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(54) **Title:** SUTURE BASED CLAMPING DEVICE

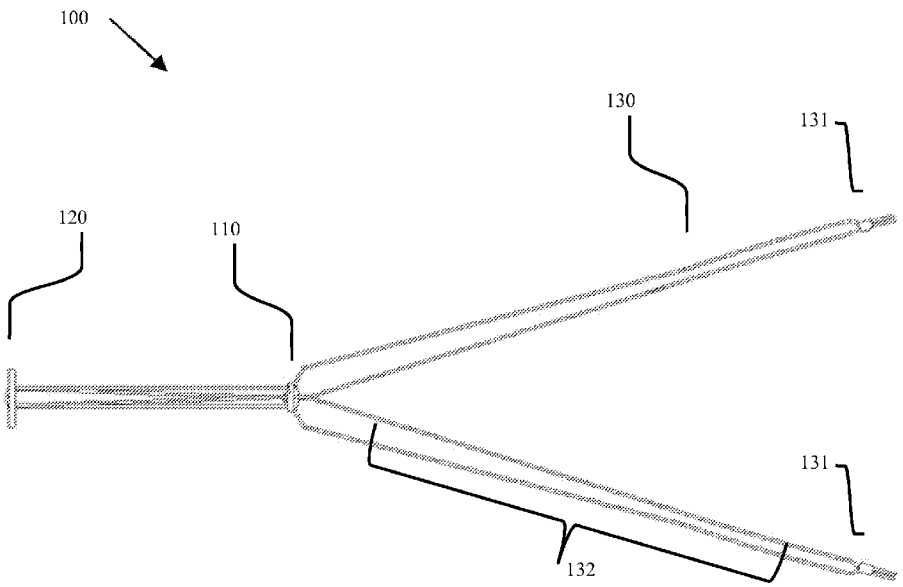

FIG. 12

(57) **Abstract:** Systems, assemblies, and methods are provided herein for fastening of one bone to another bone using one or more sutures. The features herein enable such fastening with a more accurate strength, and which can be more easily fastened in-situ.

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SUTURE BASED CLAMPING DEVICE

CROSS-REFERENCE

[0001] This application claims the benefit of U.S. Provisional Application No. 63/002,272, filed March 30, 2020, which is/are hereby incorporated by reference in its/their entirety herein.

BACKGROUND

[0002] Several medical procedures require the fastening of one bone to another bone. Some such procedures include fixation of acromioclavicular separations due to coracoclavicular ligament disruptions, fixation of dorsal distal radioulnar ligament disruptions, stabilization of the first and second metatarsals for hallux valgus reconstruction, and stabilization of the first and second metacarpal when the trapezium has been excised due to osteoarthritis.

SUMMARY

[0003] One aspect provided herein is a suture-button system comprising: a suture strand; a primary button having a plurality of primary apertures and a primary threaded portion, wherein the suture strand is inserted through a first and second primary aperture of the plurality of primary apertures; a secondary button having a plurality of secondary apertures, wherein the suture strand is inserted through a first and second secondary aperture of the plurality of secondary apertures, such that at least one targeted tissue of a subject is clamped between a distal surface of the primary button and a proximal surface of the secondary button upon applying a tension to the suture strand; and a lock having a secondary threaded portion, wherein the secondary threaded portion is removably coupled to the primary threaded portion, wherein coupling the secondary threaded portion of the lock to the threaded portion prevents the suture strand from translating through the plurality of primary apertures, thereby securing the clamping of the targeted tissue.

[0004] In some embodiments, the plurality of primary apertures comprises 2, 3, 4, or 5 primary apertures. In some embodiments, the plurality of primary apertures are equally spaced on the primary button. In some embodiments, the plurality of primary apertures are equally spaced on the primary button in a circular array. In some embodiments, the plurality of primary apertures are equally spaced on the primary button in a circular array about the primary threaded portion. In some embodiments, the plurality of primary apertures are equally spaced on the primary button in a circular array about a center axis of the secondary button. In some embodiments, a proximal surface of the primary button comprises a countersink. In some embodiments, the

primary threaded portion comprises a female threaded portion. In some embodiments, the secondary threaded portion comprises a male threaded portion. In some embodiments, the primary threaded portion comprises a male threaded portion. In some embodiments, the secondary threaded portion comprises a female threaded portion. In some embodiments, the plurality of secondary apertures comprises 2, 3, 4, or 5 secondary apertures. In some embodiments, a distal surface of the secondary button comprises a channel connecting two or more of the plurality of secondary apertures. In some embodiments, one or more edges of the secondary button are rounded or chamfered. In some embodiments, an aspect ratio between the length and width of the secondary button is about 1:1 to about 4:1. In some embodiments, the lock comprises a head and wherein the secondary threaded portion extends from the head. In some embodiments, a distal surface of the head is tapered outwards from a center axis of the lock. In some embodiments, the distal surface of the head is tapered outwards from a center axis of the lock by about 20° to about 89°. In some embodiments, the suture strand is a #1 size suture, a #2 size suture, a #3 size suture, a #4 size suture, a #5 size suture, a #6 size suture, or a #7 size suture. In some embodiments, the suture strand has a length of about 100 mm to about 1,200 mm. In some embodiments, the system comprises 2, 3, 4, 5, 6 or more suture strands. In some embodiments, the system comprises a first suture strand and a second suture strand, wherein at least a portion of the first suture strand passes within at least a portion of the second suture strand to form a suture bundle. In some embodiments, the portion of the first suture strand that passes within the second suture strand is a mesial portion of the first suture. In some embodiments, the portion of the second suture strand through which the first suture strand passes is a mesial portion of the second suture. In some embodiments, the lock comprises a driver feature, an alignment feature, or both. In some embodiments, the driver feature is opposite the secondary threaded portion. In some embodiments, the driver feature and the alignment feature are generally concentric. In some embodiments, the driver feature is proximal to the alignment feature. In some embodiments, a maximum inner diameter of the driver feature is greater than a maximum inner diameter of the alignment feature. In some embodiments, the driver feature comprises a Philips driver feature, a flathead driver feature, a torx driver feature, a hex driver feature, or a square socket feature. In some embodiments, the alignment feature has a cross sectional shape comprising a circle, a triangle, a square, a pentagon, a hexagon, an octagon, or any combination thereof. In some embodiments, the system further comprises a lock driver comprising a driving feature that is configured to rotate the lock relative to the primary button. In some embodiments, the lock driver further comprises an aligning feature configured to align the lock driver to the alignment feature of the lock. In some embodiments, the alignment feature is distal to the driving

feature. In some embodiments, at least a portion of the lock extends beyond a distal face of the primary button when the primary button is coupled to the lock. In some embodiments, a distal face of the primary button extends beyond a distal face of the lock when the primary button is coupled to the lock. In some embodiments, wherein at least one end of the suture strand is coupled to a terminator. In some embodiments: the system comprises two suture strands, wherein the plurality of primary apertures comprises four primary apertures; the plurality of secondary apertures comprises two secondary apertures; a first suture strand is inserted through a first primary aperture, through a first secondary aperture, through a second secondary aperture, and through a second primary aperture; and a second suture strand is inserted through a third primary aperture, through the first secondary aperture, through the second secondary aperture, and through a fourth primary aperture. In some embodiments: the system comprises two suture strands, wherein the plurality of primary apertures comprises four primary apertures; the plurality of secondary apertures comprises two secondary apertures; a first suture strand is inserted through a first primary aperture, through a first secondary aperture, through a second secondary aperture, and through a second primary aperture; and a second suture strand is inserted through a third primary aperture, through the second secondary aperture, through the first secondary aperture, and through a fourth primary aperture; In some embodiments, the first primary aperture and the second primary aperture are adjacent. In some embodiments, the first primary aperture and the second primary aperture are nonadjacent. In some embodiments, the system further comprises a tightening tool comprising: a threaded rod; a knob coupled to a proximal end of the threaded rod; a collar coupled to the threaded rod; an arm spinner between the knob and the collar, wherein the arm spinner comprises an aperture accepting the threaded rod; and a handle comprising a cavity, wherein at least a portion of the cavity comprises a threaded feature configured to couple to the threaded rod, wherein the lock comprises the driver feature, and wherein a distal portion of the handle comprises a tensioning feature configured to rotate the driving feature of the lock. In some embodiments, the arm spinner further comprises a terminator channel accepting the terminator. In some embodiments, the arm spinner comprises 1, 2, 3, 4, 5, 6, or more terminator channels. In some embodiments, the knob is coupled to the proximal end of the threaded rod by a pin, an adhesive, a fastener, a press-fit, a weld, or any combination thereof. In some embodiments, the collar is coupled to the threaded rod by a pin, an adhesive, a fastener, a press-fit, a weld, or any combination thereof. In some embodiments, the lock further comprises the alignment feature, and wherein the distal portion of the handle further comprises a tensioning alignment feature that couples to the alignment feature. In some embodiments, the arm spinner rotates freely about the threaded rod, the knob, or both. In some embodiments, rotating the knob

and the threaded rod in a first direction with respect with to the handle translates the spinner proximally from the handle. In some embodiments, rotating the knob and the threaded rod in a second direction opposite the first direction translates the spinner distally to the handle. In some embodiments, rotating the handle in a first direction tightens the lock against the primary button.

[0005] Another aspect provided herein is a suture-button system comprising: one or more a suture strands; a primary button having a plurality of primary apertures, and a primary threaded portion; a secondary button having a plurality of secondary apertures; and a lock having a secondary threaded portion, wherein the secondary threaded portion is removably coupled to the primary threaded portion; wherein each primary aperture has one or more of the plurality of sutures strands inserted therethrough, wherein each secondary aperture has one or more of the plurality of sutures strands inserted therethrough, and wherein coupling the secondary threaded portion of the lock to the threaded portion prevents each of the plurality of suture strands from translating through one or more of the plurality of first button apertures. In some embodiments, the plurality of primary apertures comprises 2, 3, 4, or 5 primary apertures. In some embodiments, the plurality of primary apertures are equally spaced on the primary button. In some embodiments, the plurality of primary apertures are equally spaced on the primary button in a circular array. In some embodiments, the plurality of primary apertures are equally spaced on the primary button in a circular array about the primary threaded portion. In some embodiments, the plurality of primary apertures are equally spaced on the primary button in a circular array about a center axis of the secondary button. In some embodiments, a proximal surface of the primary button comprises a countersink. In some embodiments, the primary threaded portion comprises a female threaded portion. In some embodiments, the secondary threaded portion comprises a male threaded portion. In some embodiments, the primary threaded portion comprises a male threaded portion. In some embodiments, the secondary threaded portion comprises a female threaded portion. In some embodiments, the plurality of secondary apertures comprises 2, 3, 4, or 5 secondary apertures. In some embodiments, a distal surface of the secondary button comprises a channel connecting two or more of the plurality of secondary apertures. In some embodiments, one or more edges of the secondary button are rounded or chamfered. In some embodiments, an aspect ratio between the length and width of the secondary button is about 1:1 so about 4:1. In some embodiments, the lock comprises a head and wherein the secondary threaded portion extends from the head. In some embodiments, a distal surface of the head is tapered outwards from a center axis of the lock. In some embodiments, the distal surface of the head is tapered outwards from a center of the lock by about 20° to about 89°. In some embodiments, the lock comprises a driver feature, an alignment feature, or both. In some

embodiments, the driver feature is opposite the secondary threaded portion. In some embodiments, the driver feature and the alignment feature are generally concentric. In some embodiments, the driver feature is proximal to the alignment feature. In some embodiments, a maximum inner diameter of the driver feature is greater than a maximum inner diameter of the alignment feature. In some embodiments, the driver feature comprises a Philips driver feature, a flathead driver feature, a torx driver feature, a hex driver feature, or a square socket feature. In some embodiments, the alignment feature has a cross sectional shape comprising a circle, a triangle, a square, a pentagon, a hexagon, an octagon, or any combination thereof. In some embodiments, they system further comprises a lock driver comprising a driving feature that is configured to rotate the lock about the primary button. In some embodiments, the lock driver further comprises an aligning feature configured to align the lock driver to the alignment feature of the lock. In some embodiments, the alignment feature is distal to the driving feature. In some embodiments, at least a portion of the lock extends beyond a distal face of the primary button when the primary button is coupled to the lock. In some embodiments, a distal face of the primary button extends beyond a distal face of the lock when the primary button is coupled to the lock. In some embodiments: the plurality of primary apertures comprises two primary apertures; the plurality of secondary apertures comprises two secondary apertures; the one or more suture strands consists of one suture strand; and the one suture strand is inserted through a first primary aperture, through a first secondary aperture, through a second secondary aperture, and through a second primary aperture. In some embodiments: the plurality of primary apertures comprises four primary apertures; the plurality of secondary apertures comprises two secondary apertures; the one or more a suture strands consists of two suture strands; a first suture strand is inserted through a first primary aperture, through a first secondary aperture, through a second secondary aperture, and through a second primary aperture; and a second suture strand is inserted through a third primary aperture, through the first secondary aperture, through the second secondary aperture, and through a fourth primary aperture; In some embodiments: the plurality of primary apertures comprises four primary apertures; the plurality of secondary apertures comprises two secondary apertures; the one or more a suture strands consists of two suture strands; a first suture strand is inserted through a first primary aperture, through a first secondary aperture, through a second secondary aperture, and through a second primary aperture; and a second suture strand is inserted through a third primary aperture, through the second secondary aperture, through the first secondary aperture, and through a fourth primary aperture; In some embodiments, the first primary aperture and the second primary aperture are adjacent. In some embodiments, the first primary aperture and the second primary aperture are nonadjacent. In some embodiments, the

system further comprises a tightening tool comprising: a threaded rod; a knob coupled to a proximal end of the threaded rod; a collar coupled to the threaded rod; an arm spinner between the knob and the tensioning collar, wherein the arm spinner comprises an aperture accepting the threaded rod; and a handle comprising a cavity, wherein at least a portion of the cavity comprises a threaded feature configured to couple to the threaded rod, wherein the lock comprises the driver feature, and wherein a distal portion of the handle comprises a tensioning feature configured to rotate the driving feature of the lock. In some embodiments, the arm spinner further comprises a terminator channel accepting the terminator. In some embodiments, the arm spinner comprises 1, 2, 3, 4, 5, 6, or more terminator channels. In some embodiments, the knob is coupled to the proximal end of the threaded rod by a pin, an adhesive, a fastener, a press-fit, a weld, or any combination thereof. In some embodiments, the collar is coupled to the threaded rod by a pin, an adhesive, a fastener, a press-fit, a weld, or any combination thereof. In some embodiments, the lock further comprises the alignment feature, and wherein the distal portion of the handle further comprises a tensioning alignment feature that couples to the alignment feature. In some embodiments, the arm spinner rotates freely about the threaded rod, the knob, or both. In some embodiments, rotating the knob and the threaded rod in a first direction with respect with to the handle translates the spinner proximally from the handle. In some embodiments, rotating the knob and the threaded rod in a second direction opposite the first direction translates the spinner distally towards the handle. In some embodiments, rotating the handle in a first direction tightens the lock against the primary button. In some embodiments, the suture is a #1 size suture, a #2 size suture, a #3 size suture, a #4 size suture, a #5 size suture, a #6 size suture, or a #7 size suture. In some embodiments, the suture has a length of about 100 mm to about 1,200 mm. In some embodiments, the system comprise 2, 3, 4, 5, 6 or more suture strands. In some embodiments, the system comprise a first suture strand and a second suture strand, wherein at least a portion of the first suture strand passes within at least a portion of the second suture strand to form a suture bundle 170. In some embodiments, the portion of the first suture strand that passes within the second suture strand is a mesial portion of the first suture. In some embodiments, the portion of the second suture strand through which the first suture strand passes is a mesial portion of the second suture.

[0006] Another aspect provided herein is a suture-button assembly comprising: two or more suture-button systems; and an insertion plate comprising a plurality of insertion plate apertures, each insertion plate aperture accepting at least one suture strand. In some embodiments, the plurality of insertion plate apertures comprises 2, 3, 4, 5, 6, or more insertion plate apertures. In some embodiments, the assembly further comprises an insertion screw, wherein the insertion

plate further comprises a screw hole; configured to removable couple to the insertion screw. In some embodiments, the screw hole is positioned between two of the plurality of insertion plate apertures. In some embodiments, the insertion screw comprises a first portion configured to removably couple to the screw hole and a second portion configured to attach to a bone of a patient.

[0007] Another aspect provided herein is a method of assembling a suture button, the method comprising: providing the suture-button system of any one or more embodiments described herein, wherein: the plurality of primary apertures comprises a first primary aperture and a second primary aperture; the plurality of secondary apertures comprises a first secondary aperture and a second secondary aperture; and the one or more a suture strands consists of one suture strand; inserting the one suture strand through the first primary aperture; inserting the one suture strand through the first secondary aperture; inserting the one suture strand through the second secondary aperture; and inserting the one suture strand through the second primary aperture. In some embodiments, the method further comprises inserting the secondary button through a hole in a bone or tissue. In some embodiments, the method further comprises rotating the secondary button after its insertion through the hole in the bone or tissue such that a proximal face of the secondary button lies against the bone or tissue. In some embodiments, the method further comprises coupling the secondary threaded portion of the lock with the primary threaded portion of the primary button to prevent the suture strand from translating through the first primary aperture and the second primary aperture. In some embodiments, the method further comprises providing the tightening tool of any one or more embodiments described herein. In some embodiments, the secondary threaded portion and the primary threaded portion are coupled by the tightening tool. In some embodiments, the method further comprises tightening the suture strand with respect to the primary button, the secondary button, or both, with the tightening tool.

[0008] Another aspect provided herein is a method of assembling a suture button, the method comprising: providing the suture-button system of any one or more embodiments described herein, wherein: the plurality of primary apertures comprises a first primary aperture, a second primary aperture, a third primary aperture, and a fourth primary aperture; the plurality of secondary apertures comprises a first secondary aperture and a second secondary aperture; and the one or more a suture strands consists of a first suture strand and a second suture strand; inserting the first suture strand through the first primary aperture; inserting the first suture strand through the first secondary aperture; inserting the first suture strand through the second secondary aperture; inserting the first suture strand through the second primary aperture; inserting the second suture strand through the third primary aperture; inserting the second suture

strand through the first secondary aperture; inserting the second suture strand through the second secondary aperture; and inserting the second suture strand through the fourth primary aperture. In some embodiments, the method further comprises inserting the secondary button through a hole in a bone or tissue. In some embodiments, the method further comprises rotating the secondary button after its insertion through the hole in the bone or tissue such that a proximal face of the secondary button lies against the bone or tissue. In some embodiments, the method further comprises coupling the secondary threaded portion of the lock with the primary threaded portion of the primary button to prevent the first suture strand and the second suture strand from translating through the plurality of primary apertures. In some embodiments, the method further comprises providing the tightening tool of any one or more embodiments described herein. In some embodiments, the secondary threaded portion and the primary threaded portion are coupled by the tightening tool. In some embodiments, the method further comprises tightening the first suture strand and the second suture strand with respect to the primary button, the secondary button, or both, with the tightening tool.

[0009] Another aspect provided herein is a method of assembling a suture button, the method comprising: providing the suture-button system of any one or more embodiments described herein, wherein: the plurality of primary apertures comprises a first primary aperture, a second primary aperture, a third primary aperture, and a fourth primary aperture; the plurality of secondary apertures comprises a first secondary aperture and a second secondary aperture; and the one or more a suture strands consists of a first suture strand and a second suture strand; inserting the first suture strand through the first primary aperture; inserting the first suture strand through the first secondary aperture; inserting the first suture strand through the second secondary aperture; inserting the first suture strand through the second primary aperture; inserting the second suture strand through the third primary aperture; inserting the second suture strand through the second secondary aperture; inserting the second suture strand through the first secondary aperture; and inserting the second suture strand through the fourth primary aperture. In some embodiments, the method further comprises inserting the secondary button through a hole in a bone or tissue. In some embodiments, the method further comprises rotating the secondary button after its insertion through the hole in the bone or tissue such that a proximal face of the secondary button lies against the bone or tissue. In some embodiments, the method further comprises coupling the secondary threaded portion of the lock with the primary threaded portion of the primary button to prevent the first suture strand and the second suture strand from translating through the plurality of primary apertures. In some embodiments, the method further comprises providing the tightening tool of any one or more embodiments described herein. In

some embodiments, the secondary threaded portion and the primary threaded portion are coupled by the tightening tool. In some embodiments, the method further comprises tightening the first suture strand and the second suture strand with respect to the primary button, the secondary button, or both, with the tightening tool.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The novel features of the disclosure are set forth with particularity in the appended claims. A better understanding of the features and advantages of the present disclosure will be obtained by reference to the following detailed description that sets forth illustrative embodiments, in which the principles of the disclosure are utilized, and the accompanying drawings of which:

[0011] FIG. 1 shows a front-view illustration of an exemplary suture-button assembly, per an embodiment herein;

[0012] FIG. 2 shows a right-side-view illustration of an exemplary suture-button assembly, per an embodiment herein;

[0013] FIG. 3 shows a top-view illustration of an exemplary suture-button assembly, per an embodiment herein;

[0014] FIG. 4 shows a bottom-view illustration of an exemplary suture-button assembly, per an embodiment herein;

[0015] FIG. 5 shows a perspective illustration of an exemplary primary button, per an embodiment herein;

[0016] FIG. 6A shows a bottom-view illustration of an exemplary primary button, per an embodiment herein;

[0017] FIG. 6B shows a first cross-sectional illustration of an exemplary primary button, per an embodiment herein;

[0018] FIG. 6C shows a second cross-sectional illustration of an exemplary primary button, per an embodiment herein;

[0019] FIG. 7A shows a perspective illustration of an exemplary lock, per an embodiment herein;

[0020] FIG. 7B shows a top-view illustration of an exemplary lock, per an embodiment herein;

[0021] FIG. 7C shows a cross-sectional illustration of an exemplary lock, per an embodiment herein;

[0022] FIG. 7D shows a side view illustration of an exemplary lock, per an embodiment herein;

[0023] FIG. 8 shows a cross-sectional illustration of an exemplary lock coupled to an exemplary primary button, per an embodiment herein;

[0024] FIG. 9A shows a perspective illustration of an exemplary secondary button, per an embodiment herein;

[0025] FIG. 9B shows a bottom-view illustration of an exemplary secondary button, per an embodiment herein;

[0026] FIG. 9C shows a cross-sectional illustration of an exemplary secondary button, per an embodiment herein;

[0027] FIG. 10A shows a perspective illustration of an exemplary bundle 170 of sutures, per an embodiment herein;

[0028] FIG. 10B shows a cross-sectioned illustration of an exemplary bundle 170 of sutures, per an embodiment herein;

[0029] FIG. 11A shows a perspective illustration of an exemplary suture-button assembly with a first suture loop, per an embodiment herein;

[0030] FIG. 11B shows a perspective illustration of an exemplary suture-button assembly with a first suture loop and a second suture loop, per an embodiment herein;

[0031] FIG. 12 shows an illustration of an exemplary suture-button assembly with a first suture loop and a second suture loop, per an embodiment herein;

[0032] FIG. 13 shows a top-view illustration of an exemplary suture-button assembly with an insertion needle 220 device, per an embodiment herein;

[0033] FIG. 14A shows a perspective illustration of an exemplary suture-button assembly with an exemplary lock driver, per an embodiment herein;

[0034] FIG. 14B shows a perspective illustration of an exemplary suture-button assembly with an exemplary lock driver and an exemplary insertion plate, per an embodiment herein;

[0035] FIG. 15A shows a perspective illustration of an exemplary lock driver, per an embodiment herein;

[0036] FIG. 15B shows a front-view illustration of an exemplary lock driver, per an embodiment herein;

[0037] FIG. 16A shows a detailed perspective illustration of an exemplary lock driver, per an embodiment herein;

[0038] FIG. 16B shows a bottom-view illustration of an exemplary lock driver, per an embodiment;

[0039] FIG. 17A shows a detailed perspective illustration of the driving feature of an exemplary lock driver rotating the lock, per an embodiment herein;

[0040] FIG. 17B shows a front cross-sectioned illustration of the driving feature and the aligning feature of an exemplary lock driver rotating the lock, per an embodiment herein;

[0041] FIG. 17C shows a first front cross-sectioned illustration of the driving feature and the aligning feature of an exemplary lock driver rotating the lock, per an embodiment herein;

[0042] FIG. 17D shows a second front cross-sectioned illustration of the driving feature and the aligning feature of an exemplary lock driver rotating the lock, per an embodiment herein;

[0043] FIG. 18 shows a front-view illustration of an exemplary suture-button system having a tightening tool, per an embodiment;

[0044] FIG. 19A shows a front-view illustration of an exemplary tightening tool in a collapsed position, per an embodiment herein;

[0045] FIG. 19B shows a front cross-sectioned illustration of an exemplary tightening tool in the collapsed position, per an embodiment herein;

[0046] FIG. 19C shows a front-view illustration of an exemplary tightening tool in an expanded position, per an embodiment herein;

[0047] FIG. 20 shows a top-view illustration of an exemplary tightening tool, per an embodiment herein;

[0048] FIG. 21 shows a perspective exploded illustration of an exemplary tightening tool, per an embodiment herein;

[0049] FIG. 22A shows a detailed bottom-left-front perspective illustration of a tensioning feature and an alignment feature of an exemplary tightening tool, per an embodiment herein;

[0050] FIG. 22B shows a detailed top-right-front illustration of an exemplary tightening tool engaged with an exemplary lock, per an embodiment herein;

[0051] FIG. 22C shows a cross-section illustration of an exemplary tightening tool engaging with the lock, per an embodiment herein;

[0052] FIG. 23 shows a front-view illustration of an exemplary suture-button assembly comprising two suture-button systems and an insertion plate, per an embodiment herein;

[0053] FIG. 24 shows a perspective illustration of an exemplary insertion plate coupled to an exemplary insertion screw, per an embodiment herein;

[0054] FIG. 25A shows a perspective illustration of the exemplary insertion plate, per an embodiment herein;

[0055] FIG. 25B shows a detailed top-right-front illustration of the exemplary insertion plate, per an embodiment herein;

[0056] FIG. 25C shows a cross-section illustration of the exemplary insertion plate, per an embodiment herein;

[0057] FIG. 26A shows a perspective illustration of an insertion screw, per an embodiment herein;

[0058] FIG. 26B shows a front-view illustration of an insertion screw, per an embodiment herein;

[0059] FIG. 27A shows a perspective illustration of inserting a suture strand through a first primary aperture of the primary button, per an embodiment herein;

[0060] FIG. 27B shows a perspective illustration of inserting a suture strand through a first and second secondary aperture of the secondary button, per an embodiment herein;

[0061] FIG. 27C shows a perspective illustration of inserting a suture strand through a second primary aperture of the primary button, per an embodiment herein;

[0062] FIG. 28A shows a cross-section illustration of inserting a suture strand through a first primary aperture of the primary button, per an embodiment herein;

[0063] FIG. 28B shows a perspective illustration of inserting a suture strand through a first secondary aperture and a second secondary aperture of the secondary button, per an embodiment herein;

[0064] FIG. 28C shows a perspective illustration of inserting a suture strand through a first primary aperture of the primary button, per an embodiment herein;

[0065] FIG. 28D shows a perspective illustration of inserting a suture strand through a second primary aperture of the primary button, per an embodiment herein;

[0066] FIG. 29A shows a cross-section illustration of inserting a first and second suture strand through the respective apertures of the primary button, per an embodiment herein; and

[0067] FIG. 29B shows a perspective illustration of a lock securing a first and second suture strand inserted through the respective apertures of the primary button, per an embodiment herein.

DETAILED DESCRIPTION

[0068] Potential applications of the devices, systems, and methods herein include but are not limited to fixation of acromioclavicular separations due to coracoclavicular ligament disruptions, fixation of dorsal distal radioulnar ligament disruptions, stabilization of the first and second metatarsals for hallux valgus reconstruction, and stabilization of the first and second metacarpal when the trapezium has been excised due to osteoarthritis.

Suture-Button Systems

[0069] One aspect provided herein per **FIGS. 1-13B** is a suture-button system **100**. In some embodiments, the suture-button system comprises one or more suture strands **130**, a primary

button **110**, a secondary button **120**, and a lock **140**. In some embodiments, the lock **140** couples to the primary button **110**.

[0070] In some embodiments, the suture strand **130** is a standard suture. In some embodiments, the suture strand **130** is a medical grade suture. In some embodiments, the suture is a #1 size suture, a #2 size suture, a #3 size suture, a #4 size suture, a #5 size suture, a #6 size suture, or a #7 size suture. In some embodiments, the suture strand **130** has a length of about **100** mm to about 1,**200** mm. In some embodiments, the system **100** comprises 2, 3, 4, 5, 6 or more suture strands **130**. As disclosed herein, the terms suture and suture strands are used interchangeably.

[0071] In some embodiments, per **FIGS. 1-4**, and **10A-13**, the system **100** comprises a first suture strand **130** and a second suture strand **130**. In some embodiments, the first suture strand **130** and the second suture strand **130** are bundled **170** together. In some embodiments, per **FIGS. 10A** and **10B,** at least a portion of the second suture strand **130** is hollow or comprises a channel, wherein at least a portion of the first suture strand **130** passes within at least a portion of the hollow portion or the channel of the second suture strand **130** to form a suture bundle **170**. In some embodiments, the portion of the first suture strand **130** that passes within the second suture strand **130** is a mesial portion of the first suture. In some embodiments, the portion of the second suture strand **130** through which the first suture strand **130** passes is a mesial portion of the second suture. Alternatively, in some embodiments, the system **100** comprises three or more suture strands **130**, wherein one or more of the three or more suture strands **130** are bundled **170** together. In some embodiments, bundling the suture strands **130** together reduces fraying upon contact and/or movement with respect to the secondary button **120**. In some embodiments, one or two of the three or more suture strands **130** pass within one or two other passes within at least a portion of another suture strand **130**.

[0072] In some embodiments, per **FIGS. 11A-13**, two ends of a suture strand **130** are coupled to each other. Further, in some embodiments two ends of a suture strand **130** are coupled to each other to form a suture loop 132. In some embodiments, two ends of a suture strand **130** are tied together in a knot to form a suture loop. In some embodiments, per **FIG. 12**, two ends of a suture strand **130** are coupled to each other by a terminator 131**.** In some embodiments, at least one end of a suture strand **130** is coupled to the terminator 131. In some embodiments, both ends of a suture strand is coupled to a terminator 131. In some embodiments, the terminator is coupled to both ends of the suture to form a suture loop 132. In some embodiments, the terminator 131 is coupled to both ends of each of two sutures to form two suture loops 132. In some embodiments, the terminator 131 is coupled to the suture by a crimp, a fastener, an adhesive, a tie, or any combination thereof. In some embodiments, an outer diameter of the terminator 131 is greater

than twice an outer diameter of the suture strands **130**. In some embodiments, the suture loops 132 ease hand tensioning.

[0073] In some embodiments, tension applied to one or more suture loops adjusts the distance between the primary and secondary buttons. In some embodiments, tension applied to one or more suture loops brings the primary and secondary buttons closer together. In some embodiments, tension applied to one or more suture loops provides a clamping pressure or force about a bone or tissue located between the primary and secondary buttons. In some embodiments, tension is applied by tightening the one or more suture loops. In some embodiments, the one or more suture loops are tightened by pulling on the one or more suture loops. In some embodiments, the one or more suture loops are pulled in a proximal direction relative to the primary button.

[0074] In some embodiments, per **FIGS. 5** and **6**, the primary button **110** comprises four primary apertures **111** and a primary threaded portion **112**. Alternatively, in some embodiments, the primary button **110** comprises 2, 3, 5, 6, or more primary apertures **111**. Further, per **FIGS. 5** and **6**, the four primary apertures **111** are equally spaced apart on the primary button **110** in a circular array about the primary threaded portion **112** and/or about a center axis of the secondary button **120**. As shown, the primary apertures **111** are circular. Alternatively, the primary apertures **111** are oblong or polygonal.

[0075] In some embodiments, per **FIGS. 5**, **6C**, and **8**, a proximal surface **113** of the primary button **110** is tapered towards the primary threaded portion **112**. In some embodiments, per **FIG. 6C**, the proximal surface **113** of the primary button **110** is tapered at an angle of about 30°, about 35°, about 40°, about 45°, about 50°, about 55 °, about 60°, about 65°, about 70°, about 75°, about 80°, or about 85° relative to a central axis **115** concentric to the primary threaded portion **112**. In some embodiments, the proximal surface **113** of the primary button **110** is tapered at an angle of about 30 to about 85°, including increments therein, relative to a central axis **115** concentric to the primary threaded portion. In some embodiments, the primary button proximal surface **113** is tapered at an angle of about 20° to about 89° relative to the central axis through the primary threaded portion.

[0076] As shown in **FIGS. 5**, **6A-C**, and **8**, the primary threaded portion **112** comprises a female threaded portion. Further as shown, the primary threaded portion **112** is centered within the proximal surface **113** of the primary button **110**. Alternatively, in some embodiments, the primary threaded portion **112** comprises a male threaded portion. In some embodiments, the primary threaded portion **112** comprises a straight threaded portion. In some embodiments, the primary threaded portion **112** comprises a tapered threaded portion. In some embodiments, the

primary threaded portion **112** comprises a machine threaded portion. In some embodiments, the primary threaded portion **112** comprises a pipe threaded portion.

[0077] In some embodiments, one or more outer edges of the primary button **110** are rounded or chamfered. In some embodiments, one or more edges of the apertures **111** on a distal face of the primary button **110** are rounded or chamfered. In some embodiments, one or more edges of the primary apertures **111** on a proximal face of the primary button **110** are rounded or chamfered. In some embodiments, one or more edges of the primary button **110** are rounded or chamfered. In some embodiments, the rounded or chamfered edges reduce and/or prevent damage to a portion of suture strand **130** passing thereover.

[0078] As shown in **FIGS. 9A-C**, the secondary button **120** comprises a first secondary aperture **121** and a second secondary aperture **121**. Alternatively, in some embodiments, the plurality of secondary apertures **121** comprises 3, 4, 5, 6, or more secondary apertures **121**. As shown, the secondary apertures **121** are oblong. Alternatively, the secondary apertures **121** are circular or polygonal. In some embodiments, each secondary aperture **121** accepts one or more suture strands **130** therethrough. In some embodiments, each secondary aperture **121** accepts 1, 2, 3, 4, 5, 6 or more suture strands **130** therethrough. In some embodiments, per **FIGS. 9B-C**, a distal surface of the secondary button **120** comprises a channel **122** connecting two or more of the plurality of secondary apertures **121**. As seen the channel **122** has a width equal to an inner width of the first secondary aperture **121**, the second secondary aperture **121**, or both. In some embodiments, the channel **122** has a depth **122A** of about 25% to about 75% of the thickness **120C** of the secondary button **120**. In some embodiments, an aspect ratio between the length **120A** and width **120B** of the secondary button **120** is about 1:1 to about 4:1. In some embodiments, the aspect ratio and/or thickness **120C** of the secondary button **120** enables its insertion through a narrow cavity in a bone.

[0079] In some embodiments, the primary button **110** has a width of about 3 mm to about 12 mm. In some embodiments, the primary button **110** has a length of about 3 mm to about 12 mm. In some embodiments, the primary button **110** has a diameter of about 3 mm to about 12 mm. In some embodiments, the primary button **110** has a thickness of about 0.5 mm to about 3 mm. In some embodiments, the secondary button **120** has a width of about 2 mm to about 7 mm. In some embodiments, the secondary button **120** has a length of about 7 mm to about 20 mm. In some embodiments, the secondary button **120** has a thickness of about 0.5 mm to about 3 mm.

[0080] Further per **FIG. 9C**, in some embodiments, one or more edges of the secondary button **120** are rounded or chamfered. In some embodiments, one or more outer edges of the secondary button **120** are rounded or chamfered. In some embodiments, one or more edges of the secondary

apertures **121**, the channel **122**, or both are rounded or chamfered. In some embodiments, one or more edges of the secondary apertures **121** on a distal face of the secondary button **120** are rounded or chamfered. In some embodiments, one or more edges of the secondary apertures **121** on a proximal face of the secondary button **120** are rounded or chamfered. In some embodiments, the rounded or chamfered edges reduce and/or prevent damage to a portion of suture passing thereover.

[0081] In some embodiments, a distance between the centers **121A, 121B** of a first secondary aperture **121** and a second secondary aperture **121** is greater than a distance between the centers of at least one pair of opposing primary apertures **111**. In some embodiments, a distance between the centers **121A, 121B** of the first secondary aperture **121** and the second secondary aperture **121** is less than a distance between the centers of at least one pair of opposing primary apertures **111**. In some embodiments, a distance between the centers **121A, 121B** of the first secondary aperture **121** and the second secondary aperture **121** is equal to a distance between the centers of at least one pair of opposing primary apertures **111**. In some embodiments, a distance between the centers **121A, 121B** of the first secondary aperture **121** and the second secondary aperture **121** is greater than a distance between the centers of at least one pair of adjacent primary apertures **111**. In some embodiments, a distance between the centers **121A, 121B** of the first secondary aperture **121** and the second secondary aperture **121** is less than a distance between the centers of at least one pair of adjacent primary apertures **111**. In some embodiments, a distance between the centers **121A, 121B** of the first secondary aperture **121** and the second secondary aperture **121** is equal to a distance between the centers of at least one pair of adjacent primary apertures **111**.

[0082] Per **FIGS. 7A-D**, the lock **140** comprises a secondary threaded portion **141** and a head **144**, wherein the secondary threaded portion **141** extends from the head **144**. As shown, the secondary threaded portion **141** comprises a male threaded portion. Alternatively, in some embodiments, the secondary threaded portion **141** comprises a female threaded portion. In some embodiments, the secondary threaded portion **141** comprises a straight threaded portion. In some embodiments, the secondary threaded portion **141** comprises a tapered threaded portion. In some embodiments, the secondary threaded portion **141** comprises a machine threaded portion. In some embodiments, the secondary threaded portion **141** comprises a pipe threaded portion. In some embodiments, the lock **140** comprises a driver feature **142**, an alignment feature **143**, or both. In some embodiments, the driver feature is disposed at least partially within the head **144**. In some embodiments, the driver feature **142** is opposite the secondary threaded portion **141**. In some embodiments, the driver feature **142** and the alignment feature **143** are generally

concentric. In some embodiments, the driver feature **142** is proximal to the alignment feature **143**. In some embodiments, a maximum inner diameter of the driver feature **142** is greater than a maximum inner diameter of the alignment feature **143**. In some embodiments, the driver feature comprises a Philips driver feature, a flathead driver feature, a torx driver feature, a hex driver feature, or a square socket feature. In some embodiments, the alignment feature **143** has a cross sectional shape comprising a circle, a triangle, a square, a pentagon, a hexagon, an octagon, or any combination thereof. In some embodiments, a proximal edge of the alignment feature **143** is rounded or chamfered.

[0083] As shown per **FIGS. 7C**, **7D**, and **8**, a distal surface **145** of the head **144** is tapered towards the secondary threaded portion **141**. In some embodiments, a distal surface **145** of the head **144** is tapered inward to the center axis **146** of the lock **140**. In some embodiments, the distal surface **145** of the head **144** is tapered outwards from the center axis **146** of the lock **140** at an angle of about 20° to about 89° relative to an axis parallel the center axis **146** of the lock **140**.

[0084] In some embodiments, per **FIG. 8**, the secondary threaded portion **141** is configured to be removably coupled to the primary threaded portion **112**. In some embodiments, coupling the secondary threaded portion **141** of the lock **140** to the primary threaded portion **112** of the primary button **110** prevents the suture strand **130** from translating through one or more of the plurality of first button apertures.

[0085] Further per **FIG. 8**, at least a portion of the tapered distal face **145** of lock **140** seats against the tapered portion of the primary button proximal surface **113** of the primary button **110**. In some embodiments, the angle that the distal face of the lock **140** tapers is equivalent to an angle that the primary button proximal face **113** tapers towards the primary threaded portion. In some embodiments, the angle between the proximal surface **113** of the primary button **110** relative to its central axis **115**, and the angle between the distal surface **145** of the head **144** relative to the center axis **146** of the lock **140** are complementary. In some embodiments, the angle between the proximal surface **113** of the primary button **110** relative to its central axis **115**, and the angle between the distal surface **145** of the head **144** relative to the center axis **146** of the lock **140** are equal. In some embodiments, at least a portion of the distal surface **145** of the head **144**, the proximal surface **113** of the primary button **110**, or both have a texture configured to increase friction against the suture strand **130**.

[0086] In some embodiments of a first suture-button system **100A**, per **FIG. 11A,** the primary button comprises a first primary aperture and a second primary aperture, the secondary button comprises a first secondary aperture and a second secondary aperture, and a single suture strand passes through the apertures of the primary and secondary buttons. In some embodiments of a

second suture-button system **100**, per **FIGS. 1**, **2**, **3**, **11B** and **12**, the primary button comprises a first primary aperture, a second primary aperture, a third primary aperture, and a fourth primary aperture, the secondary button comprises a first secondary aperture and a second secondary aperture, and a first suture strand and a second suture strand pass through one or more apertures of the primary and secondary buttons.

[0087] Per **FIGS. 1**, **2**, and **3**, for the second suture button assembly, each primary aperture **111** of the primary button has one suture strand **130** inserted therethrough. Alternatively, in some embodiments, each primary aperture **111** has two or more of the plurality of suture strands inserted therethrough. In some embodiments, each primary aperture **111** has 2, 3, 4, 5, 6 or more suture strands inserted therethrough. In some embodiments, each secondary aperture **121** has one or more of the plurality of suture strands inserted therethrough. Per **FIGS. 1**, **2** and **4**, each secondary aperture **121** has two suture strands **130** inserted therethrough. As shown, each secondary aperture **121** has one suture strand **130** inserted distally and one suture strand **130** inserted proximally therethrough. Alternatively, each secondary aperture **121** has two suture strands **130** inserted distally therethrough. Alternatively, each secondary aperture **121** has two suture strands **130** inserted proximally therethrough. Alternatively, in some embodiments, each secondary aperture **121** has three or more sutures strands **130** inserted therethrough. In some embodiments, each secondary aperture **121** has 2, 3, 4, 5, 6 or more sutures strands **130** inserted therethrough.

[0088] Per **FIG. 3**, once the plurality of suture strands has been inserted through the apertures of the primary and secondary buttons, coupling the lock **140** to the primary button **110** prevents each of the plurality of suture strands **130** from translating through one or more of the plurality of primary apertures **111**. In some embodiments, coupling the lock **140** to the primary threaded portion **141** prevents each of the plurality of suture strands **130** from translating through one or more of the plurality of primary apertures by compressing at least a portion of each of the plurality of suture strands **130** between the distal face **145** of the lock **140** and the primary button proximal face **113**.

[0089] In some embodiments, rotating the lock **140** in a first direction relative to the primary button inserts the secondary threaded portion **141** of the lock **140** distally through the primary threaded portion **113** of the primary button **110**, so as to compress at least a portion of each of the plurality of suture strands **130** located between the distal face **145** of the head **144** and the primary button proximal face **113**. In some embodiments, rotating the lock **140** in a second direction relative to the primary button, opposite the first direction, translates the secondary threaded portion **141** of the lock **140** proximally through the primary threaded portion **113** of the

primary button **110**, so as to enable each of the plurality of suture strands **130** to translate through the plurality of primary apertures **111**.

[0090] In some embodiments, per **FIG. 8**, at least a portion of the lock **140** extends beyond a distal face of the primary button **110** when the primary button **110** is coupled to the lock **140**. In some embodiments, a distal face of the primary button **110** extends beyond a distal end of the secondary threaded portion **141** of the lock **140** when the primary button **110** is coupled to the lock **140**. In some embodiments, at least a portion of the lock **140** extends beyond a distal face of the primary button **110** by an extension distance **147** of about 1 mm, 2 mm, 3 mm, 4 mm, 5 mm, 6 mm, 7 mm, 8 mm, 9 mm, 10 mm, or more when the primary button **110** is coupled to the lock **140**. In some embodiments, a distal face of the primary button **110** extends beyond a distal end of the secondary threaded portion **141** of the lock **140** by an extension distance of about 1 mm, 2 mm, 3 mm, 4 mm, 5 mm, 6 mm, 7 mm, 8 mm, 9 mm, 10 mm, or more when the primary button **110** is coupled to the lock **140**. In some embodiments, at least a portion of the lock **140** extends beyond a distal face of the primary button **110** into a bone or tissue. In some embodiments, at least a portion of the lock **140** extends beyond a distal face of the primary button **110** into a bone or tissue tunnel or hole. In some embodiments, at least a portion of the lock **140** extends beyond a distal face of the primary button **110** into a bone or tissue tunnel or hole when the primary button **110** is in contact with the bone or tissue tunnel.

[0091] In some embodiments, per **FIG. 13**, the system **100** further comprises an insertion suture **210**, an insertion needle **220**, or both. In some embodiments, the secondary button **120** is attached to the insertion needle **220** via an insertion suture **210**. In some embodiments, the insertion needle **220** is configured to be inserted through a hole in a targeted tissue, which then pulls the secondary button **120** therethrough via the insertion suture **210**. In some embodiments, pulling the secondary button **120** through the hole in the targeted tissue also pulls the one or more suture strands **130** that is coupled to the secondary button through said hole. In some embodiments, the insertion needle **220** is then disconnected from the secondary button **120** by cutting and removing the insertion suture **210**.

[0092] In some embodiments, per **FIGS. 14A-17D**, the system **100** further comprises a lock driver device **180**. In some embodiments, the lock driver **180** comprises a driving feature **182** that is configured to rotate the lock **140** relative to the primary button **110**. In some embodiments, the driving feature **182** is a male driving feature wherein the driver feature **142** of the lock **140** is a female driver feature. In some embodiments, the driving feature **182** is a female driving feature wherein the driver feature **142** of the lock **140** is a male driver feature. In some embodiments, at least a portion of the driver feature **142** fits within a portion of the driving feature **182**. In some

embodiments, at least a portion of the driving feature **182** fits within a portion of the driver feature **142**. In some embodiments, the lock driver **180** further comprises an aligning feature **183** configured to align the lock driver **180** to the alignment feature **143** of the lock **140**. In some embodiments, the aligning feature **183** is configured to align the lock driver **180** to the alignment feature **143** of the lock **140** while the lock driver **180** rotates the lock **140** relative to the primary button **110**. In some embodiments, rotating the lock driver **180** in a first direction inserts the secondary threaded portion **141** of the lock **140** distally through the primary threaded portion **113** of the primary button **110**. In some embodiments, rotating the lock driver **180** in a second direction opposite the first direction translates the secondary threaded portion **141** of the lock **140** proximally through the primary threaded portion **113** of the primary button **110**. In some embodiments, the alignment feature **183** is distal to the driving feature **182**. In some embodiments, a maximum outer diameter of the alignment feature **183** is less than a maximum outer diameter of the driving feature **182**. As shown, the driver feature **142** comprise a torx driver feature, Alternatively, in some embodiments, the driver feature **142** comprises a Philips driver feature **142**, a flathead driver feature **142**, a hex driver feature **142**, or a square socket feature. In some embodiments, the lock driver **180** enables a greater tightening force than can be applied by hand. In some embodiments, the lock driver **180** enables a more precise and tunable tightening force than can be applied by hand.

[0093] In some embodiments, per **FIGS. 18-22C**, the system **100** further comprises a tightening tool **190**. In some embodiments, the tightening tool **190** comprises: a threaded rod **194**; a knob **191**; a spinner **192**, a collar **196**, and a handle **193**. In some embodiments, the knob **191** is coupled to the threaded rod **194**. In some embodiments, the knob **191** is permanently coupled to the threaded rod **194**. In some embodiments, the knob **191** is removably coupled to the threaded rod **194**. In some embodiments, the knob **191** is coupled to a proximal end of the threaded rod **194**. In some embodiments, the collar **196** is coupled to the threaded rod **194**. In some embodiments, the collar **196** is coupled to the threaded rod **194** by a fastener, an adhesive, a pin **197**, welding or any combination thereof. In some embodiments, the spinner **192** is positioned between the knob **191** and the collar **196**. In some embodiments, the spinner **192** comprises an aperture accepting the threaded rod **194**. In some embodiments, the spinner **192** further comprises a terminator channel **192A** accepting the coupled ends of one or more suture strands **130.** In some embodiments, the spinner **192** further comprises a terminator channel **192A** accepting the terminator of the suture strand **130**. In some embodiments, the spinner **192** comprises 1, 2, 3, 4, 5, 6, or more terminator channels **192A**. In some embodiments, the handle **193** comprises a cavity, wherein at least a portion of the cavity comprises a threaded feature

configured to couple to the threaded rod **194**. In some embodiments, a distal portion of the handle **193** comprises a tensioning feature **195A** configured to rotate the driver feature of the lock **140**. In some embodiments, the knob **191** is coupled to the proximal end of the threaded rod **194** by a pin **197**, an adhesive, a fastener, a press-fit, a weld, or any combination thereof. As shown, the collar **196** is coupled to the threaded rod **194** by a fastener. Alternatively, in some embodiments, the collar **196** is coupled to the threaded rod **194** by a pin, an adhesive, a press-fit, a weld, or any combination thereof. In some embodiments, the lock **140** further comprises the alignment feature **143**, and wherein the distal portion of the handle **193** further comprises a tensioning alignment feature **195B** that couples to the alignment feature **143**. In some embodiments, rotating the knob **191** and the threaded rod **194** in a first direction with respect with to the handle **193** translates the knob **191** and the spinner distally with respect to the handle **193**. In some embodiments, rotating the knob **191** and the threaded rod **194** in a second direction opposite the first direction translates the knob **191** and the spinner proximally with respect to the handle **193**. In some embodiments, the knob **191** is rotated to translate the spinner **192** proximally or distally, so as to obtain a desired tension of suture strands **130** that are coupled to a terminator channel **192A**. In some embodiments, rotating the handle **193** in a first direction inserts the secondary threaded portion **141** of the lock **140** distally through the primary threaded portion **113** of the primary button **110**. In some embodiments, rotating the handle **193** in a second direction opposite the first direction translates the secondary threaded portion **141** of the lock **140** proximally through the primary threaded portion **113** of the primary button **110**. In some embodiments, the tightening tool **190** enables a greater tightening force than can be applied by hand. In some embodiments, the tightening tool **190** enables a more precise and tunable tightening force than can be applied by hand.

[0094] In some embodiments, applying tension between two ends of each of the one or more suture strands **130** reduces a distance between the primary button **110** and the secondary button **120**. In some embodiments, applying tension between two ends of each of the one or more suture strands **130** reduces a distance between the distal surface of the primary button **110** and a proximal surface of the secondary button **110**. In some embodiments, applying tension between two ends of each of the one or more suture strands **130** provides a clamping force between the distal surface of the primary button **110** and a proximal surface of the secondary button **110**. In some embodiments, applying tension between two ends of each of the one or more suture strands **130** increases a clamping pressure that the primary button **110** and the secondary button **110** apply to a target tissue therebetween. In some embodiments, applying tension between two ends of each of the one or more suture strands **130** increases a clamping pressure that the distal surface

of the primary button **110** and the proximal surface secondary button **110** apply to a target tissue therebetween.

[0095] In some embodiments, the target tissue comprises two or more portions of a bone, a muscle tissue, an epithelial tissue, a connective, tissue, a nervous tissue, or any combination thereof. In some embodiments, two or more of the following are clamped together between the primary button **110** and the secondary button **110**: a bone, a muscle tissue, an epithelial tissue, a connective, tissue, a nervous tissue, or any combination thereof. In some embodiments, upon tensioning of the suture strands **130**, the primary button **110** and the secondary button **120** clamp a bone to: another bone, a muscle tissue, an epithelial tissue, a connective, tissue, a nervous tissue, or any combination thereof. In some embodiments, upon tensioning of the suture strands **130**, the primary button **110** and the secondary button **120** clamp a muscle tissue to: bone, another muscle tissue, an epithelial tissue, a connective, tissue, a nervous tissue, or any combination thereof. In some embodiments, upon tensioning of the suture strands **130**, the primary button **110** and the secondary button **120** clamp an epithelial tissue to: bone, muscle tissue, another epithelial tissue, a connective, tissue, a nervous tissue, or any combination thereof. In some embodiments, upon tensioning of the suture strands **130**, the primary button **110** and the secondary button **120** clamp a connective tissue to: bone, muscle tissue, epithelial tissue, another connective, tissue, a nervous tissue, or any combination thereof. In some embodiments, upon tensioning of the suture strands **130**, the primary button **110** and the secondary button **120** clamp a nervous tissue to: bone, muscle tissue, epithelial tissue, connective, tissue, another nervous tissue, or any combination thereof.

Suture-Button Assemblies

[0096] Another aspect provided herein, per **FIGS. 23-26B**, is a suture-button assembly **200** comprising two suture-button systems **100** and an insertion plate **150**. In some embodiments, the suture button assembly **200** comprises 2, 3, 4, 5, 6, or more suture button systems **100**. As shown, the insertion plate **150** comprises two insertion plate apertures **151**, wherein each insertion plate aperture **151** accepts at least one suture strand. Alternatively, in some embodiments, each insertion plate apertures **151** accepts the sutures of 1, 2, 3, 4, 5, 6 or more suture button assemblies. In some embodiments, the plurality of insertion plate apertures **151** comprises 2, 3, 4, 5, 6, or more insertion plate apertures **151**, wherein each insertion plate aperture **151** accepts the sutures of one suture button assembly. In some embodiments, each insertion plate apertures **151** accepts 1, 2, 3, 4, 5, 6 or more sutures. In some embodiments, the plurality of insertion plate apertures **151** In some embodiments, a screw hole **152** is positioned between two of the plurality

of insertion plate apertures **151**. In some embodiments, the screw hole **152** is positioned equidistant between two of the plurality of insertion plate apertures **151**.

[0097] In some embodiments, the assembly further comprises an insertion screw **160**. In some embodiments, insertion screw **160** is configured to be removably coupled with the screw hole **152**. In some embodiments, the insertion screw **160** comprises a first portion **161**, a second portion **162** configured to attach to a bone of a patient, and a third portion **163** having length and/or diameter greater than a greatest length or diameter of the screw hole **152**. In some embodiments, the third portion **163** prevents the first portion **161** from passing through the screw hole **152** after the second portion **162** has been inserted therethrough. In some embodiments, the second portion comprises a threaded feature configured to attach to the bone of the patient.

Method of Assembling a First Suture button System

[0098] Another aspect provided herein is a method of assembling a first suture button system **100**. In some embodiments, the method comprises: providing a first suture-button system **100** wherein the primary button **110** comprises a first primary aperture **111** and a second primary aperture **111**, wherein the secondary button **120** comprises a first secondary aperture **121** and a second secondary aperture **121**, and wherein the first suture button system comprises one suture strand **130**. In some embodiments, the method comprises inserting the suture strand **130** through the first primary aperture **111**, inserting the one suture strand **130** through the first secondary aperture **121**, inserting the one suture strand **130** through the second secondary aperture **121**, and inserting the one suture strand **130** through the second primary aperture **111**. In some embodiments, one or more of the steps of inserting the suture strand **130** through the first primary aperture **111**, through the first secondary aperture **121**, through the second secondary aperture **121**, and through the second primary aperture **111** are performed simultaneously. In some embodiments, the method further comprises coupling the two ends of the suture strand **130** together. In some embodiments, the method further comprises coupling the two ends of the suture strand **130** by tying the two ends of the suture strand **130** together. In some embodiments, the method further comprises coupling the two ends of the suture strand **130** with a terminator.

[0099] In some embodiments, the method further comprises inserting the secondary button **120** through a hole in a proximal surface of a bone or tissue of a patient, and tightening the suture such that the primary button **110** and the secondary button **120** are tightly pressed against opposing surfaces of the bone. In some embodiments, the secondary button **120** is inserted through a bone or tissue hole extending through at least one bone. In some embodiments, the bone or tissue hole is a tunnel, channel, passageway, or any combination thereof. In some

embodiments, the secondary button **120** is attached to an insertion needle **220** via one or more insertion suture **210** loops. In some embodiments, the insertion suture **210** loops may be formed by passing an insertion suture **210** through one or more secondary apertures **121** in the secondary button **120** and attaching both free ends of the one or more insertion suture strands **210** to the insertion needle **220**. In some embodiments, the free ends of the one or more insertion suture strands **210** are attached to the insertion needle **220** via crimping. In some embodiments, the insertion needle **220** may be inserted through said bone or tissue hole on a first side of the bone or tissue, and received on a second side, such that the secondary button **120** is pulled through the hole in its most narrow configuration. In some embodiments, the secondary button **120**, after passing through the bone or tissue hole in its most narrow configuration, is then pivoted such that it lies flat against the bone or tissue. In some embodiments, the secondary button **120** lies against the bone or tissue on its length **120A**. In some embodiments, the primary button **110** and secondary button **120** are disposed on either side of the bone or tissue hole with the suture **130** extending through the bone or tissue hole. In some embodiments, the insertion needle **220** is disconnected from the secondary button by cutting and removing the insertion suture **210**. In some embodiments, the suture strand **130** is tightened, such that the primary and secondary buttons apply a clamping force or pressure on a first and second side of a bone or tissue.

[0100] As described herein, tightening the suture includes applying a tension to the coupled ends of the suture **130**. In some embodiments, pulling the coupled ends of the suture **130** applies tension to the suture. In some embodiments, pulling the coupled ends of the suture **130** in a proximal direction applies tension to the suture. In some embodiments, the tightening is performed by hand. In some embodiments, the tightening is performed by the lock driver described herein. In some embodiments, the tightening is performed by rotating the tightening tool **190** herein. In some embodiments, the tightening comprises inserting the suture strand loop **130** within the terminator channels **192A** of the spinner **192**, coupling the tensioning feature **195A** and the driver feature of the lock **140**, and rotating the knob **191** with respect to the handle **193**. In some embodiments, the tightening comprises inserting the suture strand loop **130** within the terminator channels **192A** of the spinner **192**, coupling the tensioning feature **195A** and the driver feature of the lock **140**, rotating the knob **191** with respect to the handle **193**, and rotating the tightening tool **190** with respect to the driving feature of the lock **140**. In some embodiments, rotating the knob **191** in a first direction translates the spinner **192** and terminator channels **192A** proximally from the handle **193**, thereby tightening the suture strand **130**. In some embodiments, rotating the knob **191** in a second direction translates the spinner **192** and terminator channels **192A** distally to the handle **193**, thereby loosening the suture strand **130**, and decreasing the

tension. In some embodiments, once the desired tension is reached the lock **140** is tightened against the primary button **110** such that the suture is locked in place therebetween. In some embodiments, the lock **140** is loosened against the primary button **110** to enable readjustment of the tension of the suture strand, wherein the lock **140** is subsequently tightened against the primary button **110** once the desired tension is reached. In some embodiments, the method further comprises trimming the loose ends of the suture.

Method of Assembling a Second Suture Button System

[0101] Further provided herein, per **FIGS. 27A-29B**, is a method of assembling a second suture button system **100**. In some embodiments, the method comprises providing a second suture-button system **100** wherein the primary button **110** comprises a first primary aperture **111**, a second primary aperture **111**, a third primary aperture **111**, and a fourth primary aperture **111**, the secondary button **120** comprises a first secondary aperture **121** and a second secondary aperture **121**, and the one or more a suture strands **130** consists of a first suture strand **130** and a second suture strand **130**.

[0102] In some embodiments, the method comprises: inserting the first suture strand **130** through the first primary aperture **111**; inserting the first suture strand **130** through the first secondary aperture **121**; inserting the first suture strand **130** through the second secondary aperture **121**; inserting the first suture strand **130** through the second primary aperture **111**; inserting the second suture strand **130** through the third primary aperture **111**; inserting the second suture strand **130** through the first secondary aperture **121**; inserting the second suture strand **130** through the second secondary aperture **121**; and inserting the second suture strand **130** through the fourth primary aperture **111**. In some embodiments, one or more of the inserting the first suture strand **130** through the first primary aperture **111**, inserting the first suture strand **130** through the first secondary aperture **121**, inserting the first suture strand **130** through the second secondary aperture **121**, inserting the first suture strand **130** through the second primary aperture **111**, inserting the second suture strand **130** through the third primary aperture **111**, inserting the second suture strand **130** through the first secondary aperture **121**, inserting the second suture strand **130** through the second secondary aperture **121**, and inserting the second suture strand **130** through the fourth primary aperture **111** are performed simultaneously.

[0103] In some embodiments, the method comprises: inserting the first suture strand **130** through the first primary aperture **111**; inserting the first suture strand **130** through the first secondary aperture **121**; inserting the first suture strand **130** through the second secondary aperture **121**; inserting the first suture strand **130** through the second primary aperture **111**; inserting the second

suture strand **130** through the third primary aperture **111**; inserting the second suture strand **130** through the second secondary aperture **121**; inserting the second suture strand **130** through the first secondary aperture **121**; and inserting the second suture strand **130** through the fourth primary aperture **111**. In some embodiments, one or more of the inserting the first suture strand **130** through the first primary aperture **111**, inserting the first suture strand **130** through the first secondary aperture **121**, inserting the first suture strand **130** through the second secondary aperture **121**, inserting the first suture strand **130** through the second primary aperture **111**, inserting the second suture strand **130** through the third primary aperture **111**, inserting the second suture strand **130** through the second secondary aperture **121**, inserting the second suture strand **130** through the first secondary aperture **121**, and inserting the second suture strand **130** through the fourth primary aperture **111** are performed simultaneously.

[0104] Per **FIG. 29A**, both the first primary aperture **111** and the third primary aperture **111** are adjacent to the second primary aperture **111** and the fourth primary aperture **111**. Further as shown, the first primary aperture **111**, the second primary aperture **111**, the third primary aperture **111** and the fourth primary aperture **111** are arrayed sequentially in a clockwise direction about the primary button **110**. Alternatively, in some embodiments, both the first primary aperture **111** and the second primary aperture **111** are adjacent to the third primary aperture **111** and the fourth primary aperture **111**. In some embodiments, the first primary aperture **111**, the third primary aperture **111**, the second primary aperture **111** and the fourth primary aperture **111** are arrayed sequentially in a clockwise direction about the primary button **110**. In some embodiments, the first primary aperture **111**, the third primary aperture **111**, the second primary aperture **111** and the fourth primary aperture **111** are arrayed sequentially in a counter-clockwise direction about the primary button **110**. In some embodiments, the first primary aperture **111**, the second primary aperture **111**, the third primary aperture **111** and the fourth primary aperture **111** are arrayed sequentially in a counter-clockwise direction about the primary button **110**.

[0105] In some embodiments, the method further comprises inserting the secondary button **120** through a hole in a bone or tissue of a patient, as described herein, and tightening the sutures such that the primary button **110** and the secondary button **120** are tightly pressed against respective surfaces of the bone or tissue. In some embodiments, the tightening is performed by hand. In some embodiments, the tightening is performed by the lock driver as described herein. In some embodiments, the tightening is performed by the tightening tool as described herein.

[0106] In some embodiments, once the desired tension is reached, the lock **140** is tightened against the primary button **110** such that the sutures are locked in place therebetween. In some embodiments, the method further comprises trimming the loose ends of the sutures.

Method of Assembling A Suture Button Assembly

[0107] Provided herein, per **FIGS. 23-26B** are methods for assembling a suture button assembly 200. In some embodiments, the method comprises inserting the primary button **110** of a first suture button system **100** into a first insertion plate aperture **151** of the insertion plate **150**, and inserting the primary button **110** of a second suture button system **100** into a second insertion plate aperture **151** of the insertion plate **150**. In some embodiments, the method comprises inserting the secondary button **120** of a first suture button system **100** into a first insertion plate aperture **151** of the insertion plate **150**, and inserting the secondary button **120** of a second suture button system **100** into a second insertion plate aperture **151** of the insertion plate **150**. In some embodiments, the method comprises inserting the primary button **110** of a first suture button system **100** into a first insertion plate aperture **151** of the insertion plate **150**, and inserting the secondary button **120** of a second suture button system **100** into a second insertion plate aperture **151** of the insertion plate **150**.

[0108] In some embodiments, the method comprises inserting each of a plurality of suture strands **130** through one or more of the secondary apertures **121** of the secondary button **120** of a first suture button system **100**, inserting each of a plurality of suture strands **130** through one or more of the secondary apertures **121** of the secondary button **120** of a second suture button system **100**, inserting each of a plurality of suture strands **130** of the first suture button system **100** through a first insertion plate aperture **151** of the insertion plate **150**, inserting each of a plurality of suture strands **130** of the second suture button system **100** through a second insertion plate aperture **151** of the insertion plate **150**, inserting each of a plurality of suture strands **130** through one or more of the primary apertures **111** of the primary button **110** of a first suture button system **100**, and inserting each of a plurality of suture strands **130** through one or more of the primary apertures **111** of the primary button **110** of a second suture button system **100**.

[0109] In some embodiments, the method further comprises inserting the insertion screw **160** into the insertion hole **152** of the insertion plate **150**. In some embodiments, the method further comprises screwing the insertion screw **160** into a bone or tissue of a patient. In some embodiments, screwing the insertion screw **160** into a bone or tissue of a patient temporarily fixates the plate to the bone or tissue of the patient while the suture-button system is deployed.

Terms and Definitions

[0110] Unless otherwise defined, all technical terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this disclosure belongs.

[0111] As used herein, the singular forms "a," "an," and "the" include plural references unless the context clearly dictates otherwise. Any reference to "or" herein is intended to encompass "and/or" unless otherwise stated.

[0112] As used herein, the term "about" in some cases refers to an amount that is approximately the stated amount.

[0113] As used herein, the term "about" refers to an amount that is near the stated amount by 10%, 5%, or 1%, including increments therein.

[0114] As used herein, the term "about" in reference to a percentage refers to an amount that is greater or less the stated percentage by 10%, 5%, or 1%, including increments therein.

[0115] As used herein, the term "generally" refers to a geometric relationship between two or more elements within tolerances of 10%, 5%, or 1%, including increments therein.

[0116] As used herein, the phrases "at least one", "one or more", and "and/or" are open-ended expressions that are both conjunctive and disjunctive in operation. For example, each of the expressions "at least one of A, B and C", "at least one of A, B, or C", "one or more of A, B, and C", "one or more of A, B, or C" and "A, B, and/or C" means A alone, B alone, C alone, A and B together, A and C together, B and C together, or A, B and C together.

EXAMPLES

[0117] The following illustrative examples are representative of embodiments of the systems, and methods described herein and are not meant to be limiting in any way.

Example 1 – Syndesmosis Repair

[0118] In one example of an ankle syndesmosis repair, suture-button assembly is used, wherein the secondary button rests on the tibia and the primary button rests on the fibula. The plate of the suture-button assembly is placed on the fibula across a fracture, so that one suture-button system is deployed on either side of the fracture. The insertion screw is used to temporarily fixate the plate to the fibula while the suture-button system is deployed.

[0119] While preferred embodiments of the present disclosure have been shown and described herein, it will be obvious to those skilled in the art that such embodiments are provided by way of example only. Numerous variations, changes, and substitutions will now occur to those skilled in the art without departing from the disclosure. It should be understood that various alternatives to

the embodiments of the disclosure described herein may be employed in practicing the disclosure.

CLAIMS

WHAT IS CLAIMED IS:

1. A suture-button system comprising:
   (a) a suture strand;
   (b) a primary button having a plurality of primary apertures and a primary threaded portion, wherein the suture strand is inserted through a first and second primary aperture of the plurality of primary apertures;
   (c) a secondary button having a plurality of secondary apertures, wherein the suture strand is inserted through a first and second secondary aperture of the plurality of secondary apertures, such that at least one targeted tissue of a subject is clamped between a distal surface of the primary button and a proximal surface of the secondary button upon applying a tension to the suture strand; and
   (d) a lock having a secondary threaded portion, wherein the secondary threaded portion is removably coupled to the primary threaded portion, wherein coupling the secondary threaded portion of the lock to the threaded portion prevents the suture strand from translating through the plurality of primary apertures, thereby securing the clamping of the targeted tissue.
2. The system of claim 1, wherein the plurality of primary apertures comprises 2, 3, 4, or 5 primary apertures.
3. The system of claim 1, wherein the plurality of primary apertures are equally spaced on the primary button.
4. The system of claim 3, wherein the plurality of primary apertures are equally spaced on the primary button in a circular array.
5. The system of claim 4, wherein the plurality of primary apertures are equally spaced on the primary button in a circular array about the primary threaded portion.
6. The system of claim 4, wherein the plurality of primary apertures are equally spaced on the primary button in a circular array about a center axis of the secondary button.
7. The system of claim 1, wherein a proximal surface of the primary button comprises a countersink.
8. The system of claim 1, wherein the primary threaded portion comprises a female threaded portion.
9. The system of claim 8, wherein the secondary threaded portion comprises a male threaded portion.

10. The system of claim 1, wherein the primary threaded portion comprises a male threaded portion.
11. The system of claim 10, wherein the secondary threaded portion comprises a female threaded portion.
12. The system of claim 1, wherein the plurality of secondary apertures comprises 2, 3, 4, or 5 secondary apertures.
13. The system of claim 1, wherein a distal surface of the secondary button comprises a channel connecting two or more of the plurality of secondary apertures.
14. The system of claim 1, wherein one or more edges of the secondary button are rounded or chamfered.
15. The system of claim 1, wherein an aspect ratio between the length and width of the secondary button is about 1:1 to about 4:1.
16. The system of claim 1, wherein the lock comprises a head and wherein the secondary threaded portion extends from the head.
17. The system of claim 16, wherein a distal surface of the head is tapered outwards from a center axis of the lock.
18. The system of claim 17, wherein the distal surface of the head is tapered outwards from a center axis of the lock by about 20° to about 89°.
19. The system of claim 1, wherein the suture strand is a #1 size suture, a #2 size suture, a #3 size suture, a #4 size suture, a #5 size suture, a #6 size suture, or a #7 size suture.
20. The system of claim 1, wherein the suture strand has a length of about 100 mm to about 1,200 mm.
21. The system of claim 1, comprising 2, 3, 4, 5, 6 or more suture strands.
22. The system of claim 21, comprising a first suture strand and a second suture strand, wherein at least a portion of the first suture strand passes within at least a portion of the second suture strand to form a suture bundle.
23. The system of claim 22, wherein the portion of the first suture strand that passes within the second suture strand is a mesial portion of the first suture.
24. The system of claim 22, wherein the portion of the second suture strand through which the first suture strand passes is a mesial portion of the second suture.
25. The system of claim 1, wherein the lock comprises a driver feature, an alignment feature, or both.
26. The system of claim 25, wherein the driver feature is opposite the secondary threaded portion.

27. The system of claim 25, wherein the driver feature and the alignment feature are generally concentric.
28. The system of claim 25, wherein the driver feature is proximal to the alignment feature.
29. The system of claim 28, wherein a maximum inner diameter of the driver feature is greater than a maximum inner diameter of the alignment feature.
30. The system of claim 25, wherein the driver feature comprises a Philips driver feature, a flathead driver feature, a torx driver feature, a hex driver feature, or a square socket feature.
31. The system of claim 25, wherein the alignment feature has a cross sectional shape comprising a circle, a triangle, a square, a pentagon, a hexagon, an octagon, or any combination thereof.
32. The system of claim 25, further comprising a lock driver comprising a driving feature that is configured to rotate the lock relative to the primary button.
33. The system of claim 32, wherein the lock driver further comprises an aligning feature configured to align the lock driver to the alignment feature of the lock.
34. The system of claim 33, wherein the alignment feature is distal to the driving feature.
35. The system of claim 1, wherein at least a portion of the lock extends beyond a distal face of the primary button when the primary button is coupled to the lock.
36. The system of claim 1, wherein a distal face of the primary button extends beyond a distal face of the lock when the primary button is coupled to the lock.
37. The system of claim 25, wherein at least one end of the suture strand is coupled to a terminator.
38. The system of claim 1, comprising two suture strands, wherein:
    (a) the plurality of primary apertures comprises four primary apertures;
    (b) the plurality of secondary apertures comprises two secondary apertures;
    (c) a first suture strand is inserted through a first primary aperture, through a first secondary aperture, through a second secondary aperture, and through a second primary aperture; and
    (d) a second suture strand is inserted through a third primary aperture, through the first secondary aperture, through the second secondary aperture, and through a fourth primary aperture;
39. The system of claim 1, comprising two suture strands, wherein:
    (a) the plurality of primary apertures comprises four primary apertures;
    (b) the plurality of secondary apertures comprises two secondary apertures;

(c) a first suture strand is inserted through a first primary aperture, through a first secondary aperture, through a second secondary aperture, and through a second primary aperture; and

(d) a second suture strand is inserted through a third primary aperture, through the second secondary aperture, through the first secondary aperture, and through a fourth primary aperture;

40. The system of claim 38, wherein the first primary aperture and the second primary aperture are adjacent.

41. The system of claim 38, wherein the first primary aperture and the second primary aperture are nonadjacent.

42. The system of claim 37, further comprising a tightening tool comprising:

(a) a threaded rod;

(b) a knob coupled to a proximal end of the threaded rod;

(c) a collar coupled to the threaded rod;

(d) an spinner between the knob and the collar, wherein the spinner comprises an aperture accepting the threaded rod; and

(e) a handle comprising a cavity, wherein at least a portion of the cavity comprises a threaded feature configured to couple to the threaded rod, wherein the lock comprises the driver feature, and wherein a distal portion of the handle comprises a tensioning feature configured to rotate the driver feature of the lock.

43. The system of claim 42, wherein the spinner further comprises a terminator channel accepting the terminator.

44. The system of claim 43, wherein the spinner comprises 1, 2, 3, 4, 5, 6, or more terminator channels.

45. The system of claim 42, wherein the knob is coupled to the proximal end of the threaded rod by a pin, an adhesive, a fastener, a press-fit, a weld, or any combination thereof.

46. The system of claim 42, wherein the collar is coupled to the threaded rod by a pin, an adhesive, a fastener, a press-fit, a weld, or any combination thereof.

47. The system of claim 42, wherein the lock further comprises the alignment feature, and wherein the distal portion of the handle further comprises a tensioning alignment feature that couples to the alignment feature.

48. The system of claim 42, wherein the spinner rotates freely about the threaded rod, the knob, or both.

49. The system of claim 42, wherein rotating the knob and the threaded rod in a first direction with respect with to the handle translates the spinner proximally from the handle.
50. The system of claim 49, wherein rotating the knob and the threaded rod in a second direction opposite the first direction translates the spinner distally towards the handle.
51. The system of claim 49, wherein rotating the handle in a first direction tightens the lock against the primary button.
52. A suture-button system comprising:
    (a) one or more a suture strands;
    (b) a primary button having a plurality of primary apertures, and a primary threaded portion;
    (c) a secondary button having a plurality of secondary apertures; and
    (d) a lock having a secondary threaded portion, wherein the secondary threaded portion is removably coupled to the primary threaded portion;
    wherein each primary aperture has one or more of the plurality of sutures strands inserted therethrough, wherein each secondary aperture has one or more of the plurality of sutures strands inserted therethrough, and wherein coupling the secondary threaded portion of the lock to the threaded portion prevents each of the plurality of suture strands from translating through one or more of the plurality of primary apertures.
53. The system of claim 52, wherein the plurality of primary apertures comprises 2, 3, 4, or 5 primary apertures.
54. The system of claim 52, wherein the plurality of primary apertures are equally spaced on the primary button.
55. The system of claim 54, wherein the plurality of primary apertures are equally spaced on the primary button in a circular array.
56. The system of claim 55, wherein the plurality of primary apertures are equally spaced on the primary button in a circular array about the primary threaded portion.
57. The system of claim 55, wherein the plurality of primary apertures are equally spaced on the primary button in a circular array about a center axis of the secondary button.
58. The system of claim 52, wherein a proximal surface of the primary button comprises a countersink.
59. The system of claim 52, wherein the primary threaded portion comprises a female threaded portion.
60. The system of claim 59, wherein the secondary threaded portion comprises a male threaded portion.

61. The system of claim 52, wherein the primary threaded portion comprises a male threaded portion.
62. The system of claim 61, wherein the secondary threaded portion comprises a female threaded portion.
63. The system of claim 52, wherein the plurality of secondary apertures comprises 2, 3, 4, or 5 secondary apertures.
64. The system of claim 52, wherein a distal surface of the secondary button comprises a channel connecting two or more of the plurality of secondary apertures.
65. The system of claim 52, wherein one or more edges of the secondary button are rounded or chamfered.
66. The system of claim 52, wherein an aspect ratio between the length and width of the secondary button is about 1:1 so about 4:1.
67. The system of claim 52, wherein the lock comprises a head and wherein the secondary threaded portion extends from the head.
68. The system of claim 67, wherein a distal surface of the head is tapered outwards from a center axis of the lock.
69. The system of claim 68, wherein the distal surface of the head is tapered outwards from a center of the lock by about 20° to about 89°.
70. The system of claim 52, wherein the lock comprises a driver feature, an alignment feature, or both.
71. The system of claim 70, wherein the driver feature is opposite the secondary threaded portion.
72. The system of claim 70, wherein the driver feature and the alignment feature are generally concentric.
73. The system of claim 70, wherein the driver feature is proximal to the alignment feature.
74. The system of claim 73, wherein a maximum inner diameter of the driver feature is greater than a maximum inner diameter of the alignment feature.
75. The system of claim 70, wherein the driver feature comprises a Philips driver feature, a flathead driver feature, a torx driver feature, a hex driver feature, or a square socket feature.
76. The system of claim 70, wherein the alignment feature has a cross sectional shape comprising a circle, a triangle, a square, a pentagon, a hexagon, an octagon, or any combination thereof.
77. The system of claim 70, further comprising a lock driver comprising a driving feature that is configured to rotate the lock about the primary button.

78. The system of claim 77, wherein the lock driver further comprises an aligning feature configured to align the lock driver to the alignment feature of the lock.
79. The system of claim 78, wherein the alignment feature is distal to the driving feature.
80. The system of claim 52, wherein at least a portion of the lock extends beyond a distal face of the primary button when the primary button is coupled to the lock.
81. The system of claim 52, wherein a distal face of the primary button extends beyond a distal face of the lock when the primary button is coupled to the lock.
82. The system of claim 52, wherein:
    (a) the plurality of primary apertures comprises two primary apertures;
    (b) the plurality of secondary apertures comprises two secondary apertures;
    (c) the one or more suture strands consists of one suture strand; and
    (d) the one suture strand is inserted through a first primary aperture, through a first secondary aperture, through a second secondary aperture, and through a second primary aperture.
83. The system of claim 52, wherein:
    (a) the plurality of primary apertures comprises four primary apertures;
    (b) the plurality of secondary apertures comprises two secondary apertures;
    (c) the one or more a suture strands consists of two suture strands;
    (d) a first suture strand is inserted through a first primary aperture, through a first secondary aperture, through a second secondary aperture, and through a second primary aperture; and
    (e) a second suture strand is inserted through a third primary aperture, through the first secondary aperture, through the second secondary aperture, and through a fourth primary aperture;
84. The system of claim 52, wherein:
    (a) the plurality of primary apertures comprises four primary apertures;
    (b) the plurality of secondary apertures comprises two secondary apertures;
    (c) the one or more a suture strands consists of two suture strands;
    (d) a first suture strand is inserted through a first primary aperture, through a first secondary aperture, through a second secondary aperture, and through a second primary aperture; and
    (e) a second suture strand is inserted through a third primary aperture, through the second secondary aperture, through the first secondary aperture, and through a fourth primary aperture;

85. The system of claim 83, wherein the first primary aperture and the second primary aperture are adjacent.
86. The system of claim 83, wherein the first primary aperture and the second primary aperture are nonadjacent.
87. The system of claim 52, further comprising a tightening tool comprising:
    (a) a threaded rod;
    (b) a knob coupled to a proximal end of the threaded rod;
    (c) a collar coupled to the threaded rod;
    (d) an spinner between the knob and the tensioning collar, wherein the spinner comprises an aperture accepting the threaded rod; and
    (e) a handle comprising a cavity, wherein at least a portion of the cavity comprises a threaded feature configured to couple to the threaded rod, wherein the lock comprises the driver feature, and wherein a distal portion of the handle comprises a tensioning feature configured to rotate the driving feature of the lock.
88. The system of claim 87, wherein the spinner further comprises a terminator channel accepting the terminator.
89. The system of claim 88, wherein the spinner comprises 1, 2, 3, 4, 5, 6, or more terminator channels.
90. The system of claim 87, wherein the knob is coupled to the proximal end of the threaded rod by a pin, an adhesive, a fastener, a press-fit, a weld, or any combination thereof.
91. The system of claim 87, wherein the collar is coupled to the threaded rod by a pin, an adhesive, a fastener, a press-fit, a weld, or any combination thereof.
92. The system of claim 87, wherein the lock further comprises the alignment feature, and wherein the distal portion of the handle further comprises a tensioning alignment feature that couples to the alignment feature.
93. The system of claim 87, wherein the spinner rotates freely about the threaded rod, the knob, or both.
94. The system of claim 87, wherein rotating the knob and the threaded rod in a first direction with respect with to the handle translates the spinner proximally from the handle.
95. The system of claim 94, wherein rotating the knob and the threaded rod in a second direction opposite the first direction translates the spinner distally towards the handle.
96. The system of claim 94, wherein rotating the handle in a first direction tightens the lock against the primary button.

97. The system of claim 52, wherein the suture is a #1 size suture, a #2 size suture, a #3 size suture, a #4 size suture, a #5 size suture, a #6 size suture, or a #7 size suture.
98. The system of claim 52, wherein the suture has a length of about 100 mm to about 1,200 mm.
99. The system of claim 52, comprising 2, 3, 4, 5, 6 or more suture strands.
100. The system of claim 52, comprising a first suture strand and a second suture strand, wherein at least a portion of the first suture strand passes within at least a portion of the second suture strand to form a suture bundle 170.
101. The system of claim 100, wherein the portion of the first suture strand that passes within the second suture strand is a mesial portion of the first suture.
102. The system of claim 100, wherein the portion of the second suture strand through which the first suture strand passes is a mesial portion of the second suture.
103. A suture-button assembly comprising:
    (a) two or more systems of claims 1 or 52; and
    (b) an insertion plate comprising a plurality of insertion plate apertures, each insertion plate aperture accepting at least one suture strand.
104. The assembly of claim 103, wherein the plurality of insertion plate apertures comprises 2, 3, 4, 5, 6, or more insertion plate apertures.
105. The assembly of claim 103, further comprising an insertion screw, wherein the insertion plate further comprises a screw hole; configured to removable couple to the insertion screw.
106. The assembly of claim 105, wherein the screw hole is positioned between two of the plurality of insertion plate apertures.
107. The assembly of claim 105, wherein the insertion screw comprises a first portion configured to removably couple to the screw hole and a second portion configured to attach to a bone of a patient.
108. A method of securing one or more sutures, the method comprising:
    (a) providing the suture-button system of claim 1 or 52, wherein:
        (i) the plurality of primary apertures comprises a first primary aperture and a second primary aperture;
        (ii) the plurality of secondary apertures comprises a first secondary aperture and a second secondary aperture; and
        (iii) the one or more a suture strands consists of one suture strand;
    (b) inserting the one suture strand through the first primary aperture;
    (c) inserting the one suture strand through the first secondary aperture;

(d) inserting the one suture strand through the second secondary aperture; and

(e) inserting the one suture strand through the second primary aperture.

109. The method of claim 108, further comprising inserting the secondary button through a hole in a bone or tissue.

110. The method of claim 109, further comprising rotating the secondary button after its insertion through the hole in the bone or tissue such that a proximal face of the secondary button lies against the bone or tissue.

111. The method of claim 108, further comprising coupling the secondary threaded portion of the lock with the primary threaded portion of the primary button to prevent the suture strand from translating through the first primary aperture and the second primary aperture.

112. The method of claim 111, further comprising providing the tightening tool of claim 87.

113. The method of claim 112, wherein the secondary threaded portion and the primary threaded portion are coupled by the tightening tool.

114. The method of claim 112, further comprising tightening the suture strand with respect to the primary button, the secondary button, or both, with the tightening tool.

115. A method of securing one or more sutures, the method comprising:

(a) providing the suture-button system of claim 1 or 52, wherein:

(i) the plurality of primary apertures comprises a first primary aperture, a second primary aperture, a third primary aperture, and a fourth primary aperture;

(ii) the plurality of secondary apertures comprises a first secondary aperture and a second secondary aperture; and

(iii) the one or more a suture strands consists of a first suture strand and a second suture strand;

(b) inserting the first suture strand through the first primary aperture;

(c) inserting the first suture strand through the first secondary aperture;

(d) inserting the first suture strand through the second secondary aperture;

(e) inserting the first suture strand through the second primary aperture;

(f) inserting the second suture strand through the third primary aperture;

(g) inserting the second suture strand through the first secondary aperture;

(h) inserting the second suture strand through the second secondary aperture; and

(i) inserting the second suture strand through the fourth primary aperture.

116. The method of claim 115, further comprising inserting the secondary button through a hole in a bone or tissue.

117. The method of claim 116, further comprising rotating the secondary button after its insertion through the hole in the bone or tissue such that a proximal face of the secondary button lies against the bone or tissue.
118. The method of claim 117, further comprising coupling the secondary threaded portion of the lock with the primary threaded portion of the primary button to prevent the first suture strand and the second suture strand from translating through the plurality of primary apertures.
119. The method of claim 118, further comprising providing the tightening tool of claim 87.
120. The method of claim 119, wherein the secondary threaded portion and the primary threaded portion are coupled by the tightening tool.
121. The method of claim 119, further comprising tightening the first suture strand and the second suture strand with respect to the primary button, the secondary button, or both, with the tightening tool.
122. A method of securing one or more sutures, the method comprising:
    (a) providing the suture-button system of claim 1 or 52, wherein:
        (i) the plurality of primary apertures comprises a first primary aperture, a second primary aperture, a third primary aperture, and a fourth primary aperture;
        (ii) the plurality of secondary apertures comprises a first secondary aperture and a second secondary aperture; and
        (iii) the one or more a suture strands consists of a first suture strand and a second suture strand;
    (b) inserting the first suture strand through the first primary aperture;
    (c) inserting the first suture strand through the first secondary aperture;
    (d) inserting the first suture strand through the second secondary aperture;
    (e) inserting the first suture strand through the second primary aperture;
    (f) inserting the second suture strand through the third primary aperture;
    (g) inserting the second suture strand through the second secondary aperture;
    (h) inserting the second suture strand through the first secondary aperture; and
    (i) inserting the second suture strand through the fourth primary aperture.
123. The method of claim 122, further comprising inserting the secondary button through a hole in a bone or tissue.

124. The method of claim 123, further comprising rotating the secondary button after its insertion through the hole in the bone or tissue such that a proximal face of the secondary button lies against the bone or tissue.
125. The method of claim 124, further comprising coupling the secondary threaded portion of the lock with the primary threaded portion of the primary button to prevent the first suture strand and the second suture strand from translating through the plurality of primary apertures.
126. The method of claim 125, further comprising providing the tightening tool of claim 87-96.
127. The method of claim 126, wherein the secondary threaded portion and the primary threaded portion are coupled by the tightening tool.
128. The method of claim 126, further comprising tightening the first suture strand and the second suture strand with respect to the primary button, the secondary button, or both, with the tightening tool.

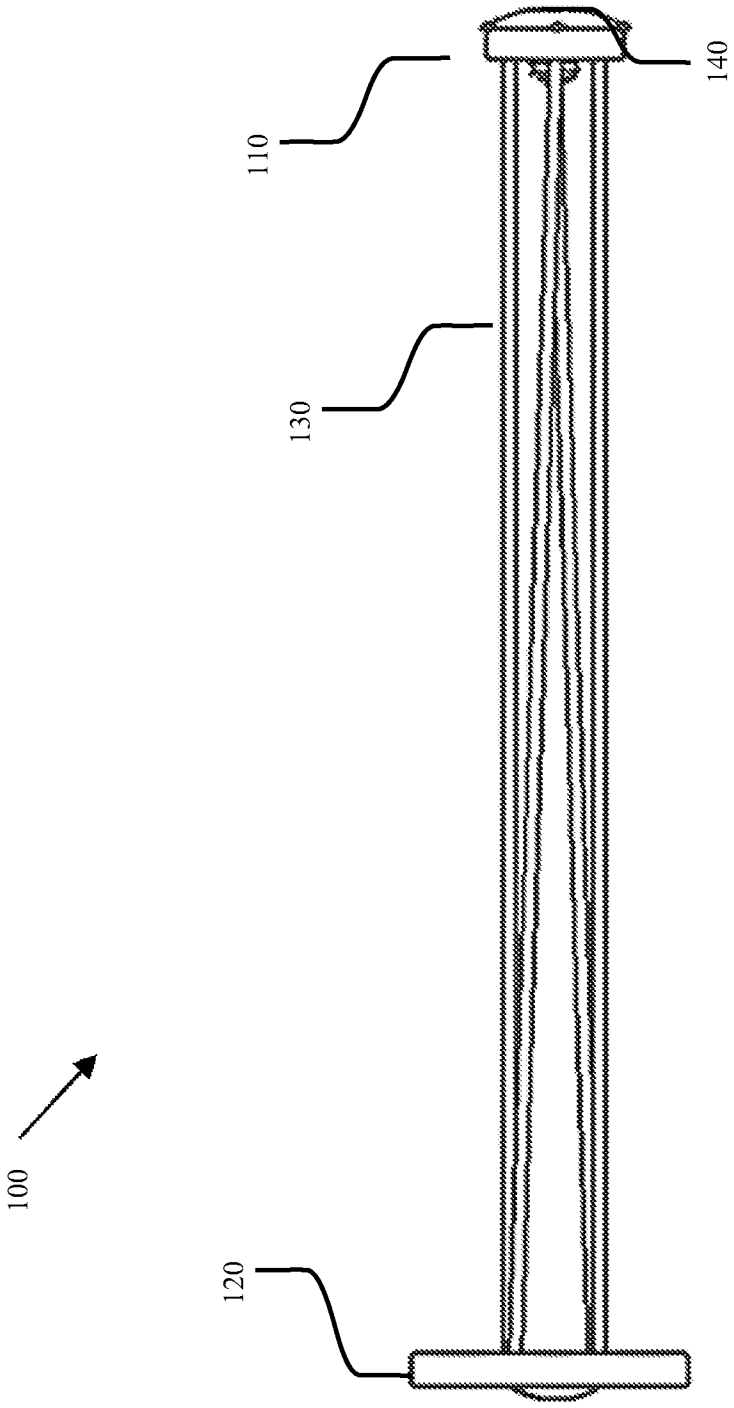

FIG. 1

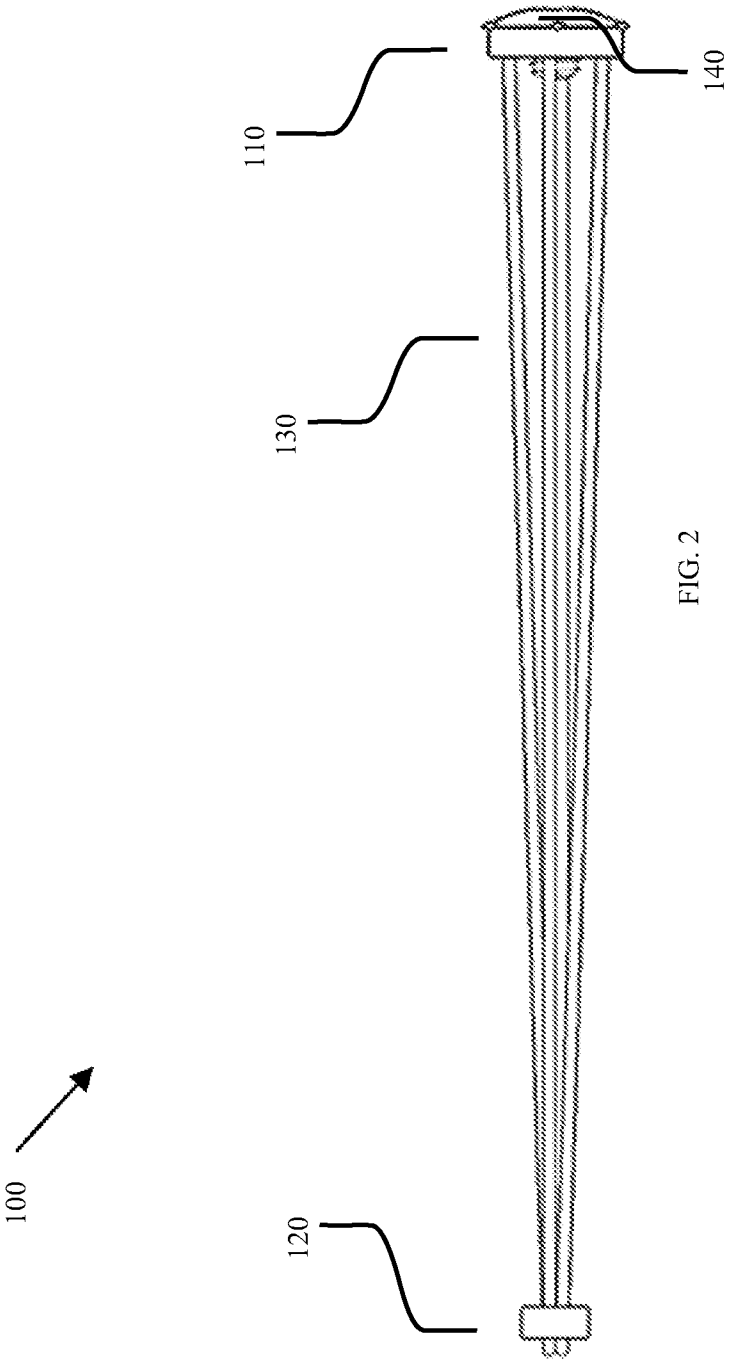

FIG. 2

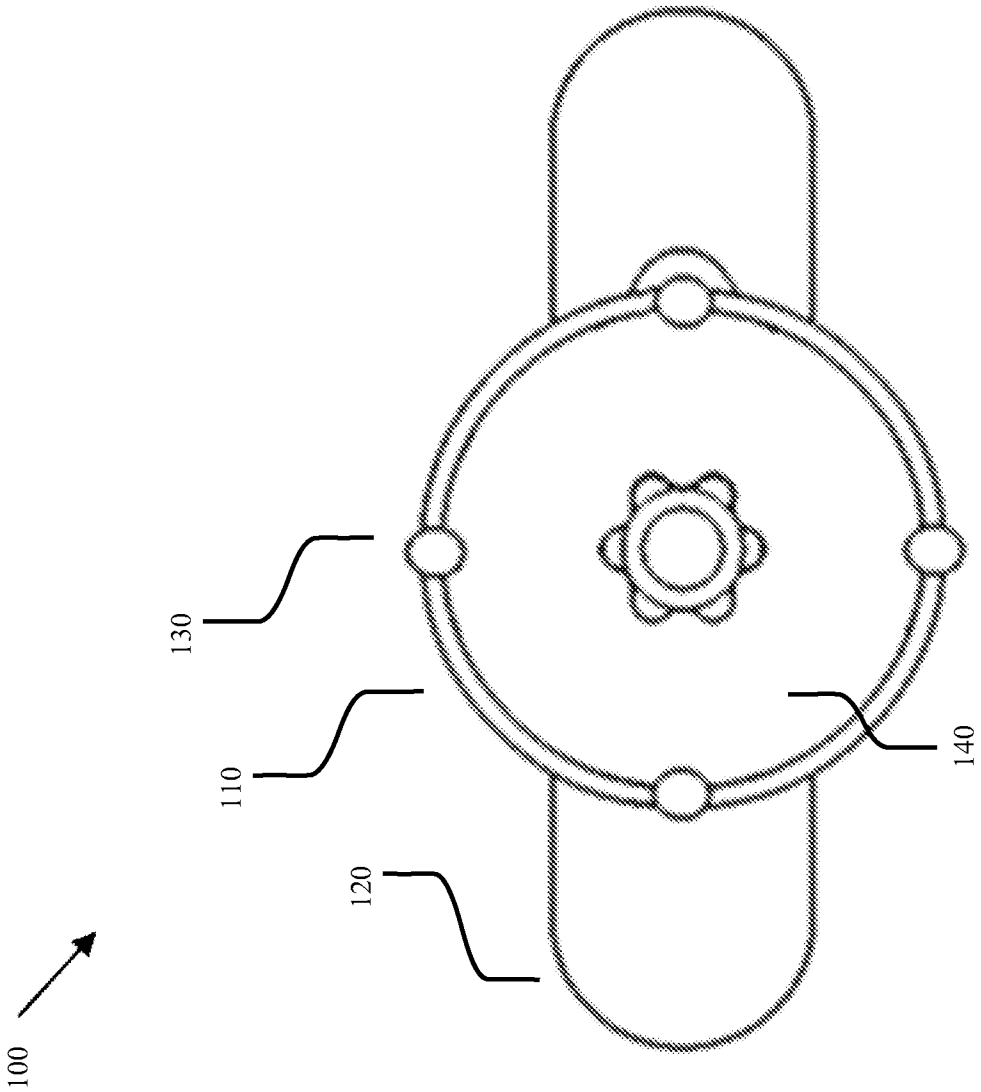

FIG. 3

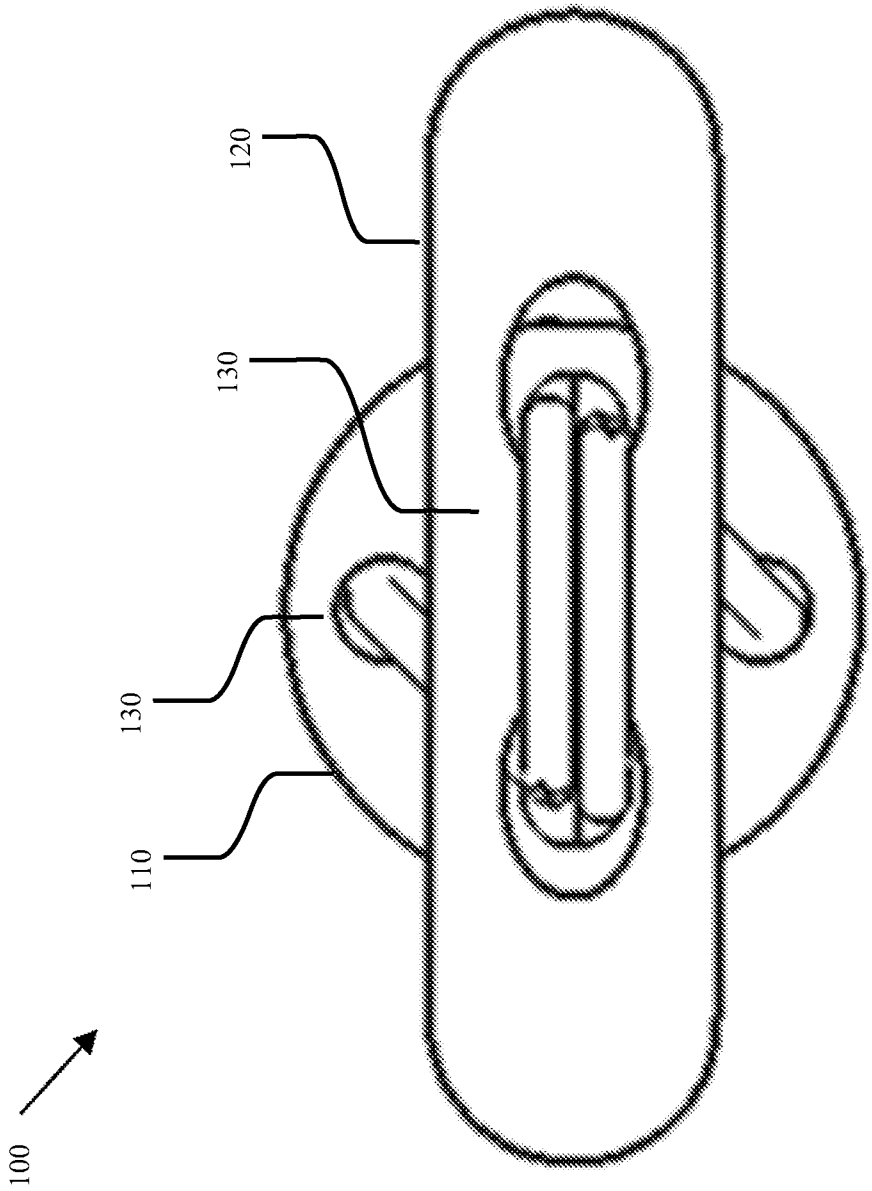

FIG. 4

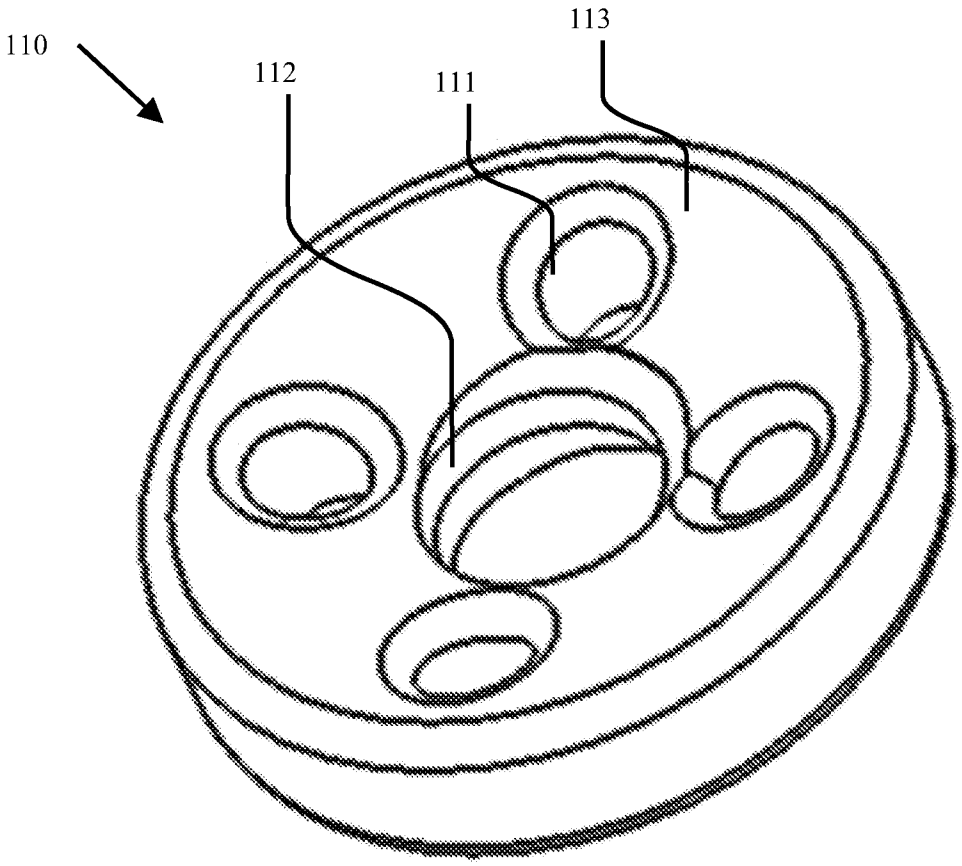

FIG. 5

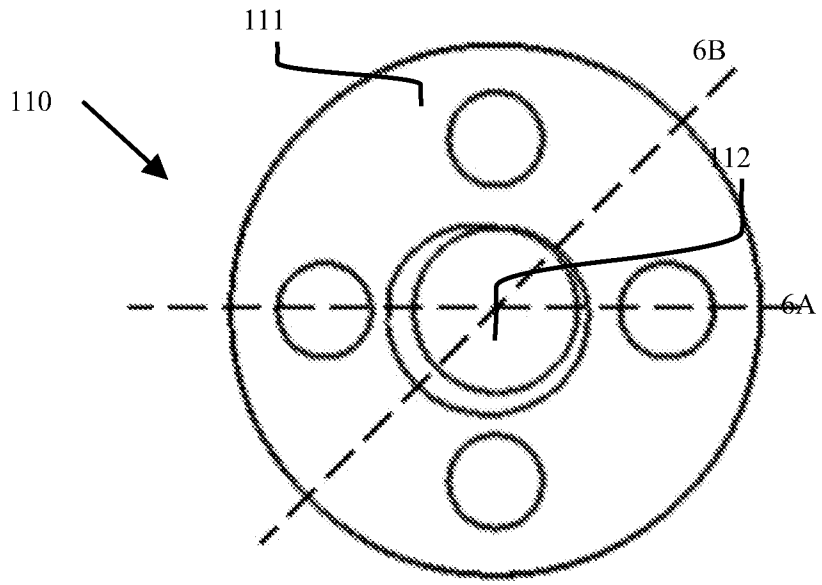

FIG. 6A

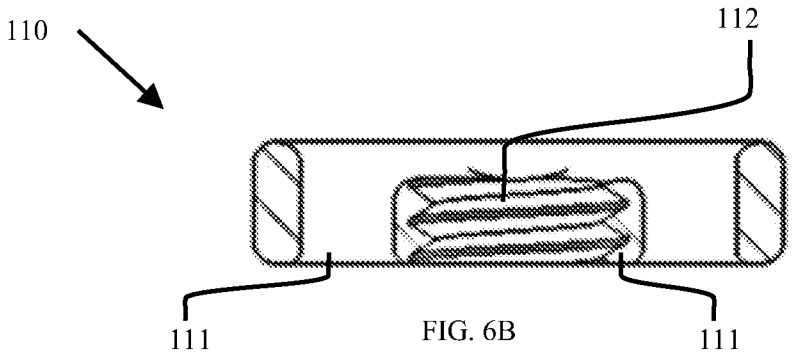

FIG. 6B

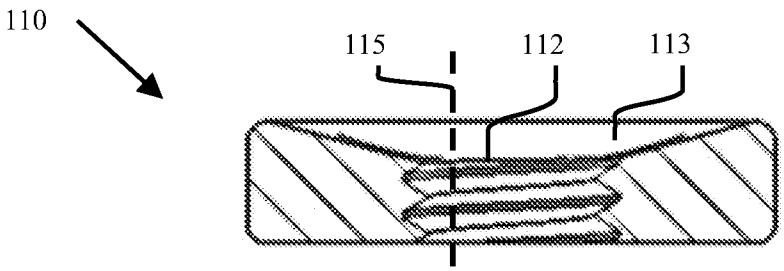

FIG. 6C

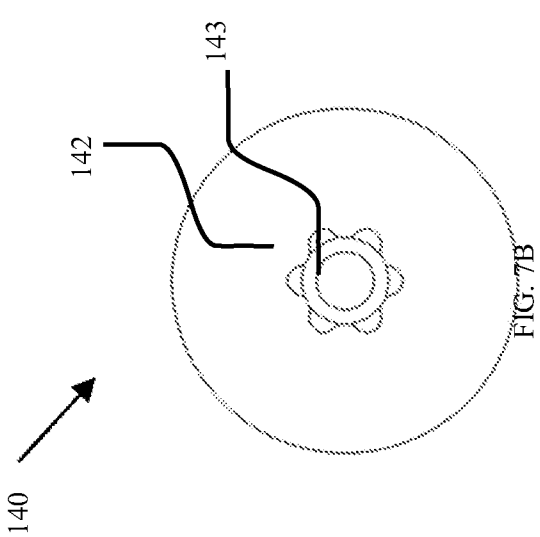

FIG. 7A

FIG. 7B

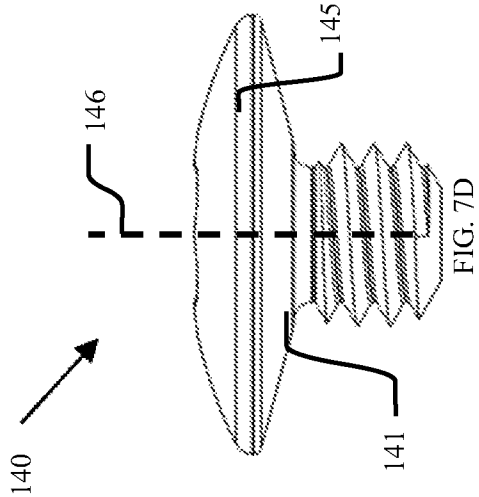

FIG. 7D

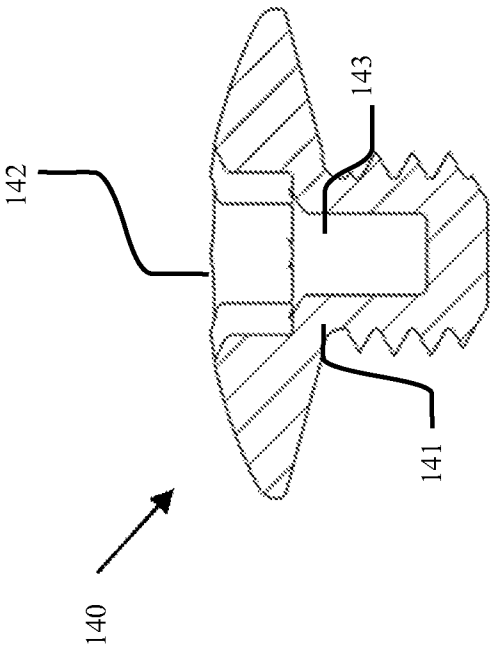

FIG. 7C

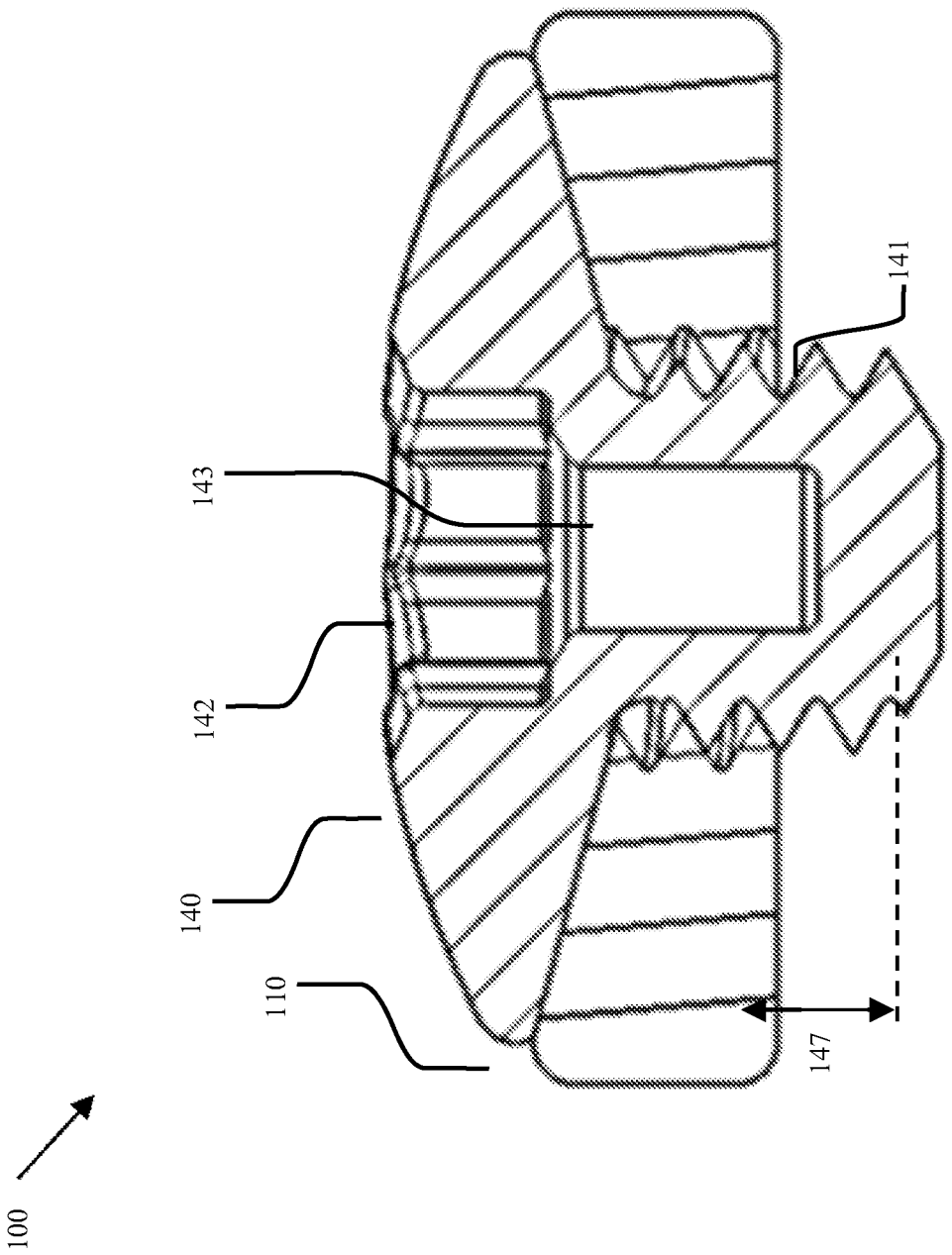

FIG. 8

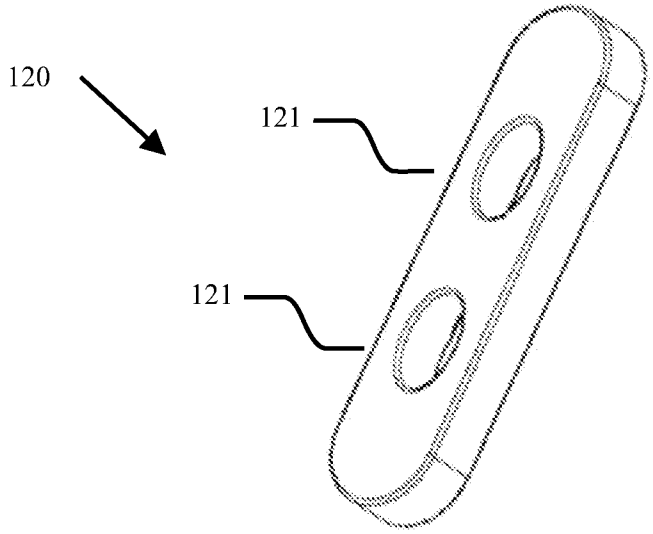

FIG. 9A

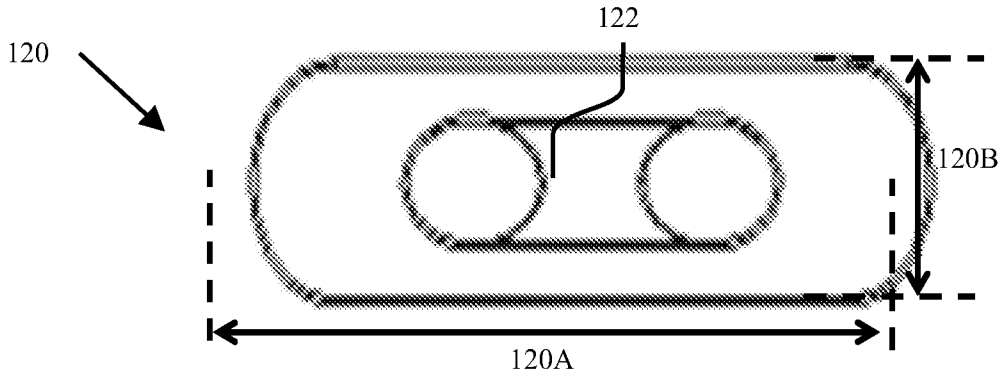

FIG. 9B

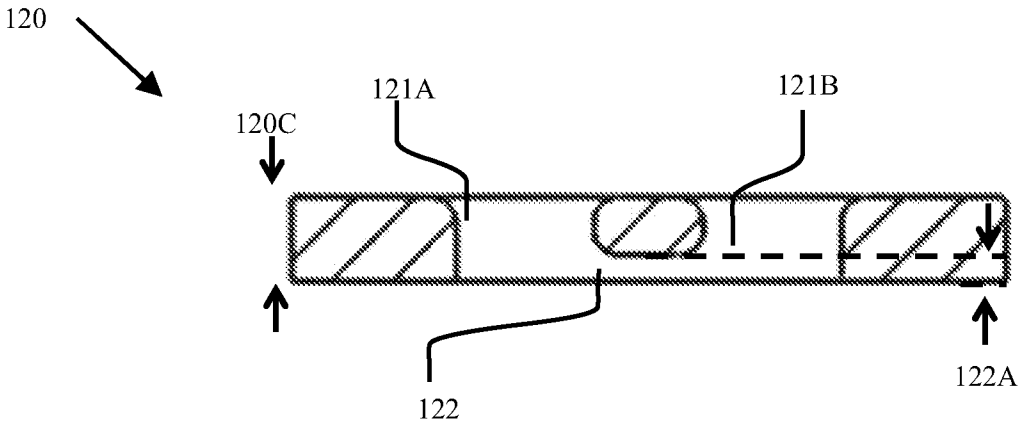

FIG. 9C

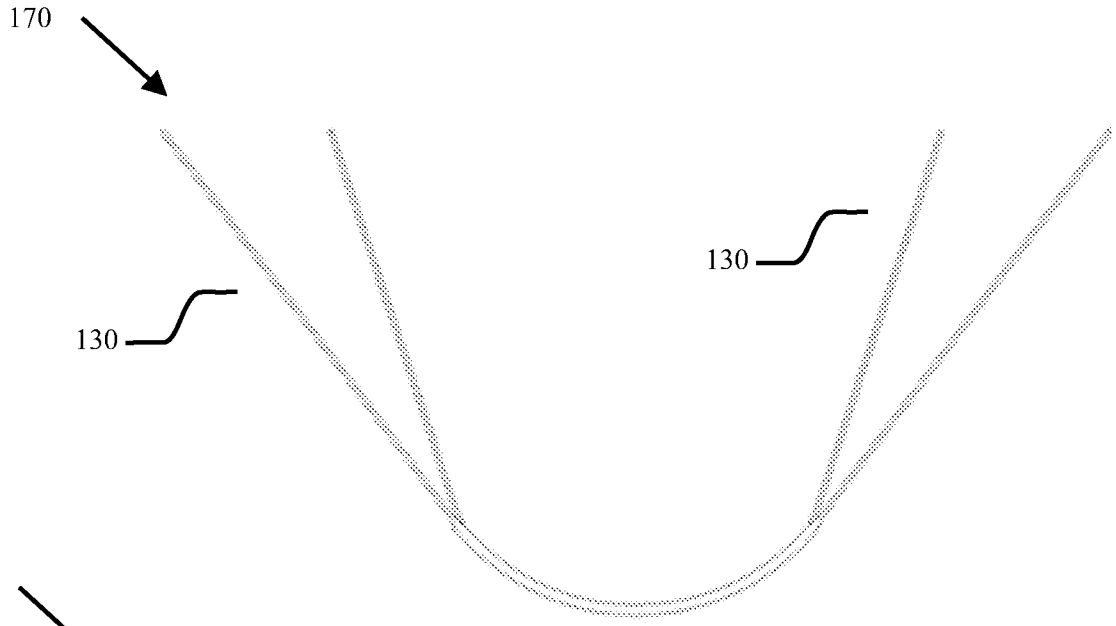

FIG. 10A

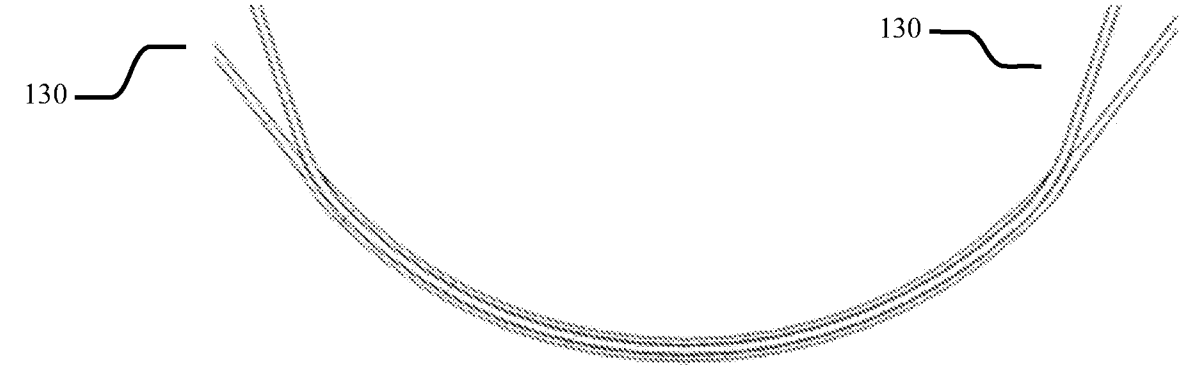

FIG. 10B

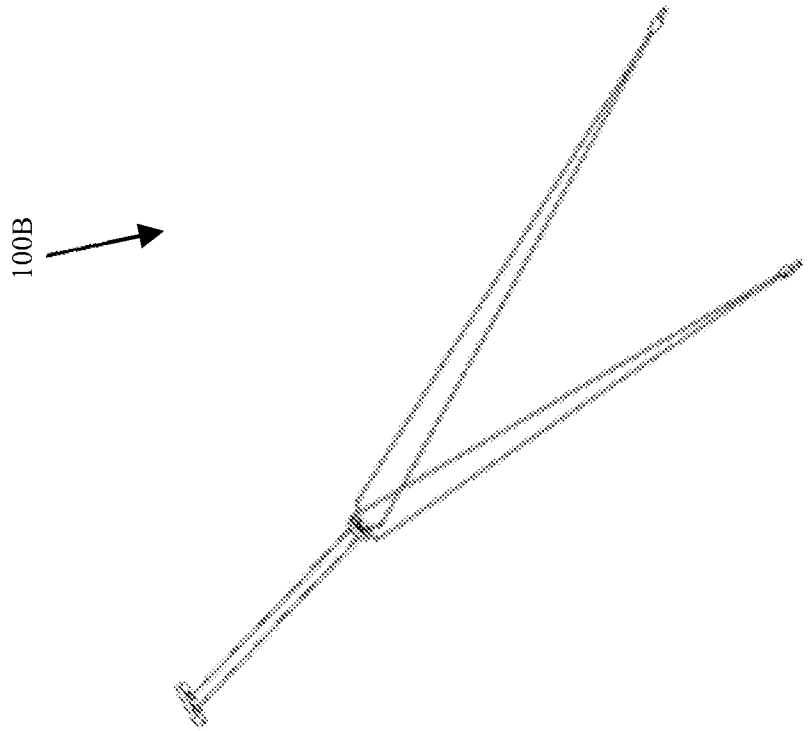

FIG. 11B

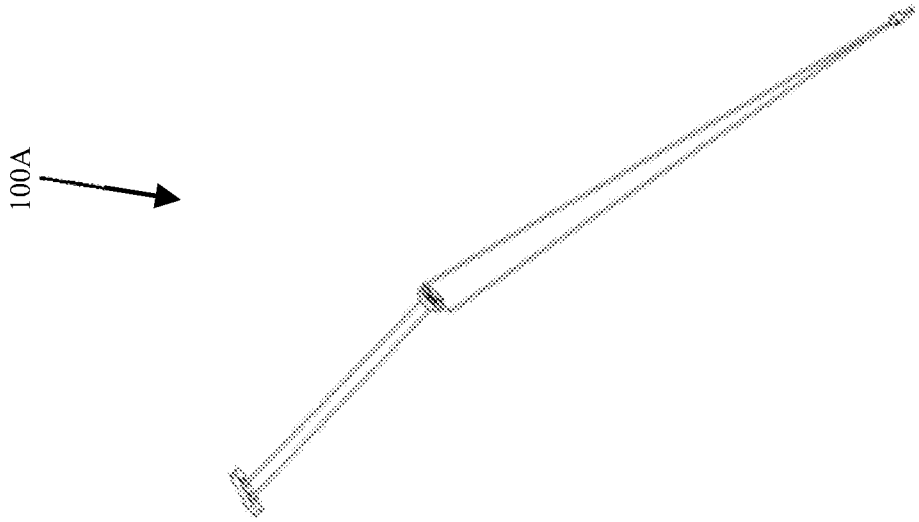

FIG. 11A

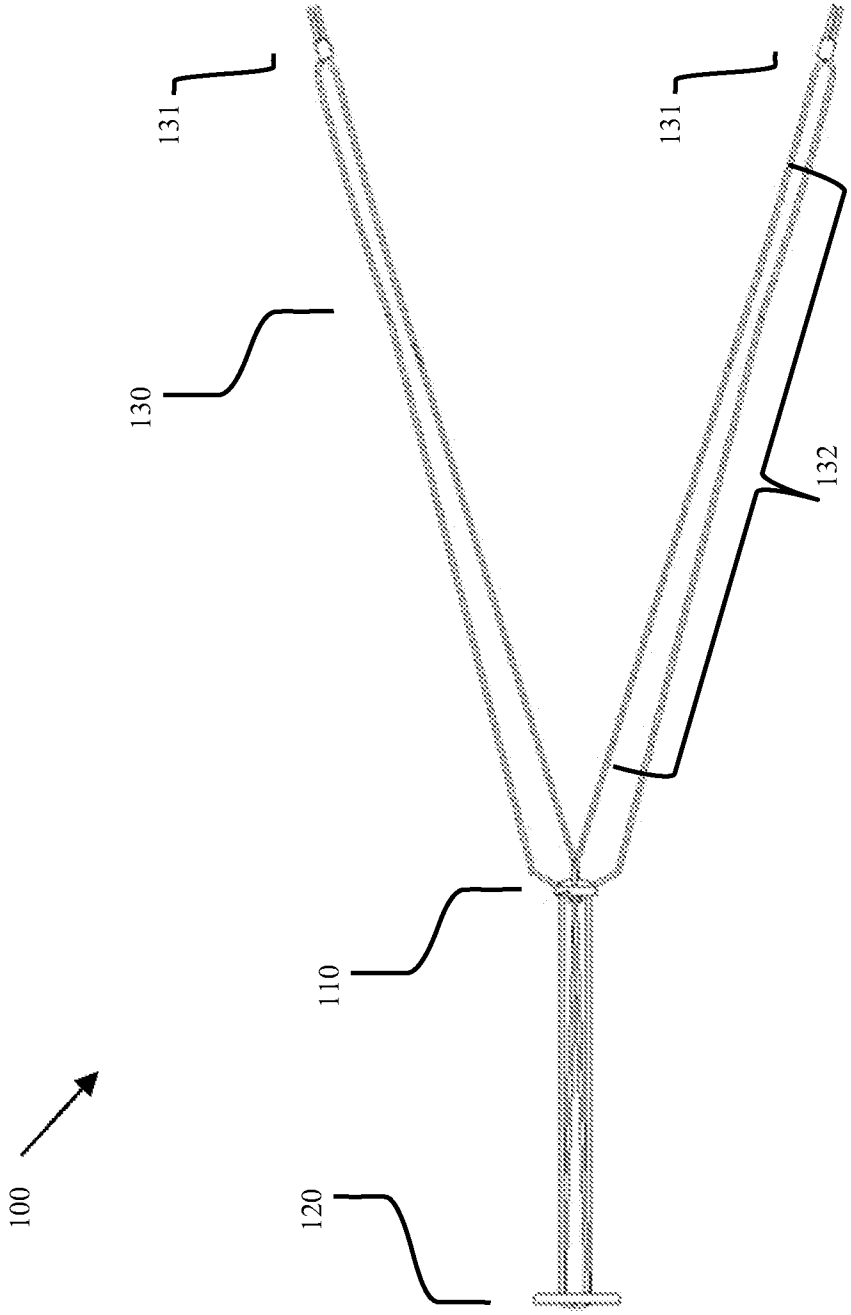

FIG. 12

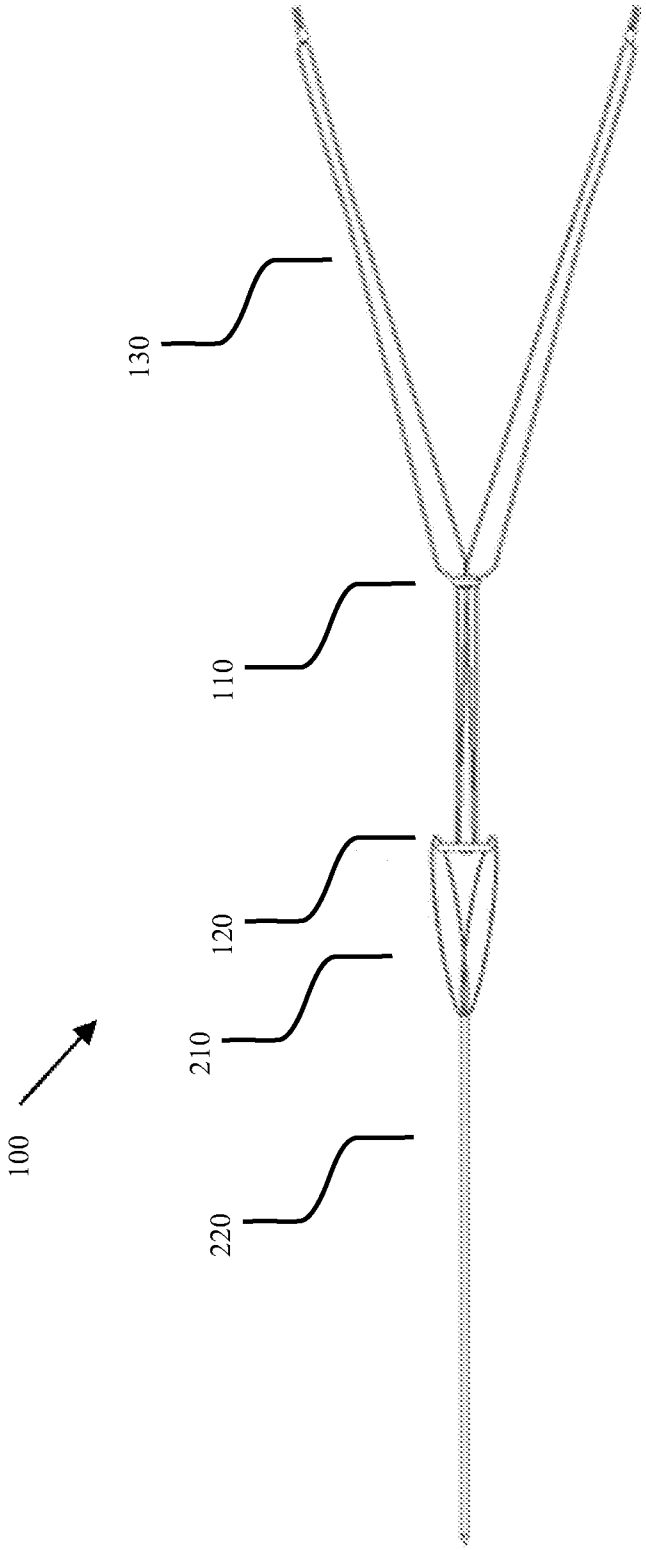

FIG. 13

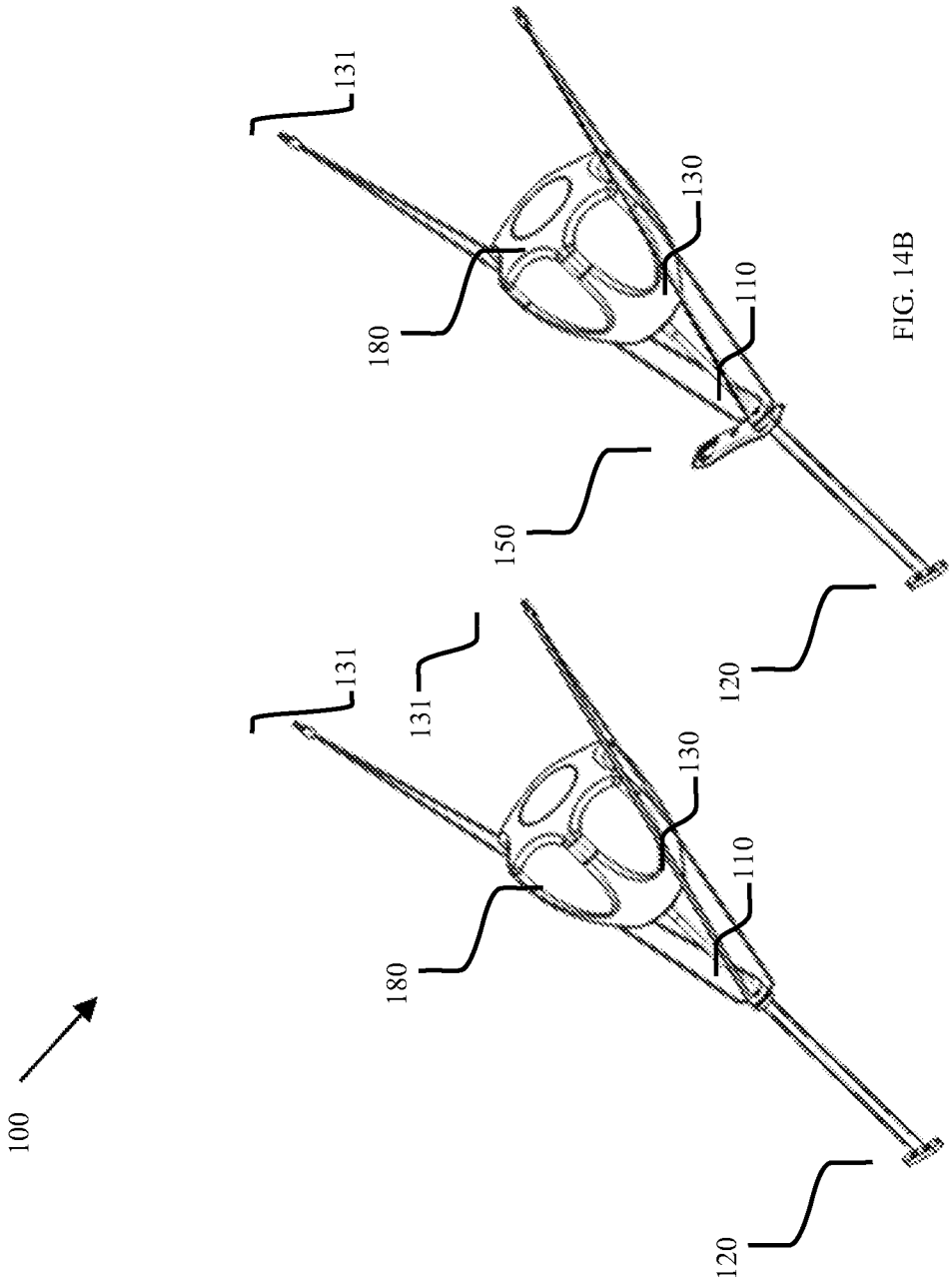

FIG. 14A

FIG. 14B

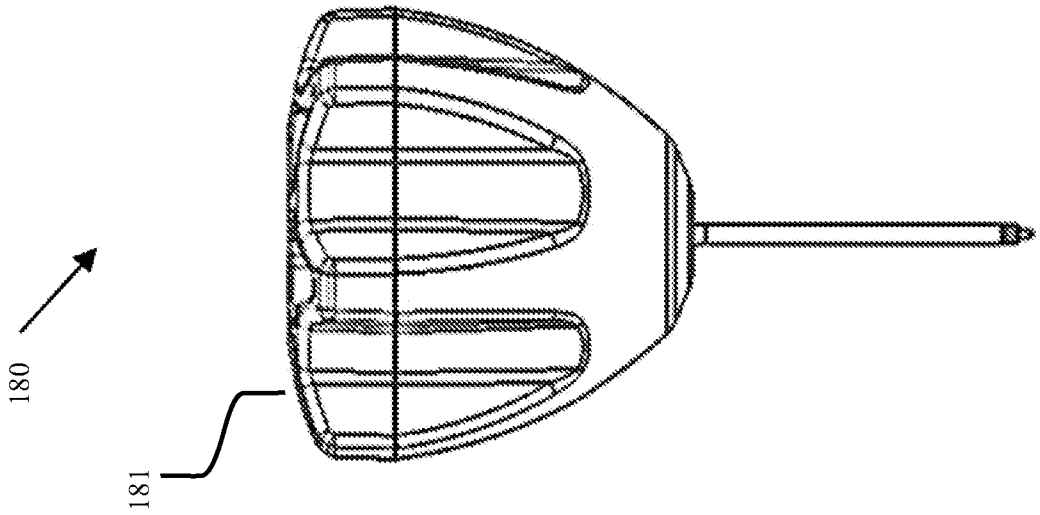

FIG. 15B

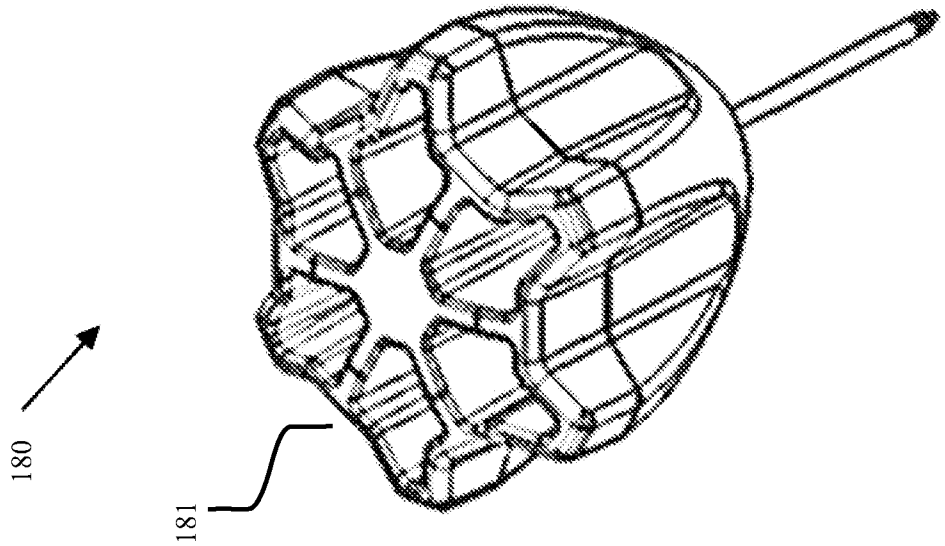

FIG. 15A

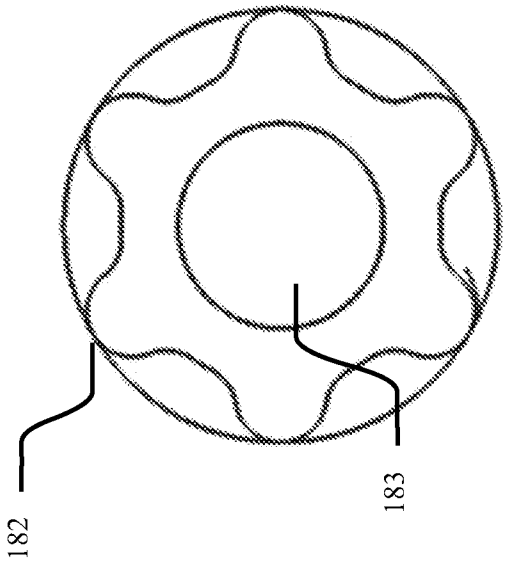

FIG. 16B

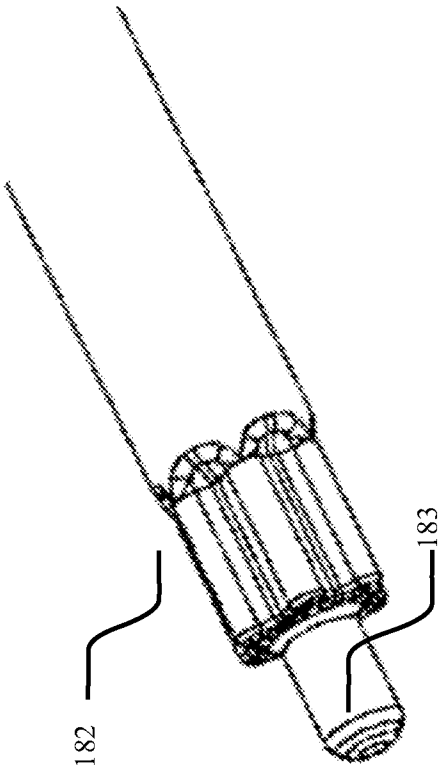

FIG. 16A

16C 16D

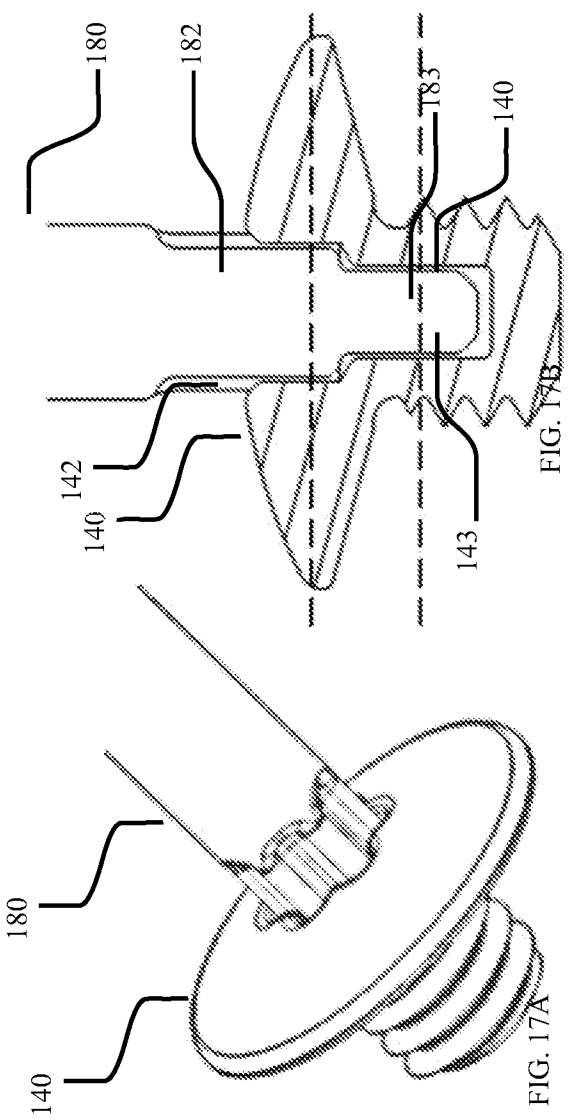

FIG. 17A

FIG. 17B

FIG. 17C

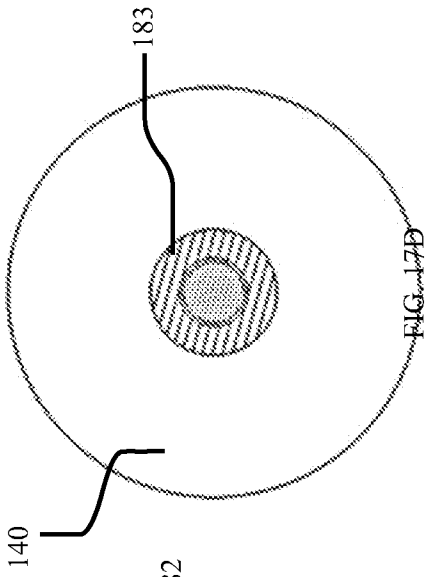

FIG. 17D

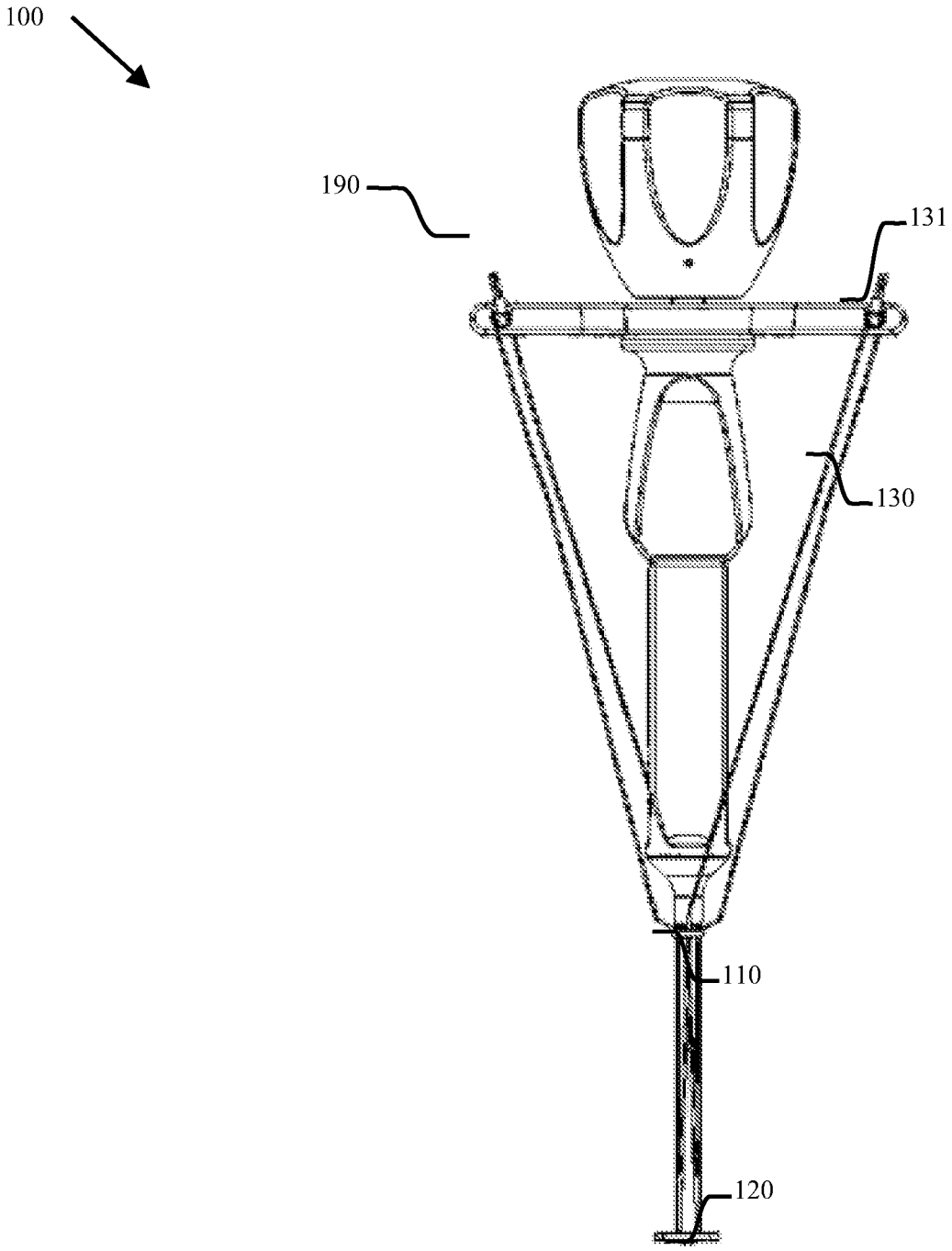

FIG. 18

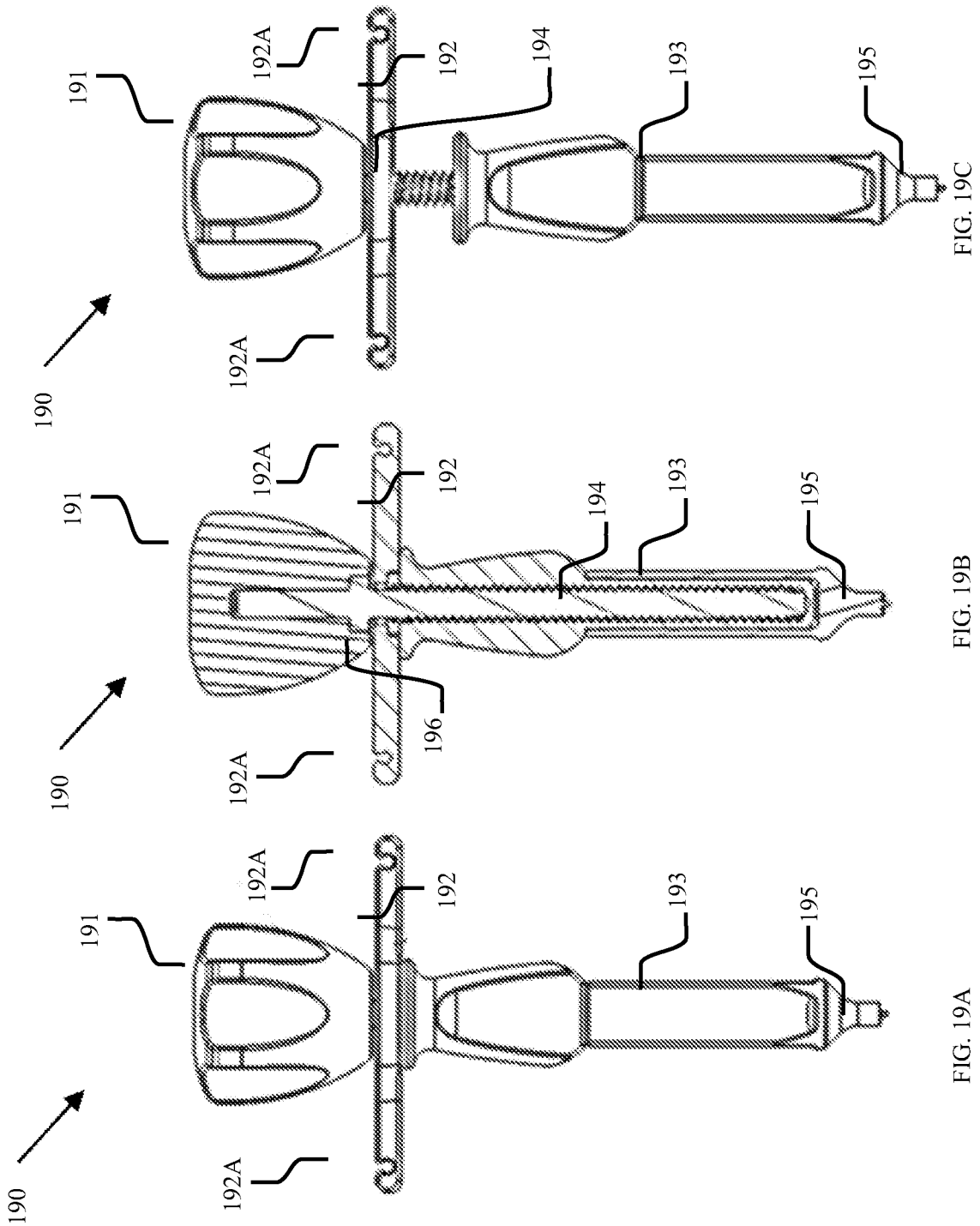

FIG. 19A

FIG. 19B

FIG. 19C

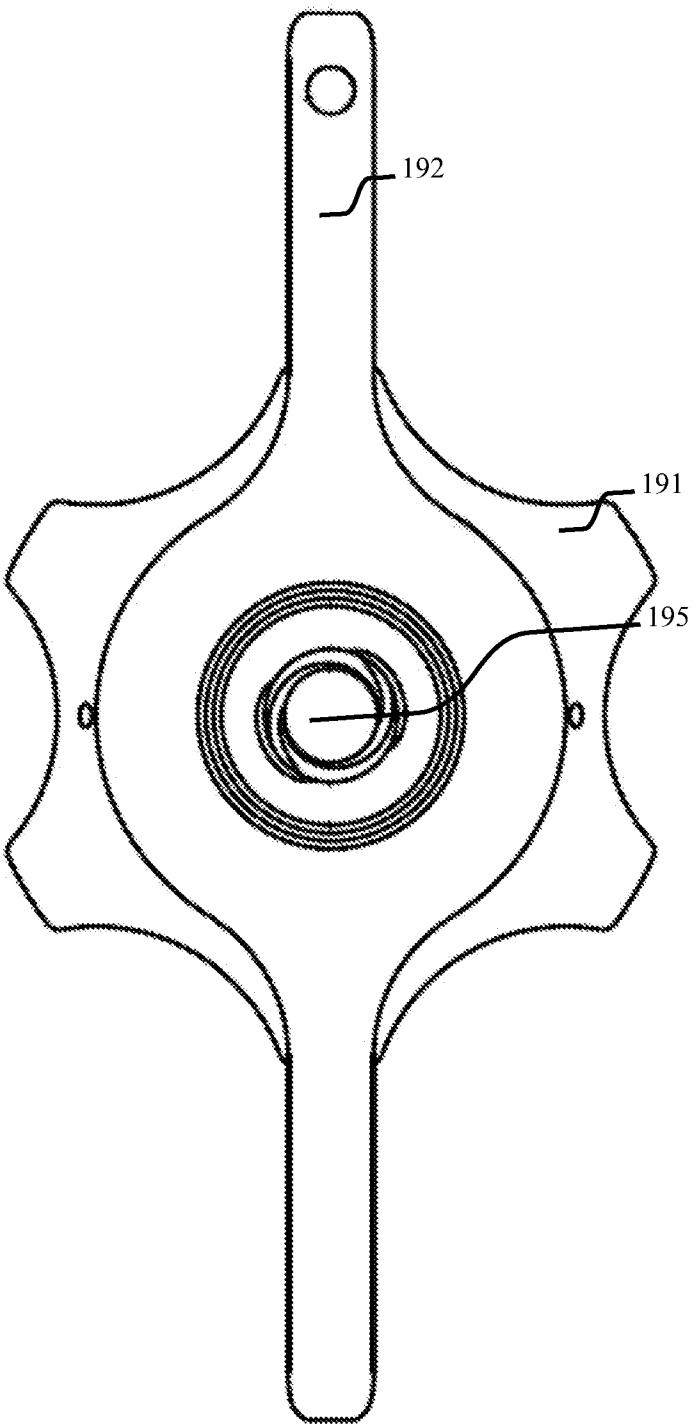

FIG. 20

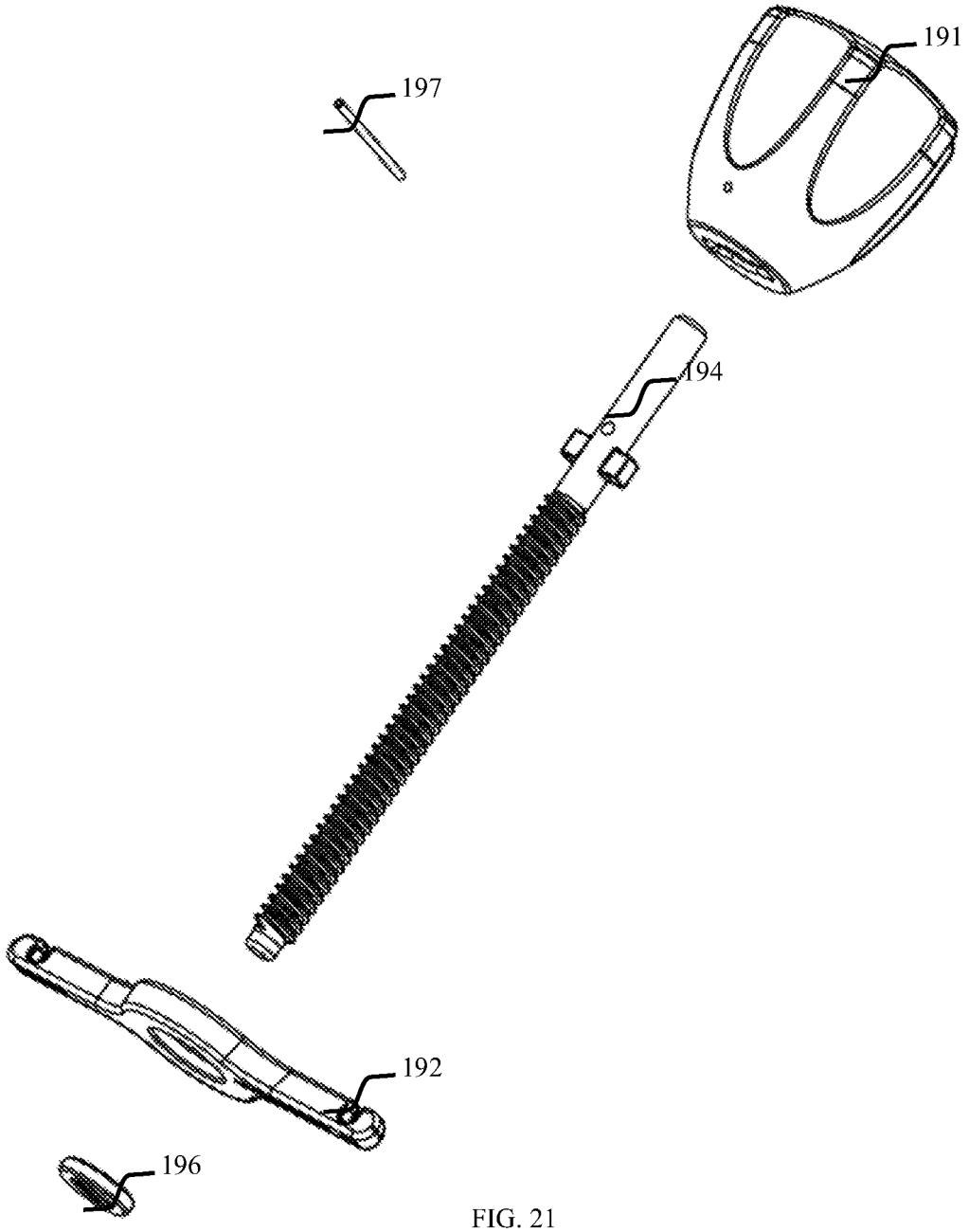

FIG. 21

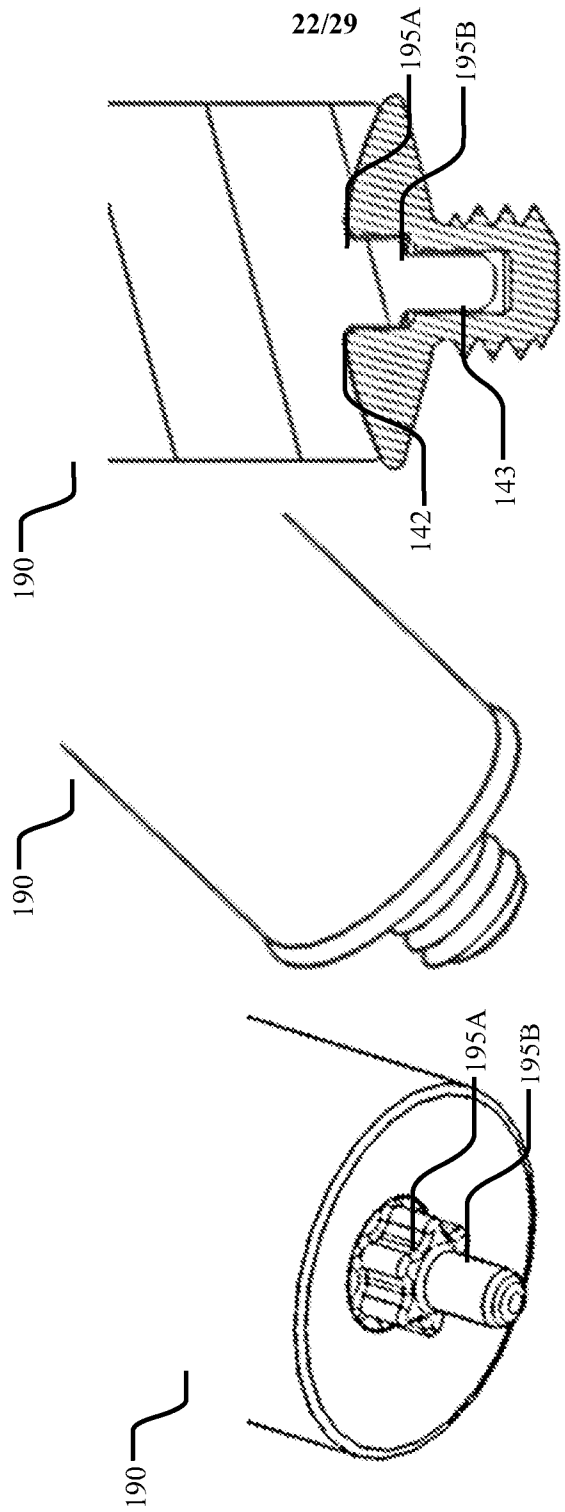

FIG. 22C

FIG. 22B

FIG. 22A

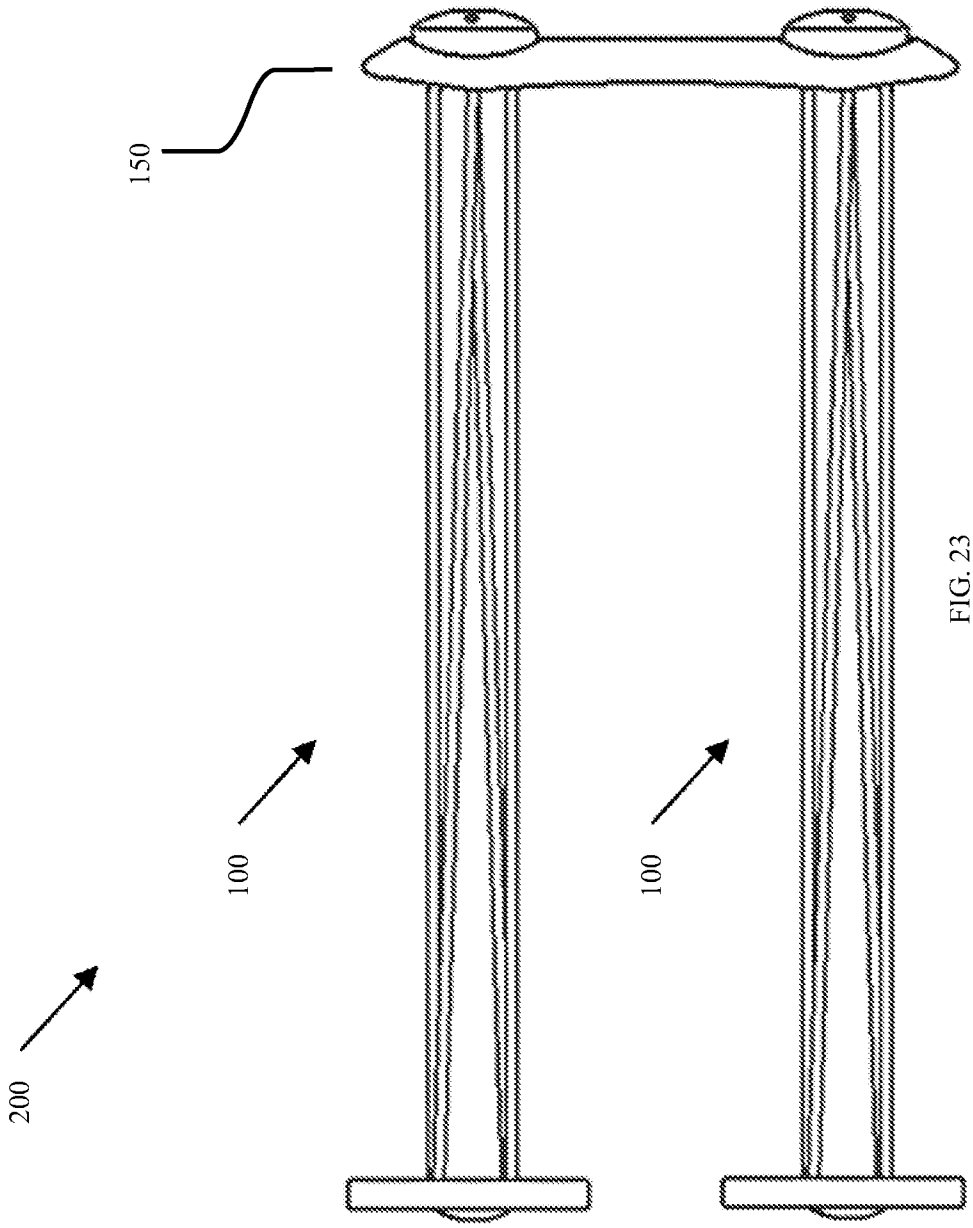

FIG. 23

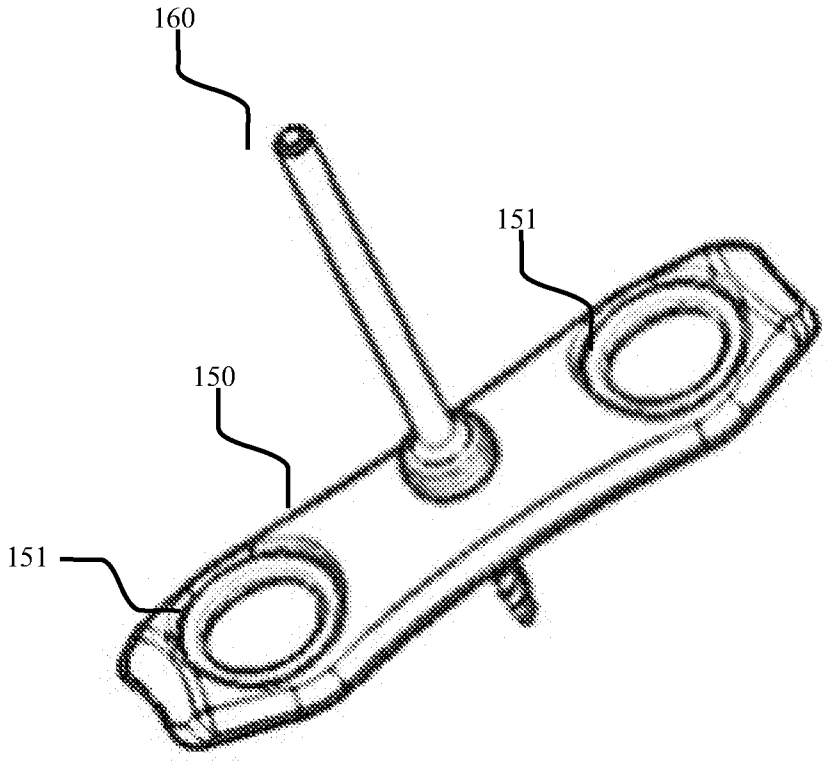

FIG. 24

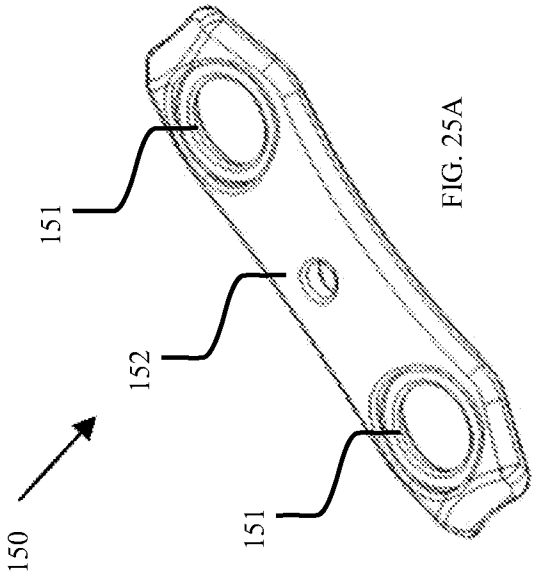

FIG. 25A

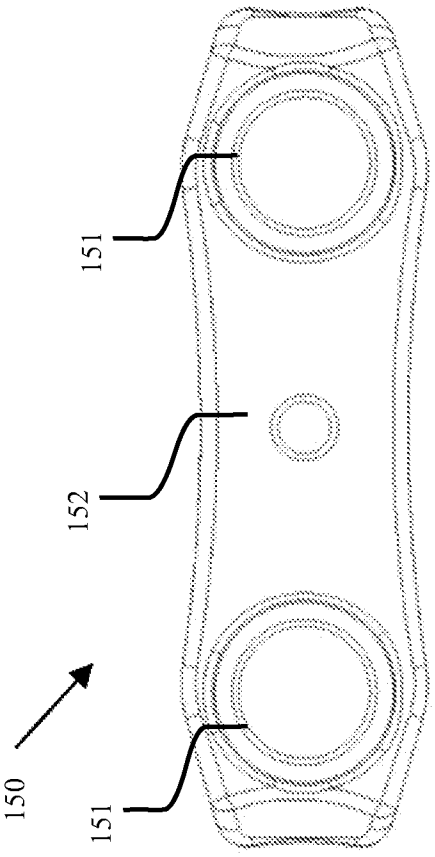

FIG. 25C

FIG. 25B

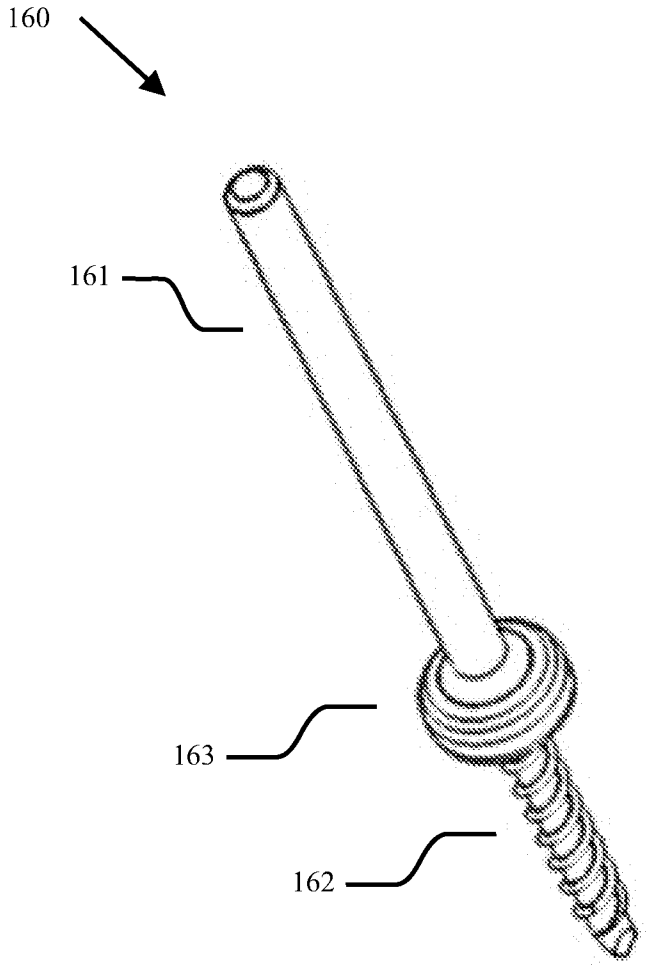

FIG. 26A

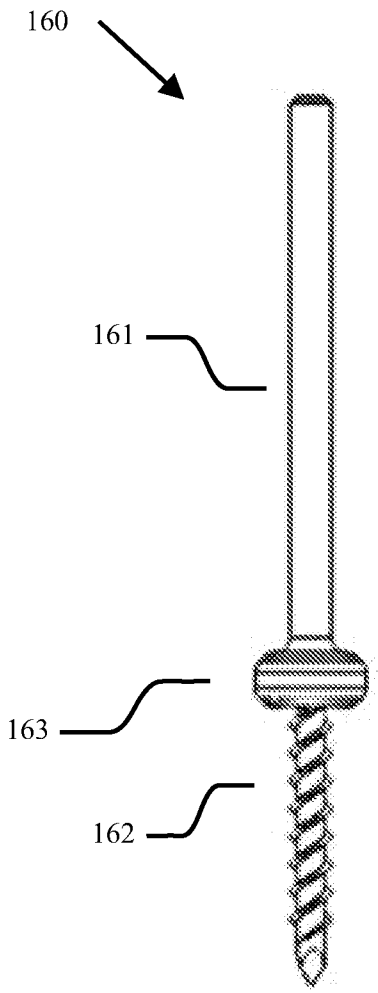

FIG. 26B

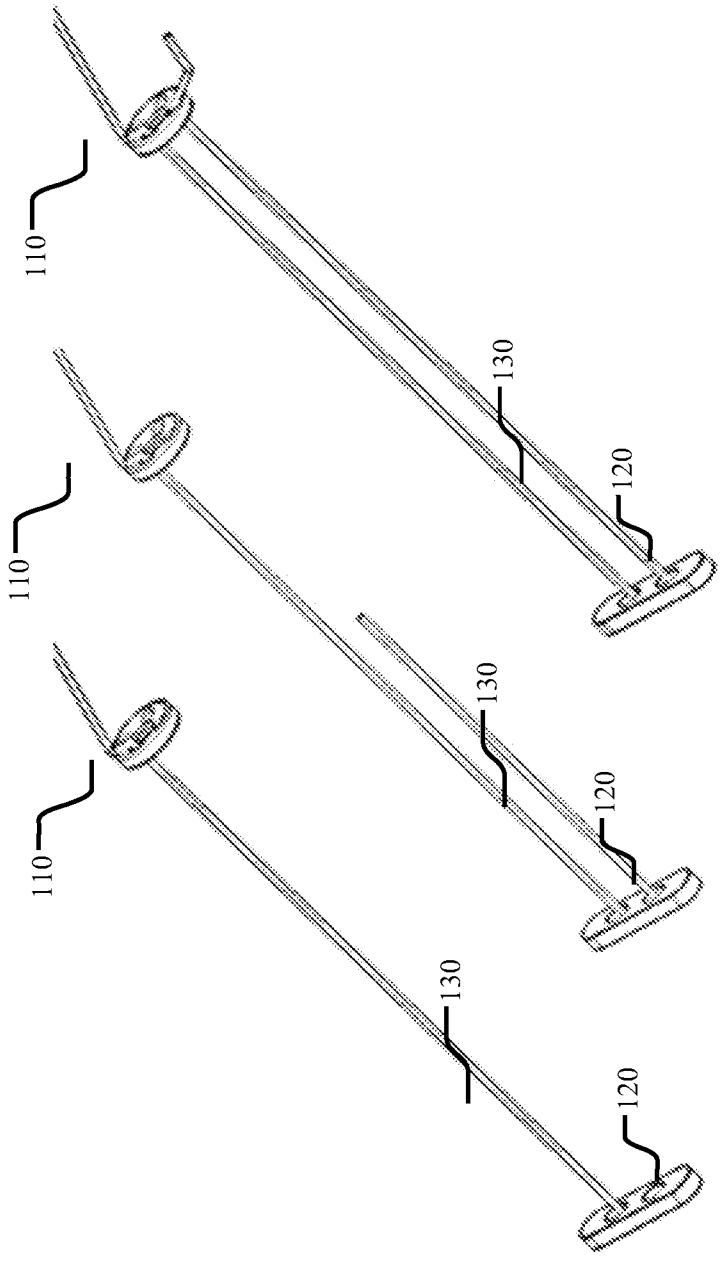

FIG. 27C

FIG. 27B

FIG. 27A

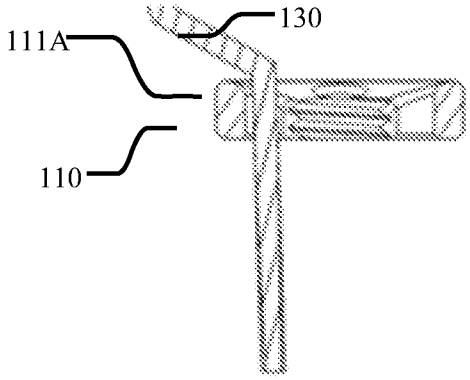

FIG. 28A

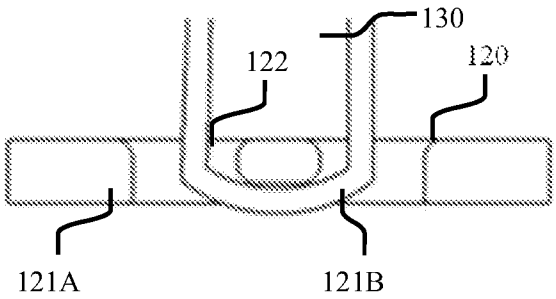

FIG. 28B

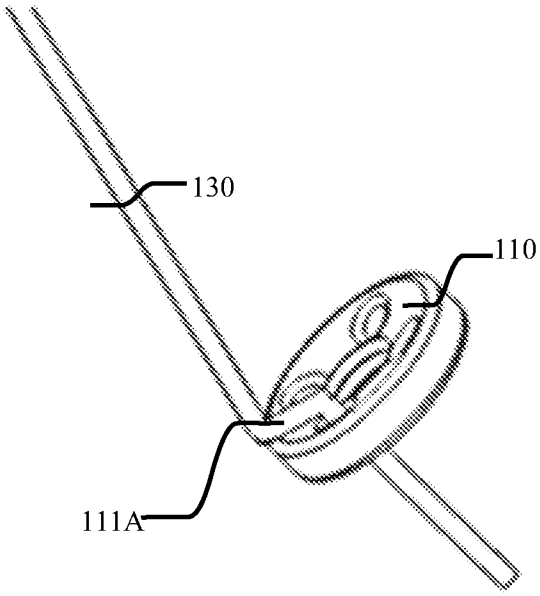

FIG. 28C

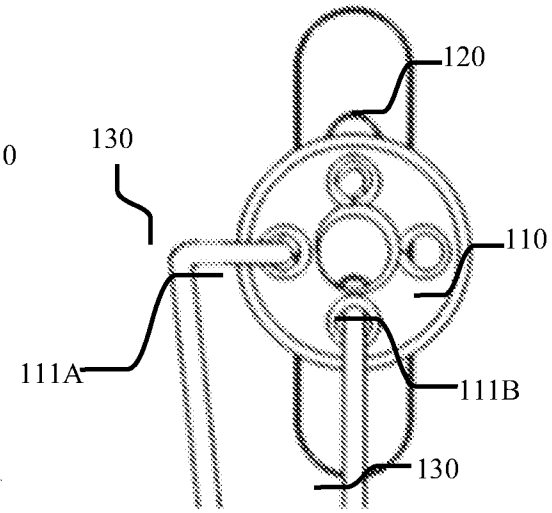

FIG. 28D

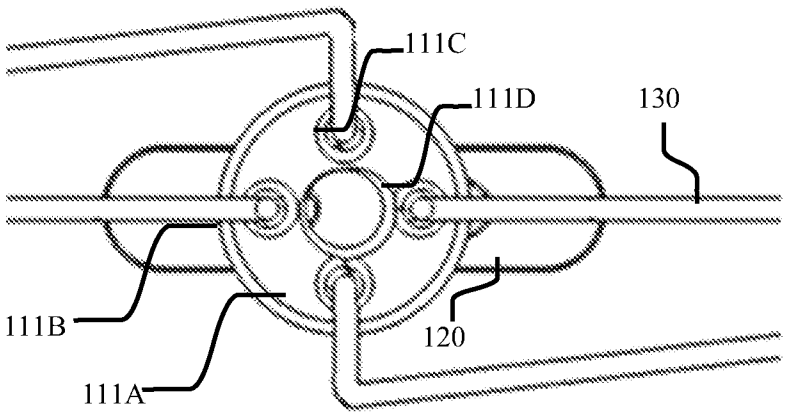

FIG. 29A

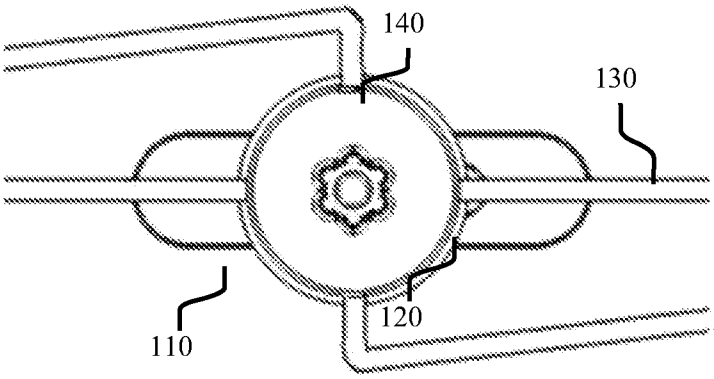

FIG. 29B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 21/23101

A. CLASSIFICATION OF SUBJECT MATTER
IPC - A61B 17/04 (2021.01)
CPC - A61B 17/0401, A61B 2017/0404

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)
See Search History document

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X – Y – A	US 2016/0089131 A1 (DALLEN MEDICAL, INC) 31 March 2016 (31.03.2016) Entire document.	1-6, 8-12, 16-18, 20-21, 25, 28-30, 35, 52-57, 59-63, 67-70, 73-75, 80, 82, 98, 99, 108-111 --- 7, 13, 22-24, 58, 64, 100-102 --- 38-51, 83-96, 103-107, 115-118, 122-125
X – Y – A	US 2014/0257294 A1 (GEDET et al.) 11 September 2014 (11.09.2014) Entire document.	1-4, 6, 8-9, 14-15, 19, 25-28, 30-32, 36-37, 52, 65-66, 70-73, 76-77, 81, 97 --- 7, 33-34, 58, 78-79 --- 38-51, 83-96, 103-107, 115-118, 122-125

☒ Further documents are listed in the continuation of Box C. ☐ 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
"D" document cited by the applicant in the international application
"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
27 May 2021 (27.05.2021)	JUN 24 2021
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Authorized officer Lee Young Telephone No. PCT Helpdesk: 571-272-4300

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 21/23101

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

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

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

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.: 112-114, 119-121, 126-128
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 additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 21/23101

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2006/0282119 A1 (PERCHIK) 14 December 2006 (14.12.2006) Entire document.	13, 64
Y -- A	US 2016/0030035 A1 (ARTHREX, INC) 04 February 2016 (04.02.2016) Entire document.	22-24, 100-102 --- 38-51, 83-96, 103-107, 115-118, 122-125
Y	US 2019/0380747 A1 (AESCULAP AG) 19 December 2019 (19.12.2019) Entire document.	33-34, 78-79
A	US 10,076,377 B2 (P TECH LLC) 18 September 2018 (18.09.2018) Entire document.	1-111, 115-118, 122-125