is wrapped around the bone the second time by moving the shuttling suture around the bone in the first direction.

[0007] In a further non-limiting embodiment of any of the foregoing methods, the suture is wrapped around bone the first time by wrapping first and second free ends of the suture and a first end of the shuttling suture around bone, and the suture is wrapped around bone the second time by providing the first and second free ends of the suture in a loop provided in a second end of the shuttling suture, and moving the second end of the shuttling suture around the bone in the first direction.

[0008] In a further non-limiting embodiment of any of the foregoing methods, the suture passer is provided by a curved needle having a first eyelet and a second eyelet.

[0009] In a further non-limiting embodiment of any of the foregoing methods, the suture is received in the first eyelet and the shuttling suture is received in second eyelet.

[0010] In a further non-limiting embodiment of any of the foregoing methods, the shuttling suture includes a first end having a first closed loop and a second end having a second closed loop, and the second closed loop is looped through the second eyelet and the shuttling suture is tightened against the suture passer.

[0011] In a further non-limiting embodiment of any of the foregoing methods, the suture passer includes a proximal end, a distal end, and a main body portion having a thickness tapering between the proximal end and the distal end.

[0012] In a further non-limiting embodiment of any of the foregoing methods, the first eyelet and the second eyelet are adjacent the proximal end of the suture passer.

[0013] In a further non-limiting embodiment of any of the foregoing methods, the suture passer includes a tip adjacent the distal end.

[0014] In a further non-limiting embodiment of any of the foregoing methods, the tip is blunt.

[0015] In a further non-limiting embodiment of any of the foregoing methods, the shuttling suture is provided by nitinol wire.

[0016] In a further non-limiting embodiment of any of the foregoing methods, the suture is a folded piece of suture.

[0017] A method for providing a fractured bone with a bone cerclage according to another aspect of the present disclosure includes, among other things, wrapping a piece of suture around bone a first time by moving a suture passer in a first direction, wrapping the suture around bone a second time by moving a shuttling suture around the bone in the first direction, and securing the suture to the bone.

[0018] In a further non-limiting embodiment of the foregoing method, the suture is wrapped around bone the first time by wrapping first and second free ends of the suture and a first end of the shuttling suture around bone, and the suture is wrapped around bone the second time by providing the first and second free ends of the suture in a loop provided in a second end of the shuttling suture, and moving the second end of the shuttling suture around the bone in the first direction.

[0019] In a further non-limiting embodiment of any of the foregoing methods, the suture passer is provided by a curved needle having a first eyelet and a second eyelet, and the suture is provided in the first eyelet and the shuttling suture is provided in the second eyelet.

[0020] In a further non-limiting embodiment of any of the foregoing methods, the shuttling suture includes a first end having a first closed loop and a second end having a second closed loop, and the second closed loop is looped through the second eyelet and the shuttling suture is tightened against the suture passer.

[0021] In a further non-limiting embodiment of any of the foregoing methods, the suture passer includes a proximal end, a distal end, and a main body portion having a thickness tapering between the proximal end and the distal end.

[0022] In a further non-limiting embodiment of any of the foregoing methods, the first eyelet and the second eyelet are adjacent the proximal end of the suture passer.

[0023] In a further non-limiting embodiment of any of the foregoing methods, the suture passer includes a tip adjacent the distal end.

[0024] In a further non-limiting embodiment of any of the foregoing methods, the suture is secured to bone by tying a knot.

[0025] The embodiments, examples and alternatives of the preceding paragraphs, the claims, or the following description and drawings, including any of their various aspects or respective individual features, may be taken independently or in any combination. Features described in connection with one embodiment are applicable to all embodiments, unless such features are incompatible.

BRIEF DESCRIPTION OF THE DRAWINGS

- [0026] The drawings can be briefly described as follows:
- [0027] Figure 1 illustrates a fractured bone provided with a suture wrap cerclage.
- [0028] Figure 2 is an external view of an example suture.
- [0029] Figure 3 is a cross-sectional view of the example suture, taken along line 3-3 of Figure 2.
- [0030] Figure 4A illustrates a first example suture passer.
- [0031] Figure 4B illustrates a second example suture passer.
- [0032] Figure 5 illustrates an example tensioner.
- [0033] Figure 6 illustrates another example suture passer.
- [0034] Figure 7A illustrates a piece of suture.
- [0035] Figure 7B illustrates the piece of suture folded lengthwise.
- [0036] Figure 8 illustrates an example method step of inserting a folded end of suture into an eyelet of a suture passer.
- [0037] Figure 9 illustrates an example method step of maneuvering the suture passer around a bone.
- [0038] Figure 10 illustrates the suture passer around the bone and in a first position.
- [0039] Figure 11 illustrates the suture passer around the bone and in a second position.
- [0040] Figure 12 illustrates an example method step of inserting free ends of suture into an eyelet of the suture passer.
- [0041] Figure 13 illustrates an example method step of tying a sliding knot, and in particular illustrates an eyelet being formed by the folded end of suture.
- [0042] Figure 14 illustrates an example method step of tying a sliding knot, and in particular illustrates the free ends of suture being placed through the eyelet.

[0043] Figure 14A illustrates an example method step of maneuvering the suture passer around bone.

[0044] Figure 14B illustrates an example method step of tying a sliding knot, and in particular illustrates an eyelet being formed by the folded suture.

[0045] Figure 14C illustrates an example method step of tying a sliding knot relative to suture that has been wrapped around bone only once.

[0046] Figure 14D illustrates a partially pre-tied knot including an eyelet provided within a sheath.

[0047] Figure 14E is a cross-sectional view of the sheath of Figure 14D.

[0048] Figure 15 illustrates an example method step of tying a sliding knot, and in particular illustrates tightening the sliding knot relative to the bone.

[0049] Figure 16 illustrates an example method step of tensioning the sliding knot using a tensioner.

[0050] Figure 17 illustrates a fractured bone having another example suture wrap cerclage.

[0051] Figure 18 illustrates an example inserter in a first position.

[0052] Figure 19 illustrates an example inserter in a second position.

[0053] Figure 20 illustrates a first example suture-retaining feature.

[0054] Figure 21 illustrates a second example suture-retaining feature.

[0055] Figure 22 illustrates a fractured bone having another example suture wrap cerclage.

[0056] Figure 23 illustrates a fractured bone having an example suture wrap cerclage, which is held in place using a bone screw.

[0057] Figure 24 illustrates the detail of an example bone screw.

[0058] Figure 25 illustrates a fractured bone having an example suture wrap cerclage, which is held in place using a bone plate.

[0059] Figure 26 illustrates an eyelet of the bone plate.

[0060] Figure 27 illustrates another example suture passer including a curved needle and shuttling suture.

[0061] Figure 28 illustrates the suture passer of Figure 27 with free ends of a piece of suture received in an eyelet of the suture passer.

[0062] Figure 29 illustrates an example method step of maneuvering the suture passer of Figure 27 around bone.

[0063] Figure 30 illustrates another example method step of maneuvering the suture passer of Figure 27 around bone.

[0064] Figure 31 illustrates another example method step of providing the free ends of the suture in a loop of the shuttling suture.

[0065] Figure 32 illustrates another example method step of pulling the shuttling suture around bone.

[0066] Figure 33 illustrates an example method step of tying a knot to secure the suture to bone.

DETAILED DESCRIPTION

[0067] This disclosure details a method and system for providing a bone cerclage. The disclosed method includes wrapping a piece of material around a bone, and securing that material relative to the bone. The wrapped material provides a bone cerclage, which maintains the relative position of fractured bone fragments to promote healing.

[0068] This disclosure includes several embodiments of a bone cerclage where the material providing the cerclage is suture. Figure 1 illustrates a non-limiting example of a suture wrap cerclage 20 provided relative to a bone 22 with a fracture 24. In this example, the bone 22 is a femur. Femurs can fracture, for example, from a traumatic injury or as the result an orthopedic procedure, such as a hip replacement. The suture wrap cerclage 20 fixes the fractured fragments of the bone 22 relative to one another, which promotes healing. While specific reference is made to femurs, it should be understood that this disclosure is not limited to femoral fractures, and extends to other bones (such as the humerus).

[0069] Again, this disclosure includes several embodiments that relate to a method and system for providing a suture wrap cerclage. In one non-limiting example of the disclosed method, a surgeon, for example, may make use of a collection of components, referred to herein as a “system.” Among other things, an example system includes suture 26, which forms the suture wrap cerclage 20.

[0070] An external view of an example suture 26 is illustrated in Figure 2, and a cross-section is shown in Figure 3. In this non-limiting example, the suture 26 is a high strength braided suture, such as Arthrex, Inc.’s FiberTape™.

[0071] In general, the suture 26 includes a multifilament cover 28 formed of a plurality of braided fibers of ultrahigh molecular weight polyethylene (UHMWPE) 30 and fibers of polyester 32. The cover 28 surrounds a core 34 formed of twisted fibers of ultrahigh molecular weight polyethylene (UHMWPE). While one example type of suture 26 is shown

and described, it should be understood that other types of suture come within the scope of this disclosure.

[0072] In addition to suture, the example system also includes a suture passer, such as the suture passer 36 illustrated in Figure 4A. As shown in Figure 4A, the suture passer 36 includes a handle 38, a cannula 40 extending distally from the handle 38, and a moveable suture carrier 42. In this example, the cannula 40 is substantially straight relative to the handle 38, and is curved at a distal end 44 to follow an expected contour of a bone (such as the bone 22 of Figure 1). The distal end 44 follows a constant radius R_1 having an origin O in an expected bone location 46.

[0073] The moveable suture carrier 42 has an eyelet 48 for receiving suture, and is moveable relative to the cannula 40 in response to a corresponding movement of an actuation member 50 adjacent a proximal end of the handle 38. The suture carrier 42 has a curve adjacent the distal end 44 substantially following a constant radius R_2 , which corresponds to the expected contour of a bone, and is substantially the same as the radius R_1 . Further, in this example, the actuation member 50 is formed as a circular ring. It should be understood that the actuation member 50 could have other configurations.

[0074] In one example, the suture carrier 42 is integrally formed with the actuation member 50. In that case, the suture carrier-actuation member structure would be formed of a semi-rigid material, such as a relatively high strength plastic material, to allow the structure to pass through the cannula 40. In other examples, the suture carrier 42 and actuation member 50 may be formed separately from one another, and, in that case, can be formed of metallic material. This disclosure is not limited to any particular material type, however.

[0075] The actuation member 50 is slidable relative to the handle 38 in a distal direction D_1 and a proximal direction D_2 . In response to movement of the actuation member 50 in the distal direction D_1 , the suture carrier 42 is moveable in a direction D_3 away from a distal

end 44 of the cannula 40. Likewise, in response to movement of the actuation member 50 in the proximal direction D_2 , the suture carrier moves in a direction D_4 toward the distal end 44 of the cannula 40. Movement of the suture carrier 42 increases the ease of passing suture around a bone.

[0076] Another example suture passer is illustrated in Figure 4B. The suture passer 536 in Figure 4B is similar to the suture passer 36 in Figure 4A, but the suture passer 536 does not include a moveable suture carrier 42 or the corresponding actuation member 50. The suture passer 536 also does not include a cannulated shaft.

[0077] In particular, the suture passer 536 includes a handle 538 and a shaft 540 projecting distally from the handle 538. The shaft 540 includes a substantially straight section 542 adjacent the handle 538, and a curved distal end 544. The distal end 544 is curved such that the distal end 544 follows a constant radius R_1 having an origin O in an expected bone location 546. The radius R_1 in this example corresponds to the expected contour of a bone. The distal end 544 includes an eyelet 548 for receiving suture. The eyelet 548 is provided adjacent a tip 550 of the distal end 544. The tip 550 in one example is sharpened to increase the ease of maneuvering the distal end 544 around bone. The tip 550 may be blunt in other examples.

[0078] The example system may further include a suture tensioner, such as the suture tensioner 52 illustrated in Figure 5. A suture tensioner is a device that allows a surgeon, for example, to tension suture to an appropriate level, such as Arthrex's AR-1529 Suture Tensioner and Tensiometer.

[0079] In general, as illustrated in Figure 5, the suture tensioner 52 includes a handle 54, a shaft 56, and an adjustment wheel 58. As will be further explained below, a free end of suture can be provided around a spool 60 connected to the adjustment wheel 58. The adjustment wheel 58 is then rotated to tension the suture. The suture tensioner 52 may optionally be used in combination with a spreader 62 (shown somewhat schematically),

configured to keep adjacent free ends of suture spaced-apart from one another as the spool rotates. The suture tensioner 52 is not required in all examples, but its use may increase the overall tightness of the suture wrap cerclage 20 relative to a hand-tensioned cerclage. Its use may further increase efficiency and repeatability relative to hand-tensioning.

[0080] While Figures 4A-4B illustrate two example suture passers 36, 536 other suture passers come within the scope of this disclosure. For instance, Figure 6 illustrates a non-cannulated suture passer 64 having a substantially straight portion 66 and a curved portion 68 at a distal end 70. At an end of the curved portion 68, the suture passer 64 includes a suture retaining member 72, which in the Figure 6 example is a notch. While a notch is shown, it should be understood that the suture passer 64 could be provided with another type of suture retainer, such as an eyelet.

[0081] A first example method of providing the suture wrap cerclage 20 will now be explained with reference to Figures 7A-16. In general, the method includes wrapping a suture around a bone at least twice, and then securing the suture to the bone. The method will be explained relative to the suture 26, suture passer 36, and the tensioner 52. While specific reference is made to these devices, it should be understood that other devices may be used. In particular, while Figures 7A-16 illustrate the suture passer 36, the suture passers 64, 536 could be used.

[0082] Initially, a piece of suture 26 (Figure 7A) is folded substantially in half (Figure 7B) about its length to provide a folded end 74, and first and second lengths 75, 77 between the folded end 74 and respective first and second free ends 76, 78. The folded end 74 is then placed in the eyelet 48 of the suture passer 36, as shown in Figure 8.

[0083] With the folded end 74 placed in the eyelet 48, the distal end 44 of the cannula 40 is maneuvered around a bone 22, as illustrated in Figure 9, to push the folded end 74 around the bone 22. As the folded end 74 is moved around the bone 22, the free ends 76, 78

are retained in their original position. In the position of Figure 10, the suture folded end 74 is only partially wrapped around the bone 22. In order to fully wrap the suture 26 around the bone 22, the suture carrier 42 is moved in the direction D_3 by distal movement of the actuation member 50 in the direction D_1 (see Figure 1). In Figure 11, the folded end 74 has been moved to a position where a surgeon, for example, can grasp the folded end, completing the first wrap around the bone 22. Again, in this example, the suture 26 is folded. Thus, the first wrap includes a wrapping of both the first and second lengths 75, 77 of suture.

[0084] Next, the surgeon maintains the position of the folded end 74, which has been wrapped around the bone, and feeds the two free ends 76, 78, which are still in their original position, through the eyelet 48, as illustrated in Figure 12. Then, the suture carrier 42 is moved in the direction D_4 to draw the free ends 76, 78 of suture back toward the cannula 40. Then, the suture passer 36 is maneuvered to pull the free ends 76, 78 back around the bone 22.

[0085] By wrapping the folded end 74 around the bone in a first direction while maintaining the position of the free ends 76, 78, and then wrapping the free ends 76, 78 about the bone in a second, opposite direction while maintaining the position of the folded end 74, the result is a single piece of folded suture that has been wrapped around the bone twice. Further, because the suture 26 is folded, the above technique provides a cerclage having the effective width of the four pieces of suture, which increases the coverage and effectiveness of the suture wrap cerclage 20.

[0086] Further, the above technique only requires a suture passer to be maneuvered around the bone and removed once, which reduces the time required to wrap the suture and reduces risk of further injury to adjacent soft tissue during surgery. While the suture 26 is wrapped around the bone 22 twice in the above example, the suture 26 could be wrapped only once or additional times depending on the severity of the fracture, for example.

[0087] Once wrapped around the bone 22, the suture 26 is then secured to the bone. In one example, a sliding knot is provided between the folded end 74 and the first and second free ends 76, 78. To provide the sliding knot, the folded end 74 is folded over an adjacent portion of the lengths 75, 77 (Figure 13) to provide an eyelet 80 (Figure 14). Figures 14A-14C illustrate an example in which the suture 26 is wrapped around the bone 22 only once. In Figure 14A, for example, the folded end 74 is passed around the bone as substantially described relative to Figures 9-11. In Figure 14B, the folded end 74 is then folded over an adjacent portion of the lengths to provide an eyelet 80 (Figure 14C). Regardless of the number of times the suture 26 is wrapped around the bone 22, the first and second free ends 76, 78 are then fed through the eyelet 80 to provide a sliding knot 81 (Figure 15), which is tightened by hand against the bone 22.

[0088] Alternatively, the sliding knot 81 could be partially pre-tied. In particular, the eyelet 80 could be provided within a sheath 83, as illustrated in Figure 14D. In this example, a sheath 83 of suture material is connected adjacent the folded end 74 prior to surgery such that a surgeon, for example, does not have to fold the suture and form the eyelet 80 during surgery. The sheath 83 in this example is substantially cylindrical, and is formed of a mesh-like suture material. In one example, suture is used to stitch the sheath 83 to the lengths 75, 77 to maintain the eyelet 80. A suture shuttle 85 may be used to pass the free ends 76, 78 through the sheath 83. Once suture is passed through the sheath 83, the sliding knot 81 can be tightened as substantially shown in Figure 15.

[0089] Further, as illustrated in Figure 14E, the sheath 83 may include one or more barbs 87 extending inwardly from a wall 89 of the sheath 83. The barbs 87 in this example are provided by a suture material and are inclined away from a sheath inlet 91. The barbs 87 are configured to engage the suture passing through the sheath 83. For example, when the sliding knot 81 is tightened, the sheath 83 essentially collapses against the suture within the sheath. In

this way, the barbs 87 are configured to allow suture to pass into through the sheath inlet 91, while resisting removal of the suture from the sheath 83. The barbs 87 are optional and are not required in all examples.

[0090] The sliding knot 81 is then tensioned. In this example, tension is applied by wrapping the first and second free ends 76, 78 around the spool 60 of the suture tensioner 52, and rotating the adjustment wheel 58 until the desired tension is reached, as generally illustrated in Figure 16. Finally, at least one knot is tied between the first and second free ends 76, 78 to hold the position and tension of the sliding knot 81. In one example, the first and second lengths 75, 77 are tied into at least one half-hitch knot, which essentially “backs up” the sliding knot 81. Other types of locking knots come within the scope of this disclosure.

[0091] The result is a suture wrap cerclage 20, as substantially illustrated in Figure 1, which supports a fractured bone under tension, and does so without implanting any metallic components into the body, and without requiring any structural changes (such as drilling or cutting) the bone 22. Further, the disclosed technique allows surgeons to provide the suture wrap cerclage efficiently and in a manner that is reliable and repeatable. While the method describes how to provide a single suture wrap cerclage 20, more severe fractures may require more than one suture wrap cerclage 20 provided along the length of the bone. In those instances, the benefits provided by this disclosure are even more apparent.

[0092] In the above-described method, the suture wrap cerclage is provided by tying at least one knot, and without implanting any structure in the body, with the exception of the suture 26. Other aspects of this disclosure, however, are “knotless,” meaning the securing step includes securing the suture 26 to the bone 22 without tying any knots.

[0093] One example knotless arrangement is shown in Figure 17. In Figure 17, a suture wrap cerclage 120 is provided around a bone 122, which in this example is a femur, having a fracture 124. The suture wrap cerclage 120 is first wrapped around the bone 122 at a

first location 126, adjacent a head 128 of the bone 122, and travels along a length L of the bone to a second location 130, which is spaced-apart from the first location 126, adjacent the condyles of the bone 122, for example.

[0094] In the example of Figure 17, the suture 132 providing the suture wrap cerclage 120 may be wrapped around the bone 122 using a suture passer similar to the suture passer 36 described above. The suture 132 is secured to bone at the second location 130 by a knotless suture anchor 134, using, for example, Arthrex's SwiveLock® or PushLock®.

[0095] In general, the knotless suture anchor 134 is positioned by an inserter 136 (Figure 18) including a distal end 138, a proximal end 140, and a longitudinal axis A between the distal end 138 and the proximal end 140. A first member including an eyelet 139 (such as an eyelet formed by a folded end of suture or a hard eyelet provided by an implant) is oriented to thread the suture 132 across the longitudinal axis A. Further, the first member is situated near the distal end 138 of the inserter and is configured to be placed in bone 122. A second member, which in one example is the anchor 134, is situated near the distal end 138 of the inserter 136. The second member 134 is moveable, by a portion of the inserter 136, relative to the first member in a distal direction toward the eyelet into a suture securing position where the second member 134 locks the suture 132 in place, as shown in Figure 19. Again, while one example has been described, other knotless anchors come within the scope of this disclosure.

[0096] In some examples, the bone 122 may be machined to prevent slippage of the suture 132 from the first location 126 to the second location 130. In one example, illustrated in Figure 20, the bone 122 may be provided with one or more notches 141 adjacent the first location 126, which are configured receive the suture 132. In another example, illustrated in Figure 21, the bone 122 may be provided with a through-hole 142 (shown in phantom) adjacent the first location 126, through which the suture 132 may be fed. The notches 141 and through-hole 142 are only examples. Other types of suture-retaining features come within the scope of

this disclosure. It should be understood that the suture-retaining features can be formed using conventional bone machining techniques, such as cutting or drilling.

[0097] Figure 22 is another example securing technique that does not involve tying knots. In the example of Figure 22, the suture wrap cerclage 220 is provided by a self-cinching suture 222 including at least one splice 224. An example type of self-cinching suture is included in Arthrex's TightRope®, which is a suture-button construct.

[0098] In general, the self-cinching suture 222 includes a first end 226, a second end 228, the splice 224, and a fixation device 230 (sometimes referred to as a "button"). In an example method, the second end 228 of the self-cinching suture is wrapped around a bone 232 one or more times (here, twice), and fed through the splice 224. In this example, the second end 228 is also fed through the fixation device 230. The second end 228 may be wrapped around the bone 232 using the above-discussed techniques.

[0099] Once wrapped, the second end 228 is pulled relative to the first end 226, which tightens the self-cinching suture 222 and cinches the suture 222 against the bone 232 to provide a suture wrap cerclage. Once tightened, the fixation device 230 maintains the position of the suture 222 relative to the bone 232. While one example self-cinching suture has been described, other types of self-cinching sutures come within the scope of this disclosure.

[00100] Figures 23-24 illustrate yet another suture securing technique. In Figure 23, a suture wrap cerclage 320 is held in place, at least in part, by a bone screw 322. An example bone screw 322 is illustrated in Figure 24. As illustrated, the bone screw 322 includes a head 324 and a threaded shank 326. The head 324 in this example is sized to hold suture between the head 324 and bone 328. The bone screw 322 can be placed in a location adjacent an expected location of the suture wrap cerclage 320. In the illustrated example, the bone screw 322 is placed below an expected location of the suture wrap cerclage 320.

[00101] In Figure 23, for example, the bone screw 322 is inserted partially into bone 328. Then, the suture providing the suture wrap cerclage 320 is wrapped about the bone per any of the above techniques. During wrapping, the bone screw 322 holds a position of the suture and prevents slippage of the suture. Once wrapped, the bone screw 322 can be tightened. When tightened, the bone screw 322—specifically the head 324—secures at least one length of suture to bone, which helps maintain the position of the suture wrap cerclage 320.

[00102] Another example suture wrap cerclage 420 is illustrated in Figures 25-26. In Figure 26, the suture wrap cerclage 420 is provided relative to a bone plate 422 which includes an eyelet 424. The bone plate 422 may be fixed to the bone at one or more locations along its length. The eyelet 424, as perhaps best seen in Figure 26, is fixed to the bone plate 422 and is configured to hold strands 426, 428 of suture in place relative to bone 430. The suture wrap cerclage 420 can be wrapped using any of the above techniques with the exception that, in this example, the strands 426, 428 pass through the eyelet. The eyelet 424 thus prevents slippage and substantially maintains a position of the suture wrap cerclage 420.

[00103] Figure 27 illustrates another example suture passer 636. In this example, the suture passer 636 is used in combination with a shuttling suture 638, which assists in wrapping suture around bone, as will be discussed below. Before getting to the method of use, the suture passer 636 in this example is provided by a curved needle 640. The curved needle 640 in this example has a proximal end 642, a distal end 644, and a main body portion 646 extending between the proximal end 642 and the distal end 644. In this example, the curved needle 640 is curved such that it follows a constant radius R_1 having an origin O in an expected bone location 648. The radius R_1 in this example corresponds to the expected contour of a bone.

[00104] In this example, the main body portion 646 includes a thickness T tapering from the proximal end 642 to the distal end 644. A tip 650 of the distal end 644 is blunt in one example. In another example, the tip 650 is sharpened.

[00105] At the proximal end 642, the suture passer 636 includes two eyelets 652, 654. Both the first and second eyelets 652, 654 are configured to receive suture. In this example, the second eyelet 654 is proximal to the first eyelet 652 and receives the shuttling suture 638.

[00106] The shuttling suture 638 includes a first end 656, a second end 658, and a length 660 between the ends 656, 658. The first and second ends 656, 658 include closed loops 662, 664, respectively. The closed loops 662, 664 are configured to receive suture and shuttle the suture between locations. The shuttling suture 638 may be provided by a nitinol wire material in some examples. This disclosure is not limited to nitinol wire, however. The shuttling suture 638 may be used to wrap suture around bone without requiring the suture passer to be backed-out around the bone, as in the method of Figures 7A-16 for example.

[00107] Figures 28-33 illustrate an example method of using the suture passer 636 and the shuttling suture 638. In Figure 28, a piece of suture 667 is folded in half about its length to provide a folded end 668 and first and second free ends 670, 672. The suture 667 is a high strength braided suture, such as Arthrex, Inc.'s FiberTape™, in one example. In this example, the first and second free ends 670, 672 are received in the first eyelet 652 of the suture passer 636. Further, the first end 656 of the shuttling suture is looped through the second eyelet 654 and pulled against the suture passer 636.

[00108] With the suture 667 and shuttling suture 638 received in the first and second eyelets 652, 654, respectively, the suture passer 636 is maneuvered around bone 674, as illustrated in Figure 29. The suture passer 636 is pushed partially around the bone 674 in a first direction to the position generally illustrated in Figure 29. The suture passer 636 is then pulled around bone in the first direction to complete a first wrap of the suture 667 around the bone 674, as illustrated in Figure 30. In one example, a surgeon retrieves and pulls the suture passer 636 by engaging the distal end 644 of the suture passer 636 with a surgical device.

[00109] In Figure 30, the first and second free ends 670, 672 of the suture 667 have been passed around the bone 674, while the folded end 668 has not been passed around the bone 674. Further, the first end 656 of the shuttling suture 638 has been wrapped around the bone 674, while the second end 658 has not.

[00110] To wrap the suture 667 around the bone 674 a second time, the free ends 670, 672 are loaded into the loop 664 at the second end 658 of the shuttling suture 638, as illustrated in Figure 31. Then, the shuttling suture 638 is pulled around the bone 674 in the first direction, as illustrated in Figure 32. The result is a piece of folded suture wrapped twice around bone. The result requires only one pass of a suture passer 636 around the bone, and one pass of a shuttling suture around the bone. The suture passer 636 does not need to be backed-out around the bone in a direction opposite the first direction. Pulling the shuttling suture 638 around the bone 674 is perhaps less invasive than backing-out the suture passer, as in some of the previously discussed examples.

[00111] Finally, the suture 667 is secured to the bone 674 using any one of the above techniques. In the example of Figure 33, the suture 667 is secured to the bone 674 by tying a knot 676.

[00112] It should be understood that the example of Figures 27-33 could be combined with any of the above techniques, including being used in combination with the tensioner 52, the knotless suture anchor 134, or the techniques associated with Figures 20-26, for example.

[00113] The suture wrap cerclages of this disclosure provide a reliable and effective bone cerclage, which promotes healing of fractured bones. Further, the disclosed methods and systems allow surgeons to provide suture wrap cerclages in an efficient manner without sacrificing consistency or quality.

[00114] It should be understood that terms such as “proximal” and “distal” are used consistent with their art-accepted meaning. These terms should not otherwise be considered limiting.

[00115] Although the different examples have the specific components shown in the illustrations, embodiments of this disclosure are not limited to those particular combinations. It is possible to use some of the components or features from one of the examples in combination with features or components from another one of the examples.

[00116] One of ordinary skill in this art would understand that the above-described embodiments are exemplary and non-limiting. That is, modifications of this disclosure would come within the scope of the claims. Accordingly, the following claims should be studied to determine their true scope and content.

CLAIMS

1. A method for providing a fractured bone with a bone cerclage, comprising:
wrapping suture around bone a first time using a suture passer;
wrapping the suture around bone a second time using a shuttling suture; and
securing the suture to the bone.
2. The method as recited in claim 1, wherein:
the suture is wrapped around the bone the first time by wrapping the suture and the shuttling suture around the bone by moving the suture carrier in a first direction; and
the suture is wrapped around the bone the second time by moving the shuttling suture around the bone in the first direction.
3. The method as recited in claim 2, wherein:
the suture is wrapped around bone the first time by wrapping first and second free ends of the suture and a first end of the shuttling suture around bone; and
the suture is wrapped around bone the second time by providing the first and second free ends of the suture in a loop provided in a second end of the shuttling suture, and moving the second end of the shuttling suture around the bone in the first direction.
4. The method as recited in claim 1, wherein the suture passer is provided by a curved needle having a first eyelet and a second eyelet.
5. The method as recited in claim 4, wherein the suture is received in the first eyelet and the shuttling suture is received in second eyelet.

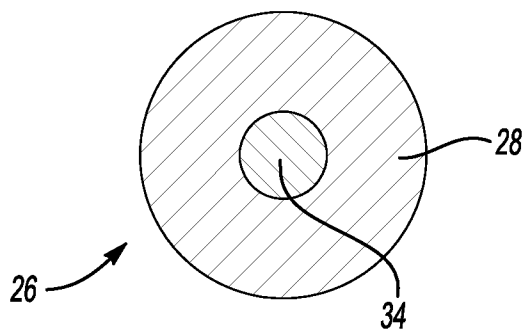
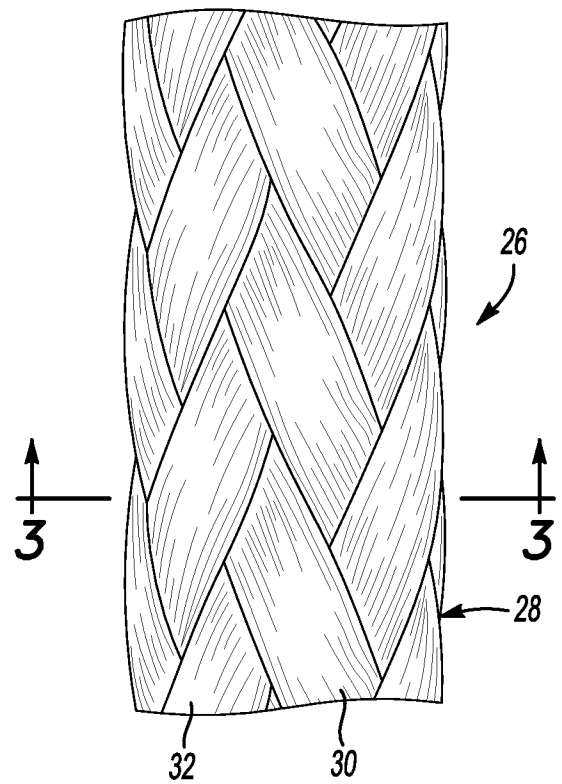
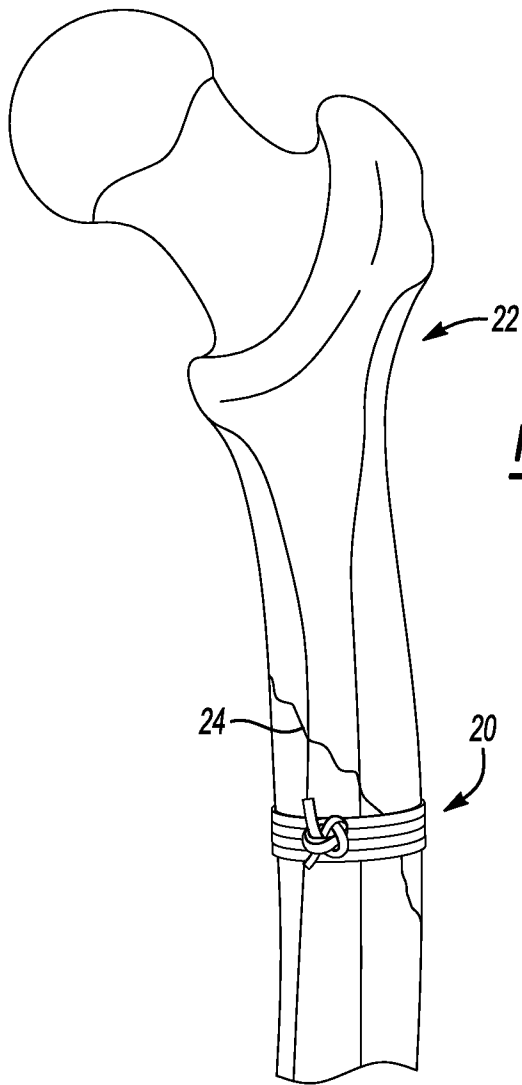
6. The method as recited in claim 5, wherein:

the shuttling suture includes a first end having a first closed loop and a second end having a second closed loop; and

the second closed loop is looped through the second eyelet and the shuttling suture is tightened against the suture passer.
7. The method as recited in claim 4, wherein the suture passer includes a proximal end, a distal end, and a main body portion having a thickness tapering between the proximal end and the distal end.
8. The method as recited in claim 7, wherein the first eyelet and the second eyelet are adjacent the proximal end of the suture passer.
9. The method as recited in claim 7, wherein the suture passer includes a tip adjacent the distal end.
10. The method as recited in claim 9, wherein the tip is blunt.
11. The method as recited in claim 1, wherein the shuttling suture is provided by nitinol wire.
12. The method as recited in claim 1, wherein the suture is a folded piece of suture.

13. A method for providing a fractured bone with a bone cerclage, comprising:
- wrapping a piece of suture around bone a first time by moving a suture passer in a first direction;
- wrapping the suture around bone a second time by moving a shuttling suture around the bone in the first direction; and
- securing the suture to the bone.
14. The method as recited in claim 13, wherein:
- the suture is wrapped around bone the first time by wrapping first and second free ends of the suture and a first end of the shuttling suture around bone; and
- the suture is wrapped around bone the second time by providing the first and second free ends of the suture in a loop provided in a second end of the shuttling suture, and moving the second end of the shuttling suture around the bone in the first direction.
15. The method as recited in claim 13, wherein:
- the suture passer is provided by a curved needle having a first eyelet and a second eyelet; and
- the suture is provided in the first eyelet and the shuttling suture is provided in the second eyelet.
16. The method as recited in claim 15, wherein:
- the shuttling suture includes a first end having a first closed loop and a second end having a second closed loop; and
- the second closed loop is looped through the second eyelet and the shuttling suture is tightened against the suture passer.

17. The method as recited in claim 15, wherein the suture passer includes a proximal end, a distal end, and a main body portion having a thickness tapering between the proximal end and the distal end.
18. The method as recited in claim 17, wherein the first eyelet and the second eyelet are adjacent the proximal end of the suture passer.
19. The method as recited in claim 18, wherein the suture passer includes a tip adjacent the distal end.
20. The method as recited in claim 13, wherein the suture is secured to bone by tying a knot.



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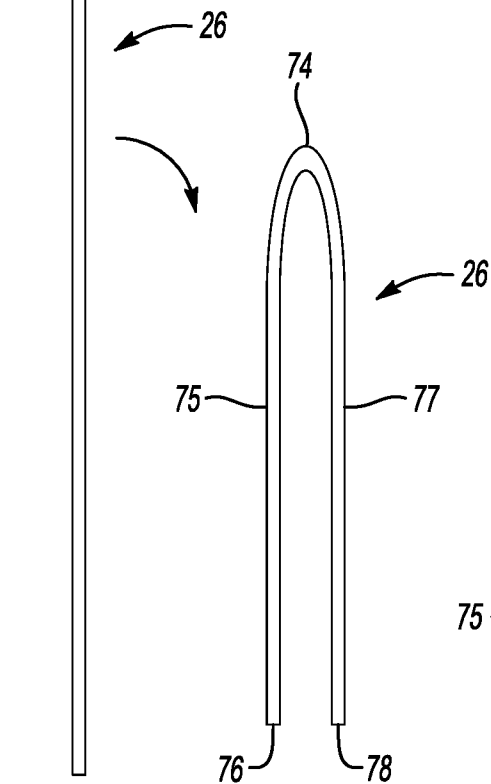
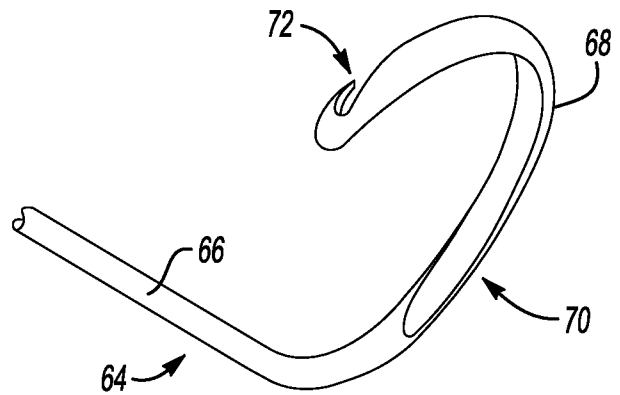
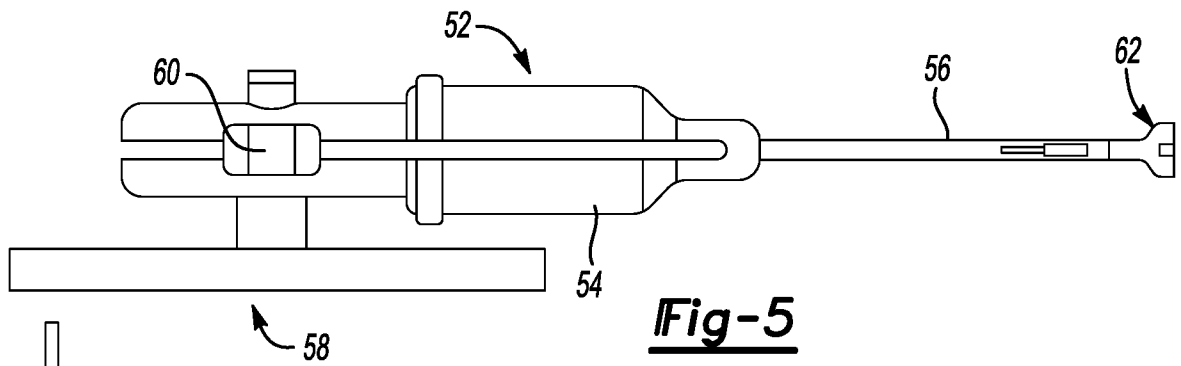
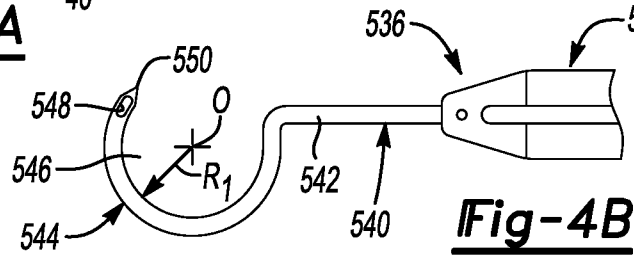
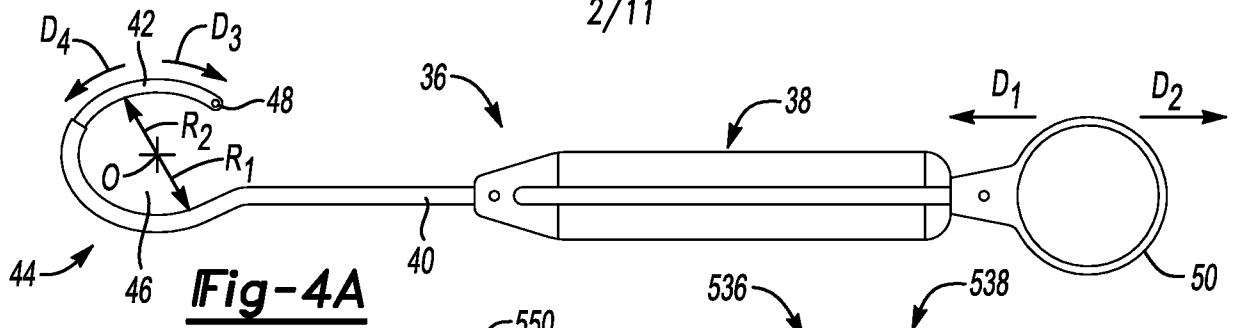
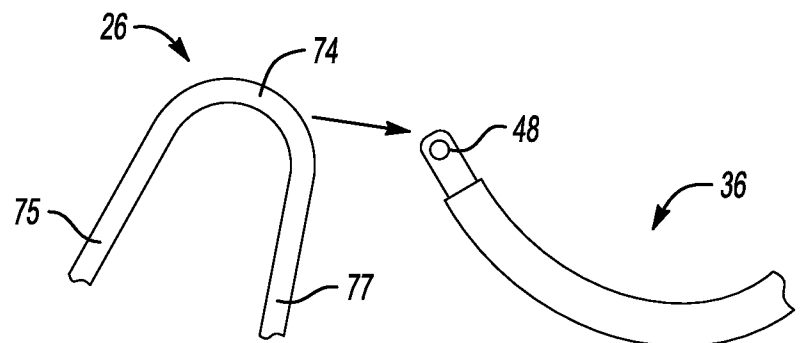
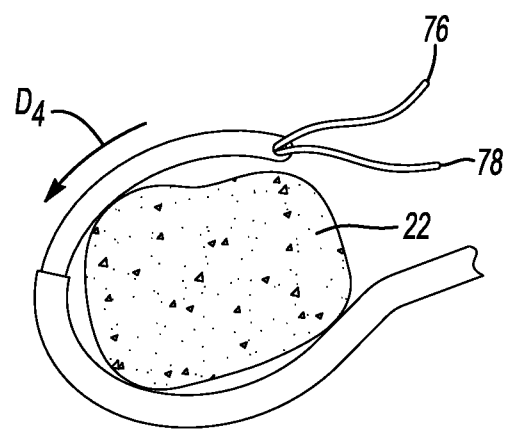
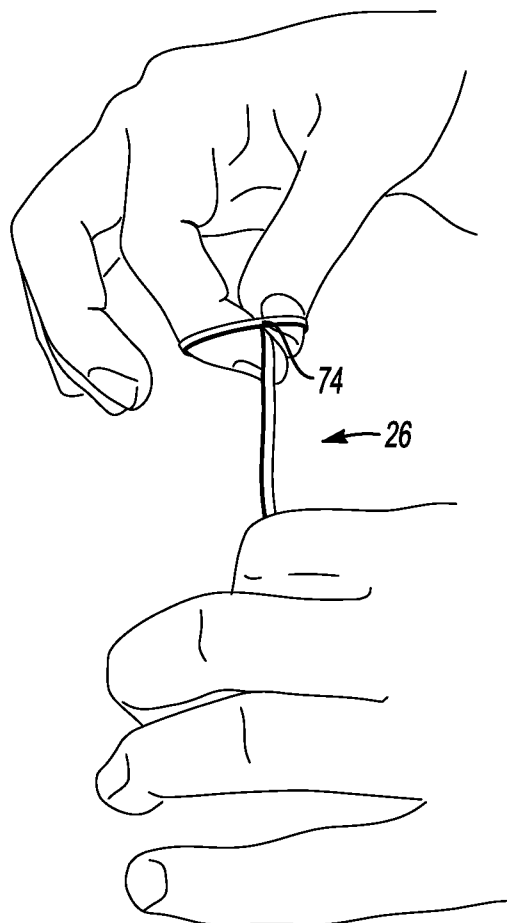
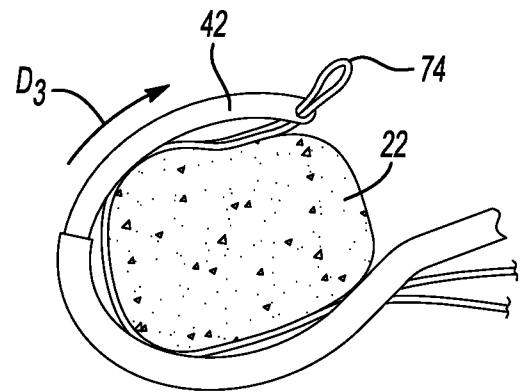
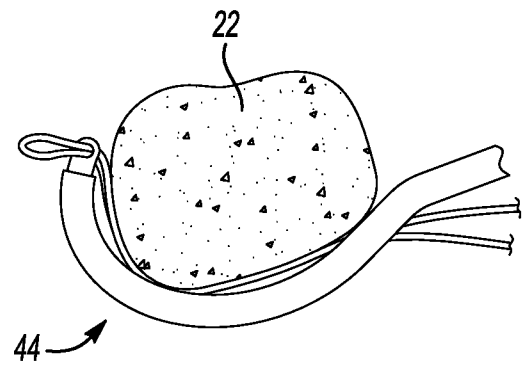
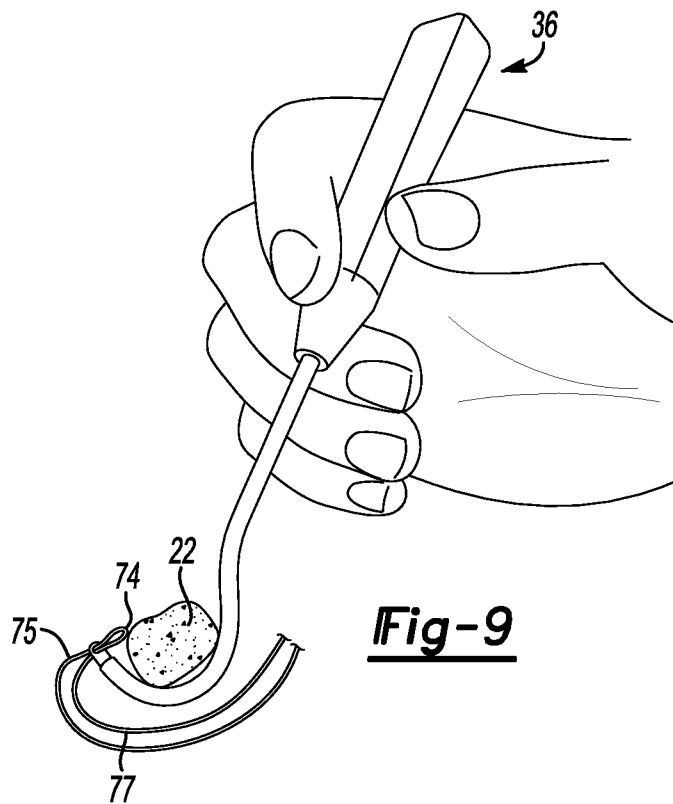
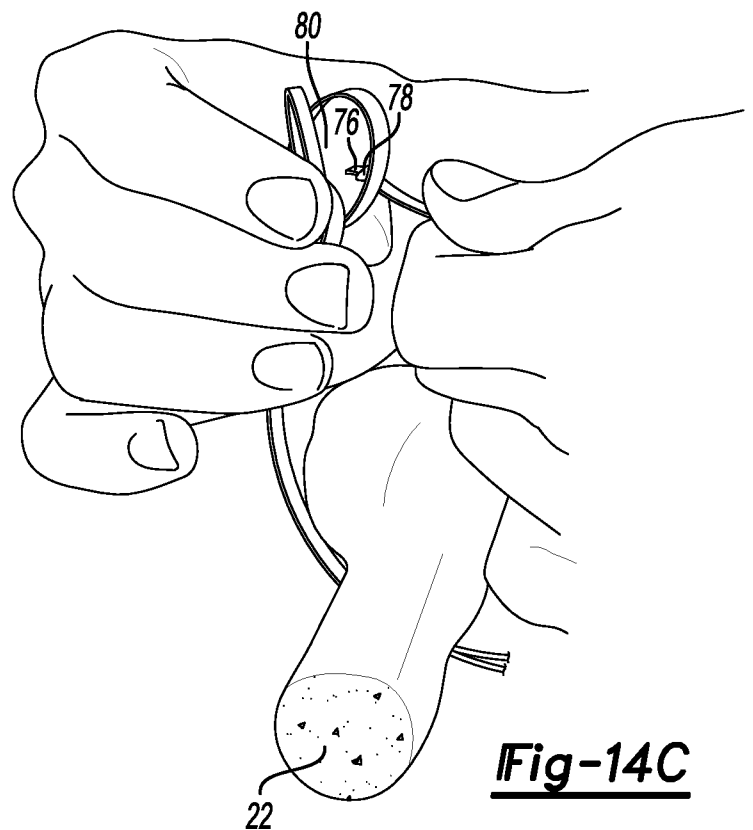
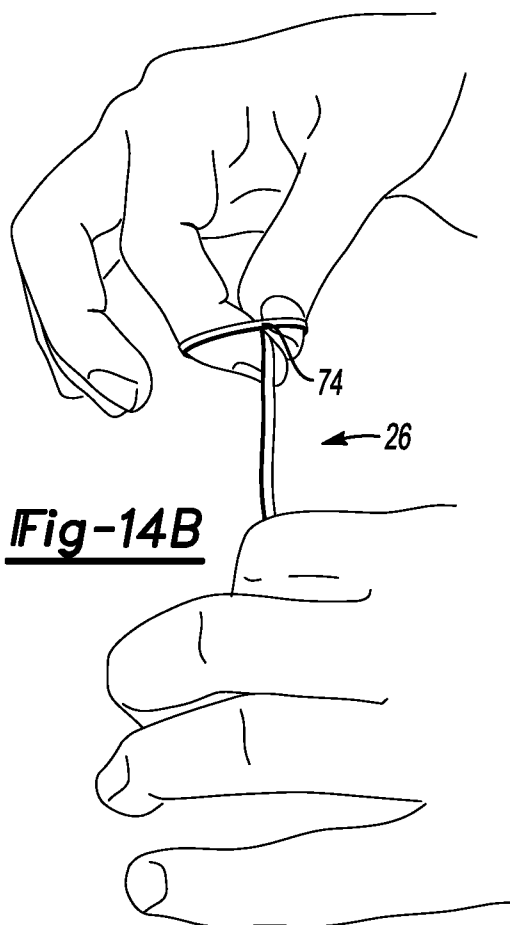
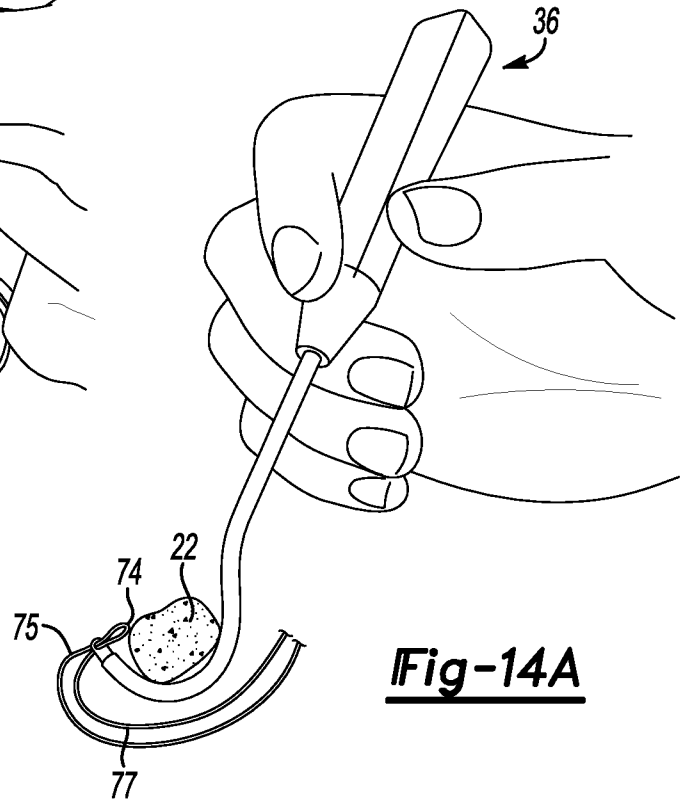
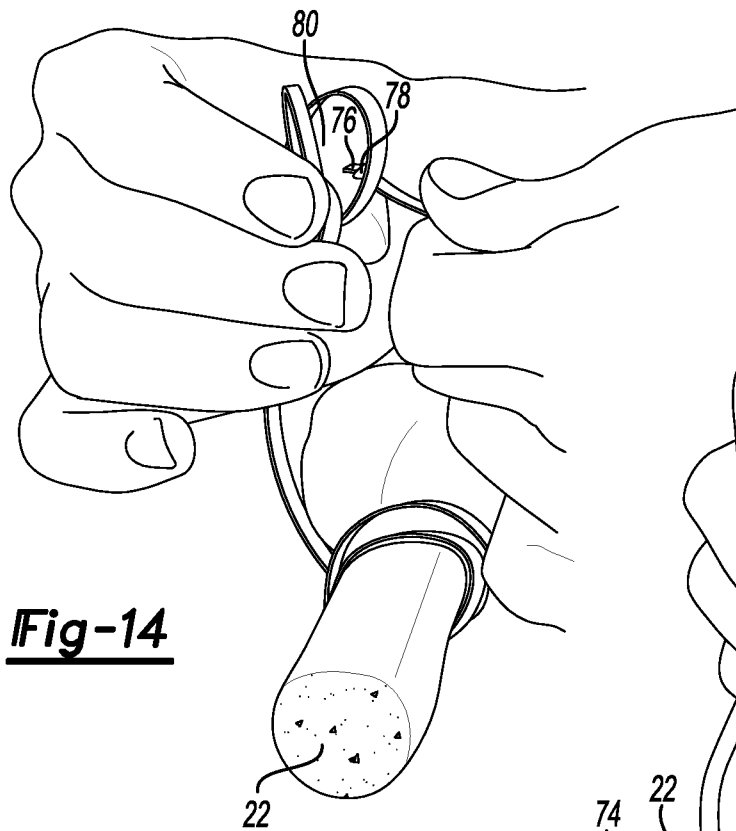


Fig-7B







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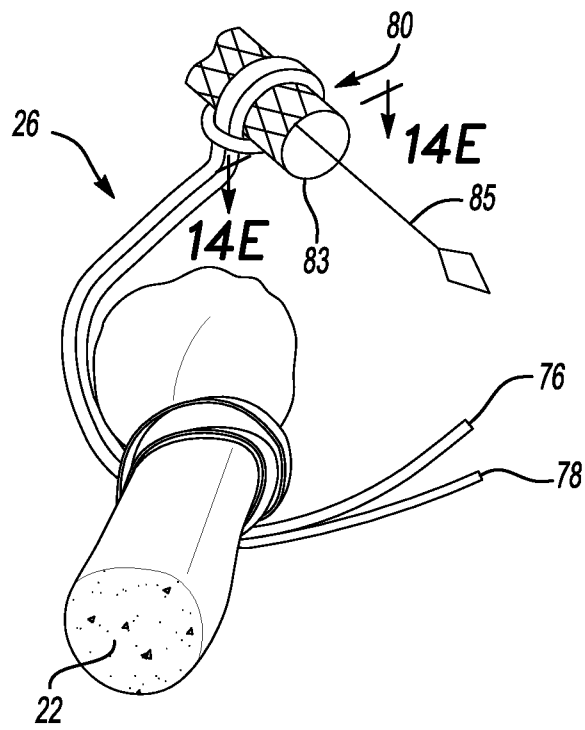


Fig-14D

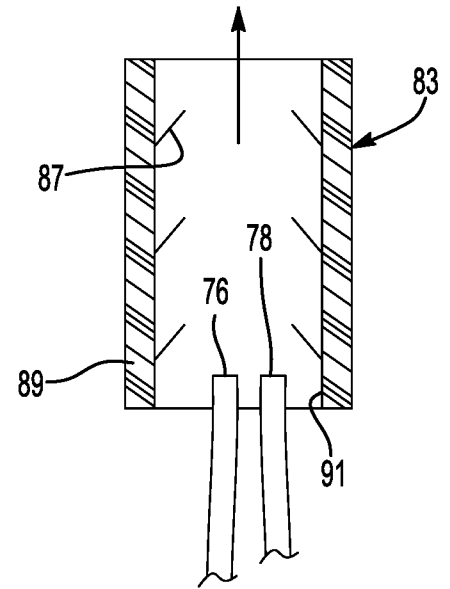


Fig-14E

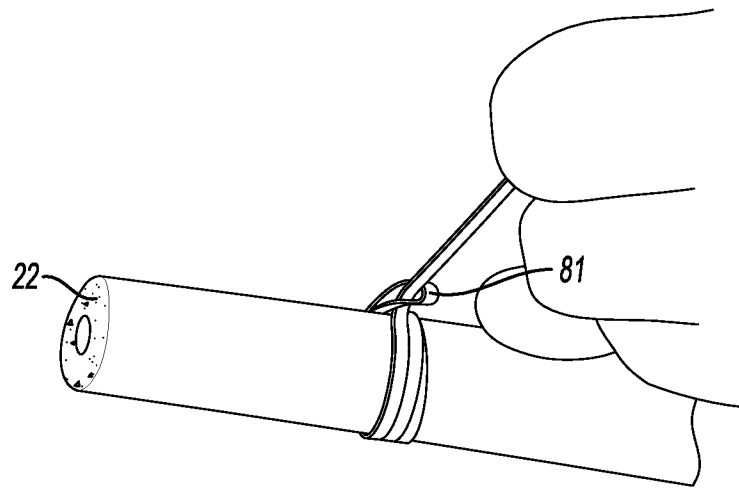


Fig-15

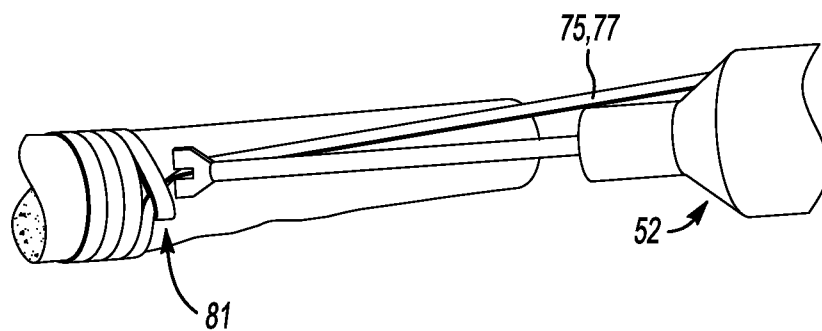


Fig-16

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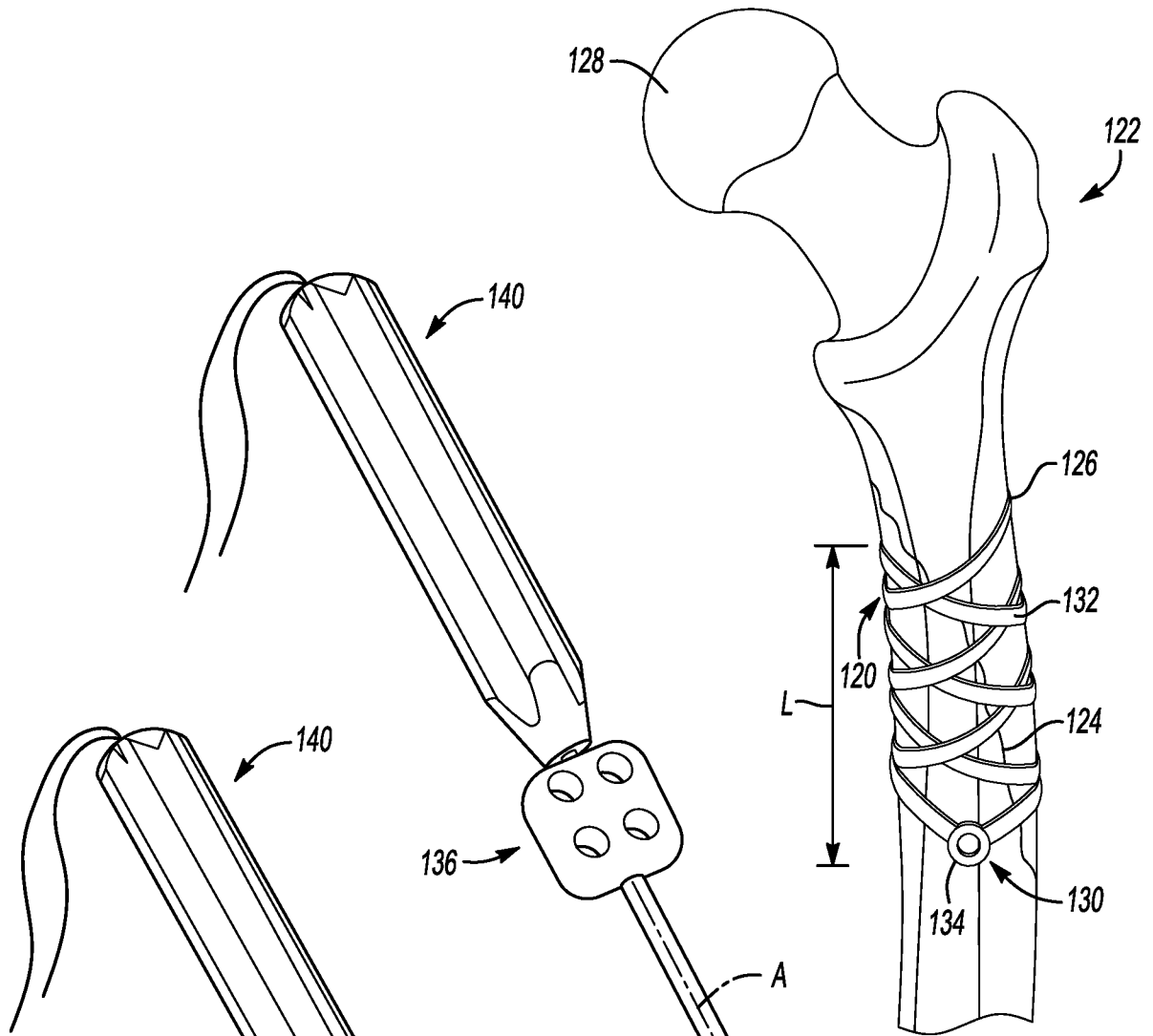


Fig-17

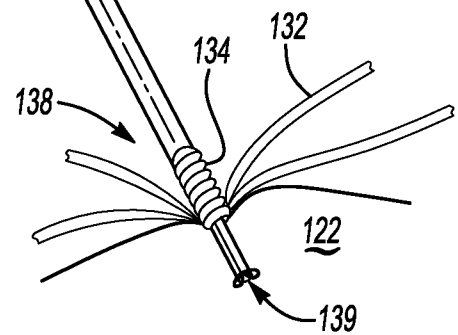
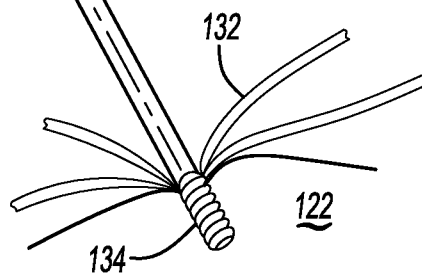


Fig-18

Fig-19



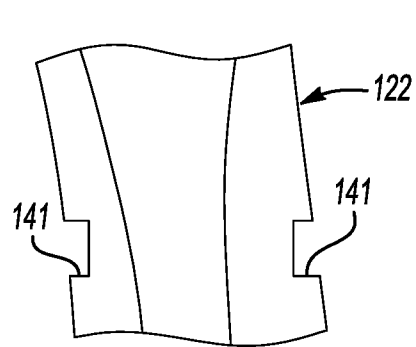


Fig-20

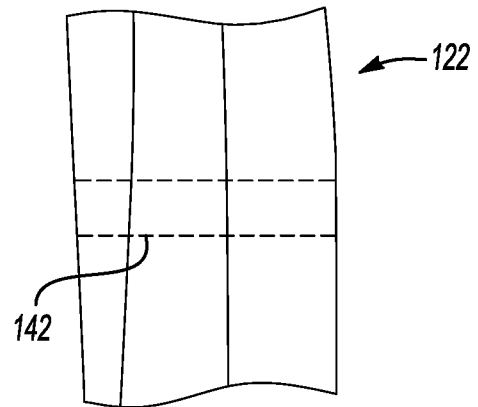


Fig-21

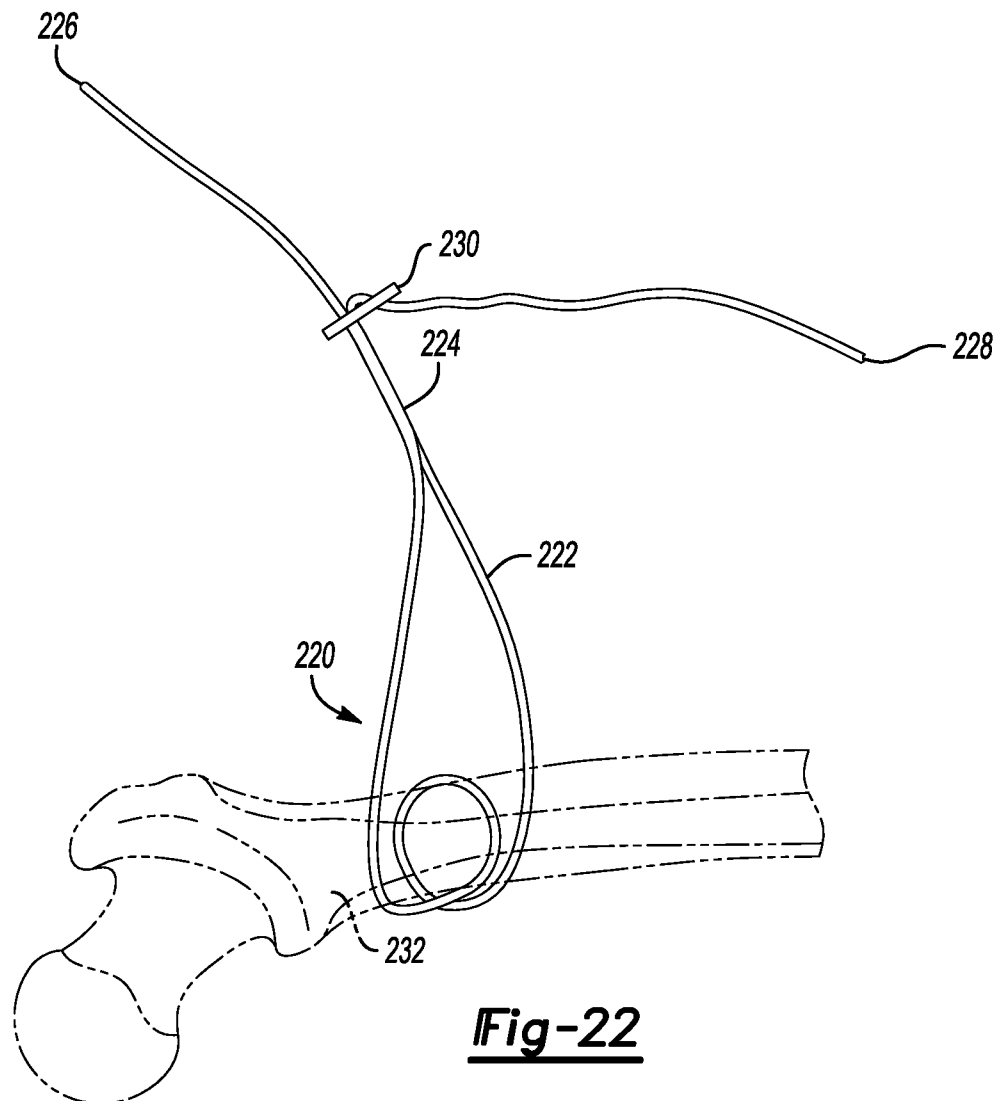


Fig-22

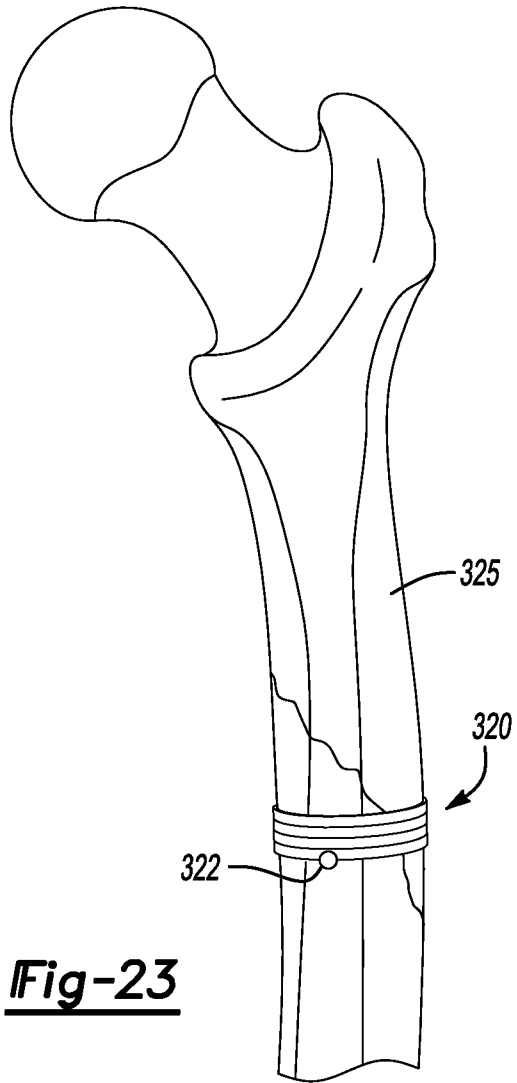


Fig-23

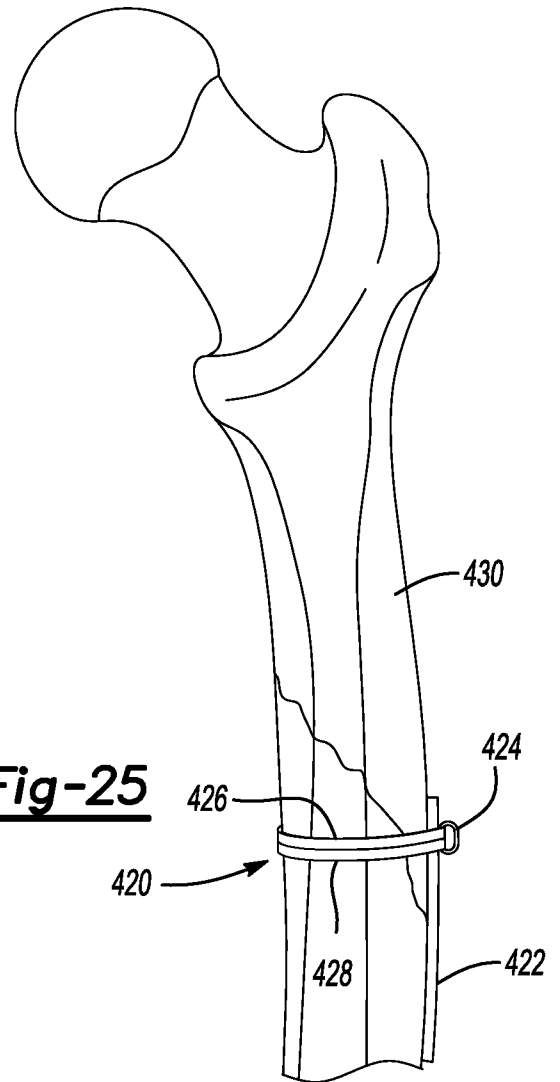


Fig-25

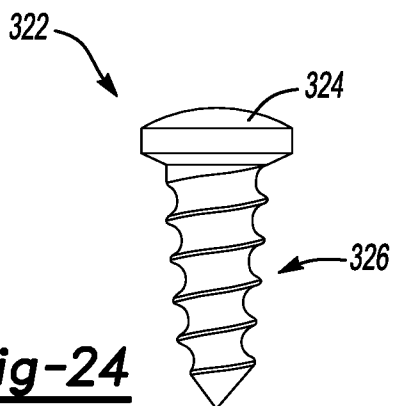


Fig-24

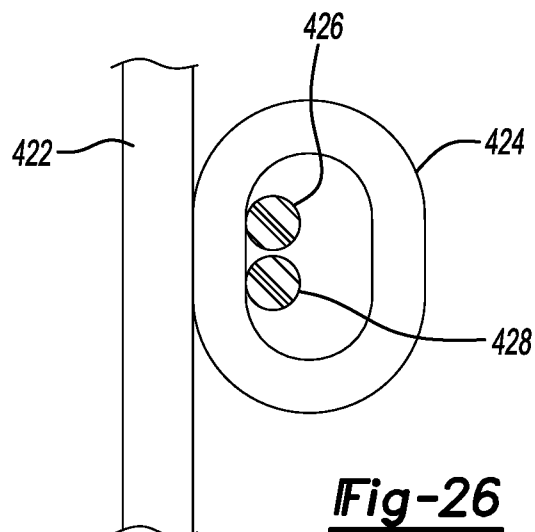
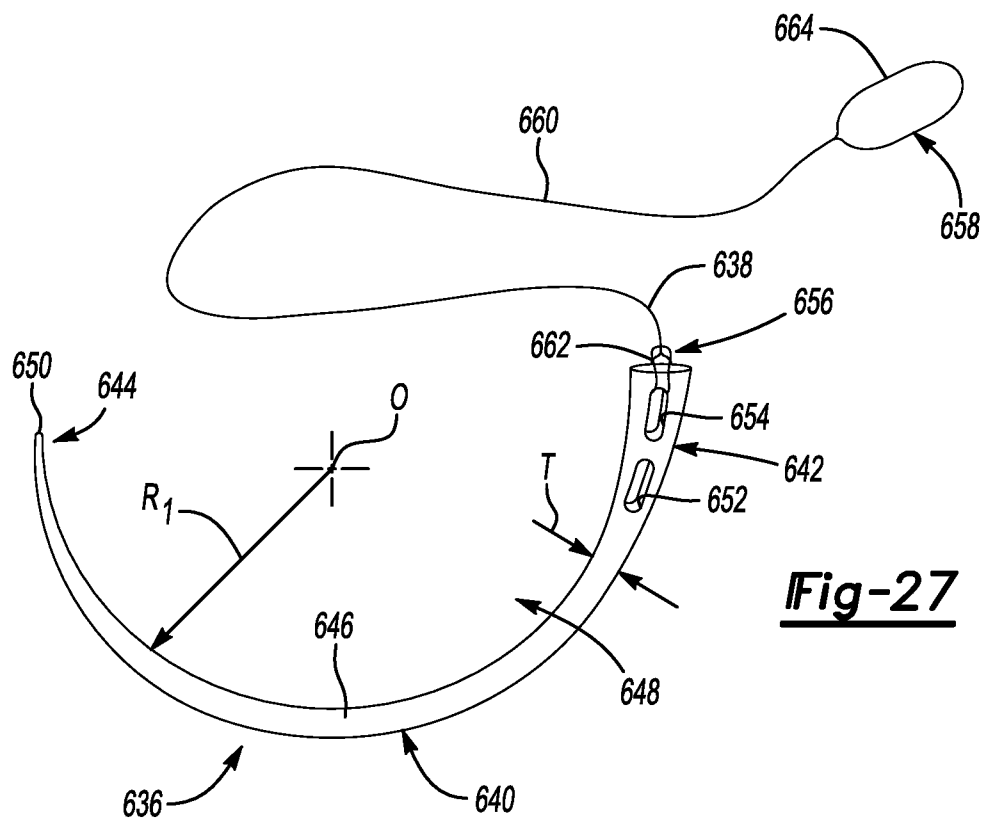
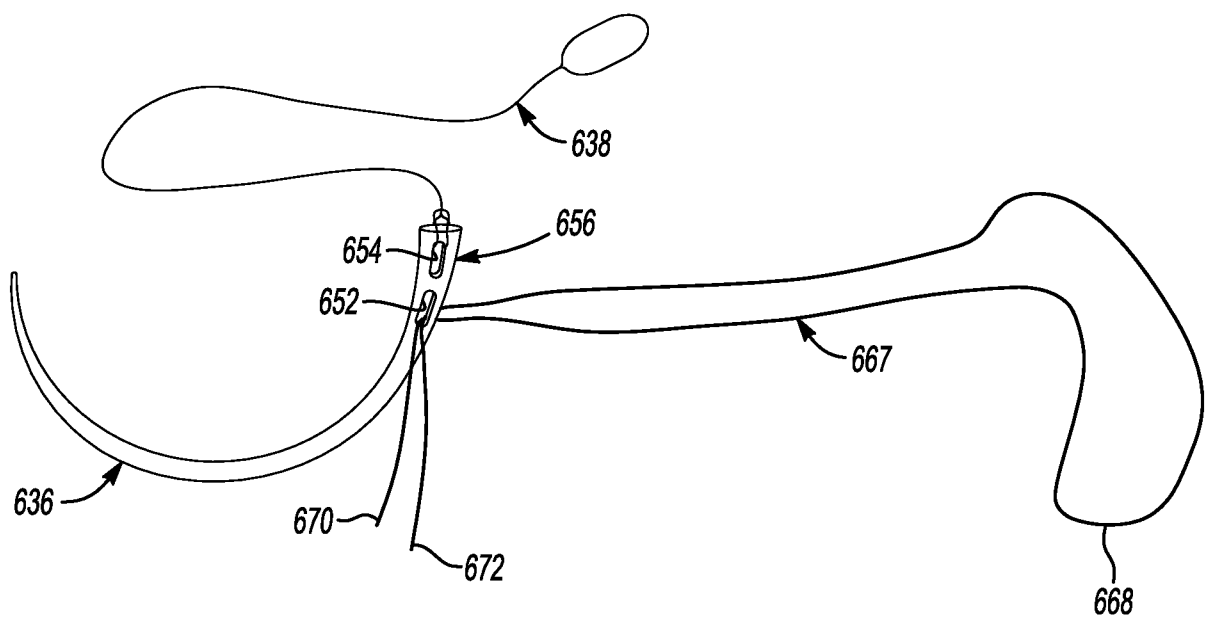


Fig-26

**Fig-27****Fig-28**

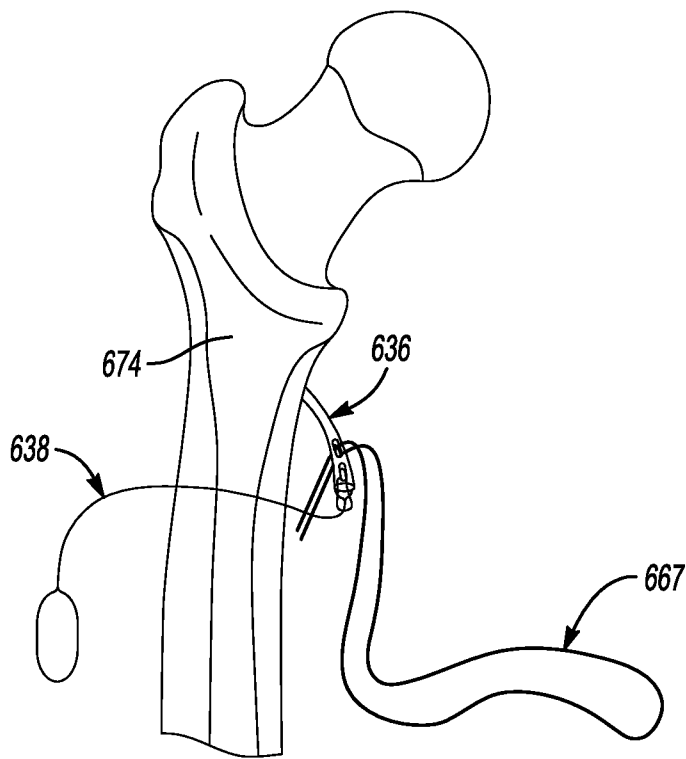


Fig-29

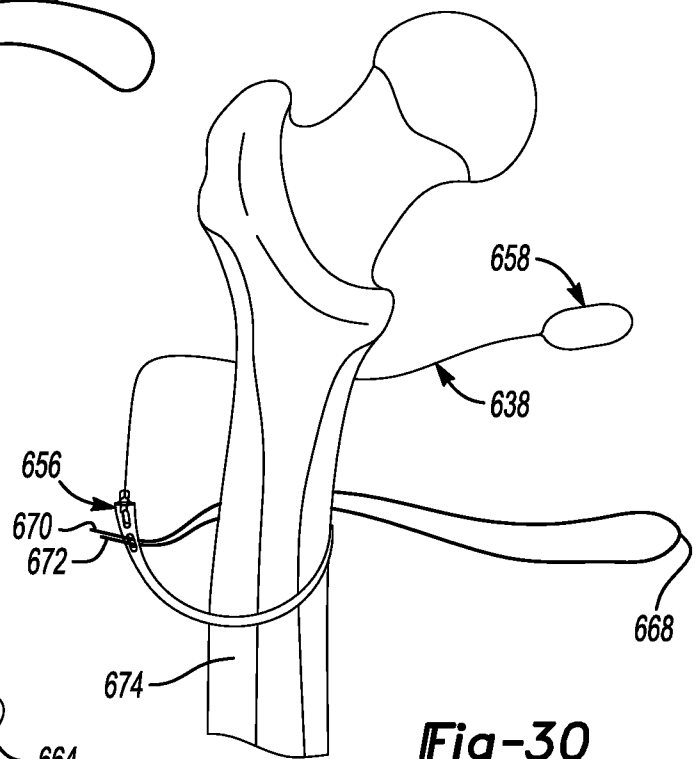


Fig-30

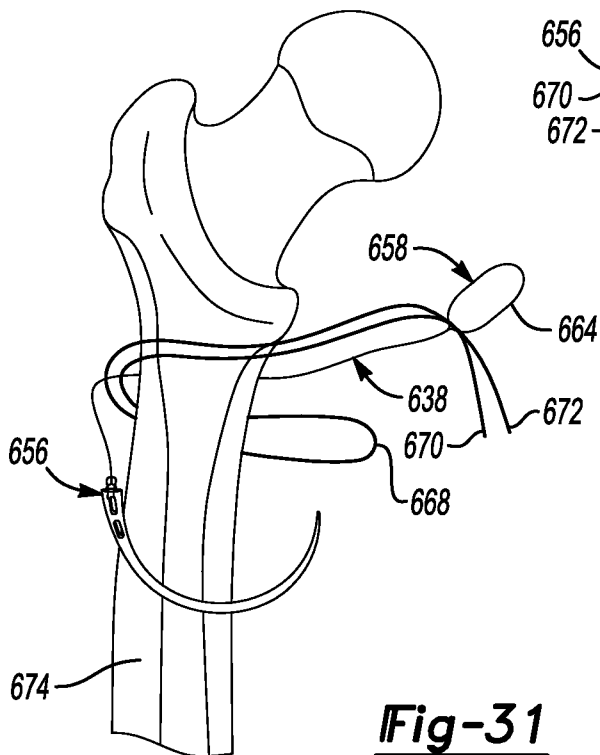


Fig-31

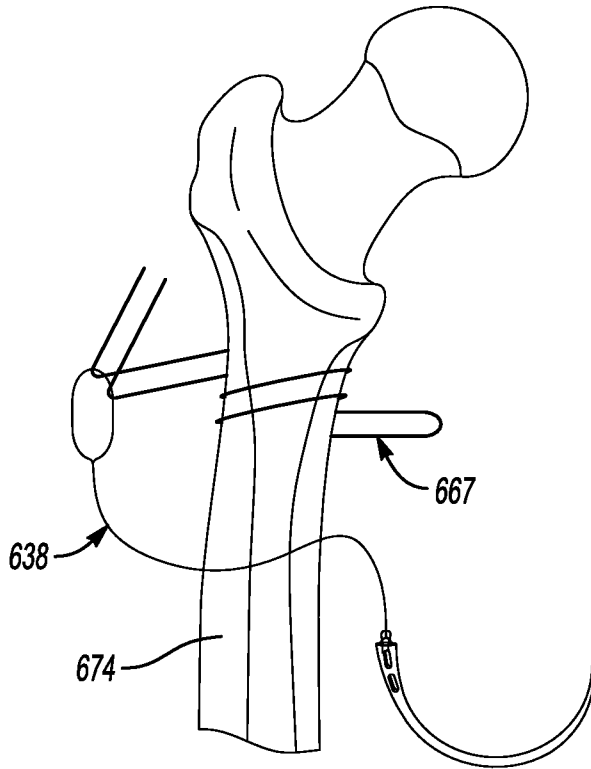


Fig-32

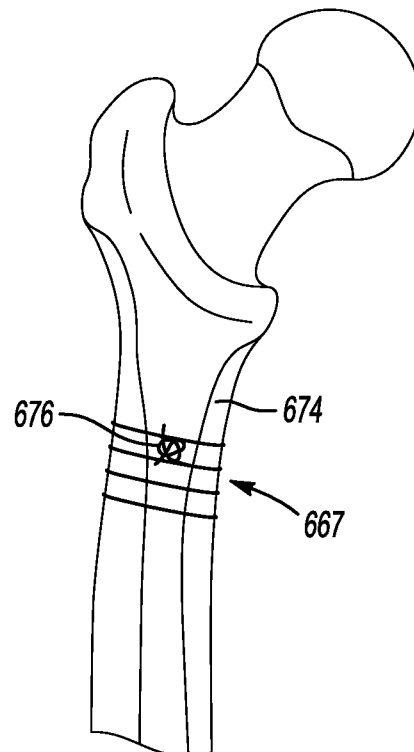


Fig-33

PATENT COOPERATION TREATY

PCT

DECLARATION OF NON-ESTABLISHMENT OF INTERNATIONAL SEARCH REPORT

(PCT Article 17(2)(a), Rules 13ter.1(c) and Rule 39)

Applicant's or agent's file reference 67145-400PCT	IMPORTANT DECLARATION	Date of mailing(<i>day/month/year</i>) 5 April 2017 (05-04-2017)
International application No. PCT/US2017/014924	International filing date(<i>day/month/year</i>) 25 January 2017 (25-01-2017)	(Earliest) Priority date(<i>day/month/year</i>) 17 March 2016 (17-03-2016)
International Patent Classification (IPC) or both national classification and IPC A61B17/04,A61B17/06,A61B17/062		
Applicant ARTHREX, INC		

This International Searching Authority hereby declares, according to Article 17(2)(a), that **no international search report will be established** on the international application for the reasons indicated below

1. ☒ The subject matter of the international application relates to:
 - a. ☐ scientific theories.
 - b. ☐ mathematical theories
 - c. ☐ plant varieties.
 - d. ☐ animal varieties.
 - e. ☐ essentially biological processes for the production of plants and animals, other than microbiological processes and the products of such processes.
 - f. ☐ schemes, rules or methods of doing business.
 - g. ☐ schemes, rules or methods of performing purely mental acts.
 - h. ☐ schemes, rules or methods of playing games.
 - i. ☒ methods for treatment of the human body by surgery or therapy.
 - j. ☐ methods for treatment of the animal body by surgery or therapy.
 - k. ☐ diagnostic methods practised on the human or animal body.
 - l. ☐ mere presentations of information.
 - m. ☐ computer programs for which this International Searching Authority is not equipped to search prior art.

2. ☒ The failure of the following parts of the international application to comply with prescribed requirements prevents a meaningful search from being carried out:

☐ the description
☒ the claims
☐ the drawings

3. ☐ The failure of the nucleotide and/or amino acid sequence listing to comply with the standard provided for in Annex C of the Administrative Instructions prevents a meaningful search from being carried out:

☐ the written form has not been furnished or does not comply with the standard.

☐ the computer readable form has not been furnished or does not comply with the standard.

4. Further comments:

Name and mailing address of the International Searching Authority  European Patent Office, P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk Tel. (+31-70) 340-2040 Fax: (+31-70) 340-3016	Authorized officer ULLRICH, Josef Tel: +49 (0)89 2399-8048
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FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 203

According to Article 17(2)(a)(i) PCT and Rule 39.1(iv) PCT the International Search Authority, in the present case the EPO, is not required to carry out a search if the subject-matter of the international application relates to methods of treatment of the human or animal body by surgery or therapy, as well as diagnostic methods. The method for providing a fractured bone with a bone cerclage defined in Claims 1-20 is a method of treatment of the human or animal body by surgery and thus no search is performed.

The applicant's attention is drawn to the fact that claims relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure. If the application proceeds into the regional phase before the EPO, the applicant is reminded that a search may be carried out during examination before the EPO (see EPO Guidelines C-IV, 7.2), should the problems which led to the Article 17(2) declaration be overcome.