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Mast et al.

(54) SPINAL TENSIONING SYSTEM, DEVICE, AND METHOD

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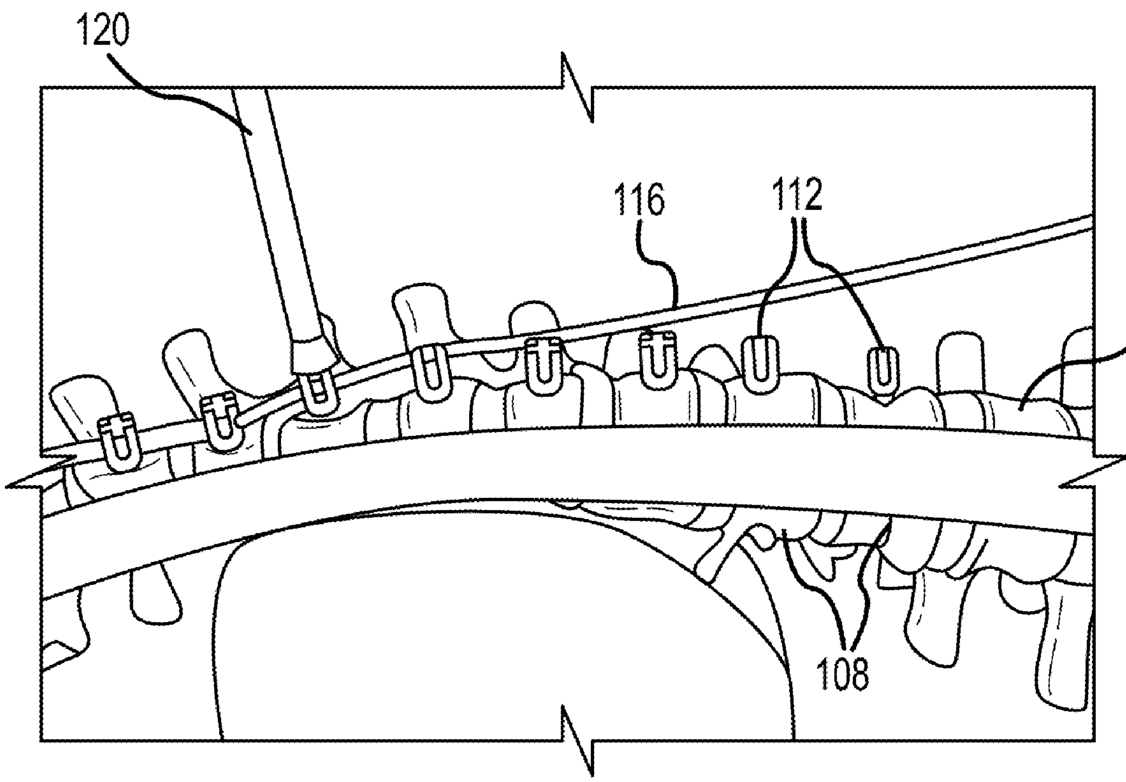
Publication Classification

(51) **Int. Cl.**
A61B 17/70 (2006.01)

(52) **U.S. Cl.**
CPC ***A61B 17/7022*** (2013.01); ***A61B 17/7044*** (2013.01)

(57) **ABSTRACT**

A bone anchor and system for applying tension via a tether or cord between bone anchors is provided. An illustrative bone anchor includes a screw having a head and a shank, where the shank defines a screw axis. The bone anchor further includes a connector attachable to the head of the screw, where the connector is configured to receive and secure a cord to the bone anchor.



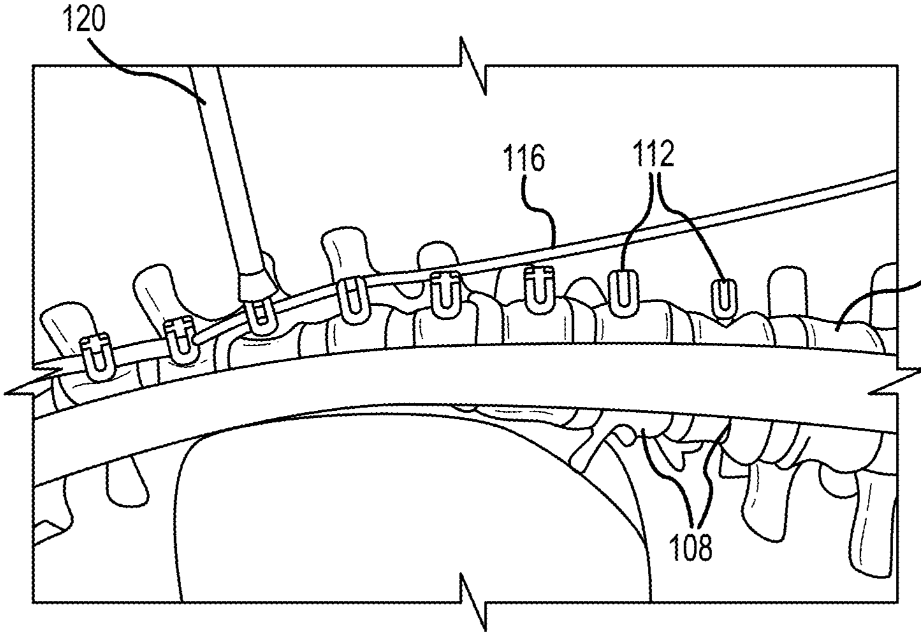


FIG.1

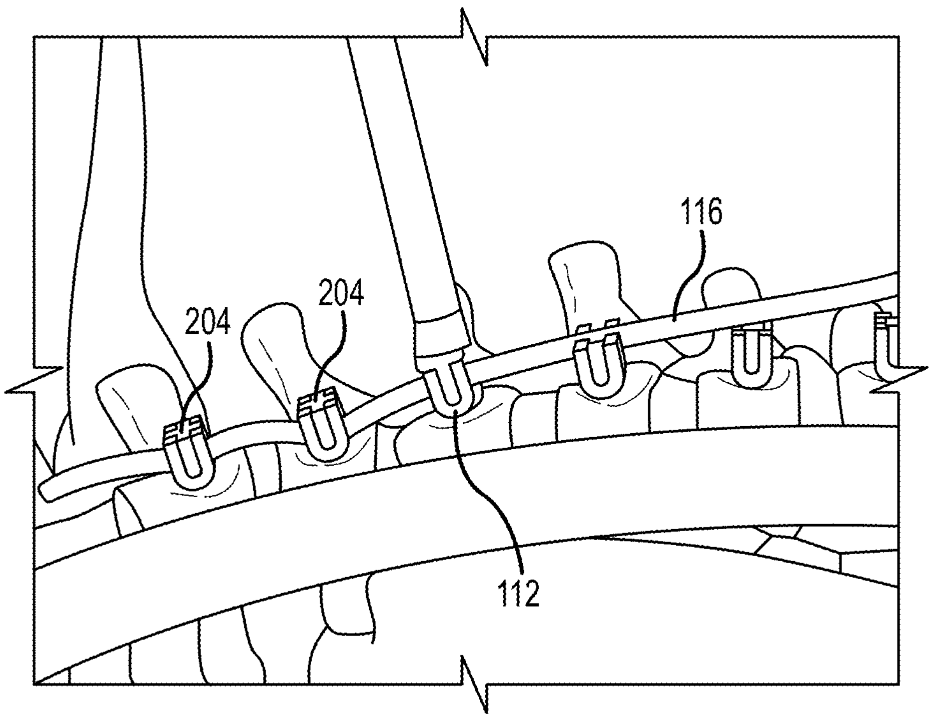


FIG.2

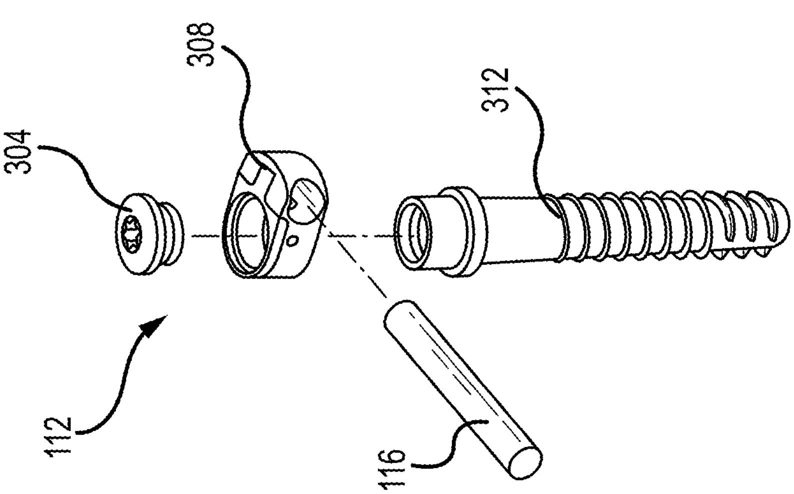


FIG.3A

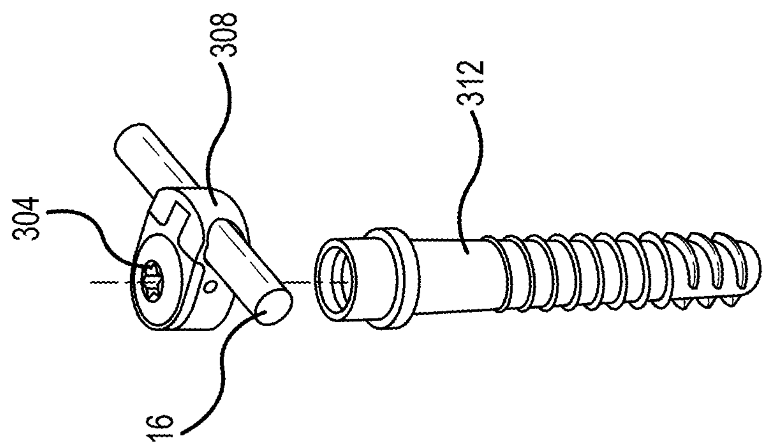


FIG.3B

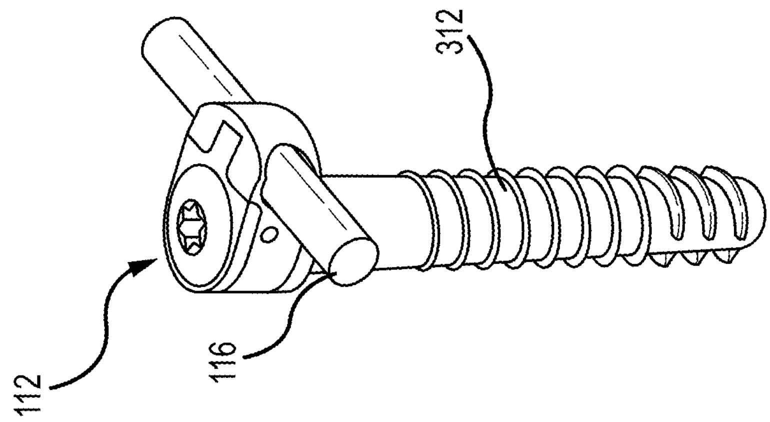


FIG.3C

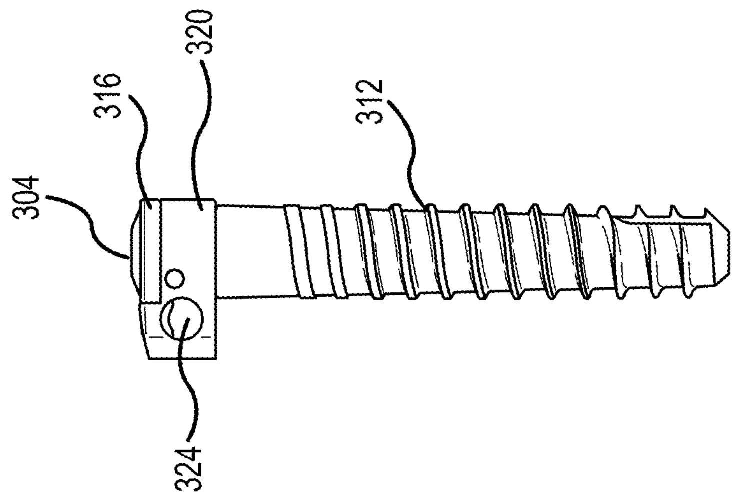


FIG.3E

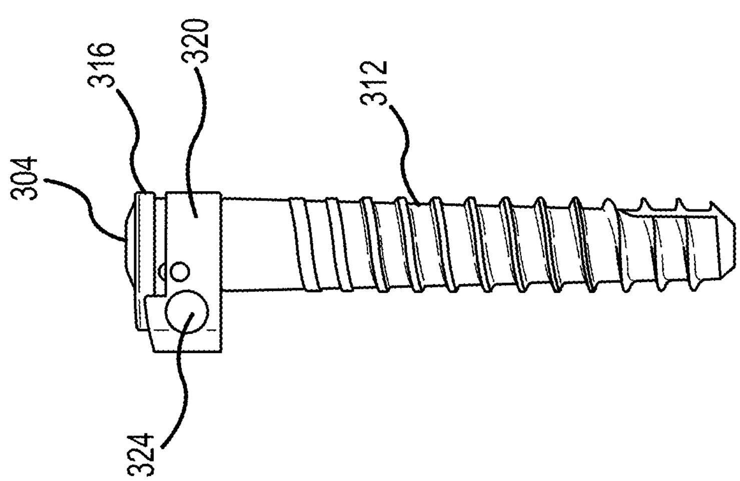


FIG.3D

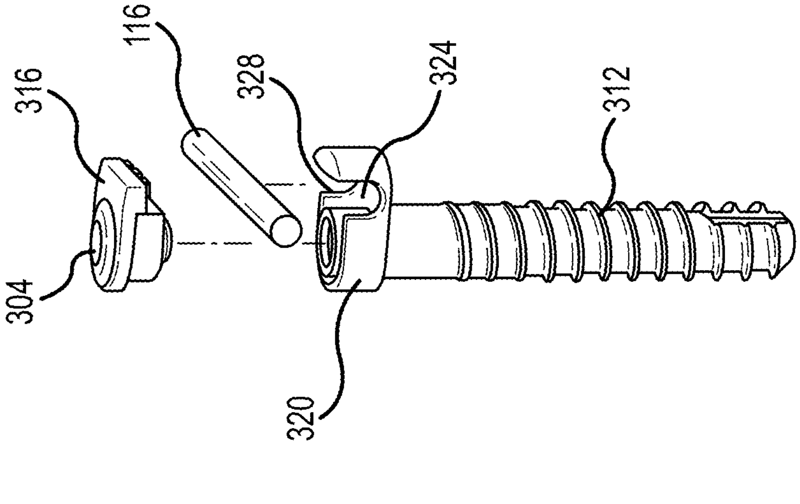


FIG.3F

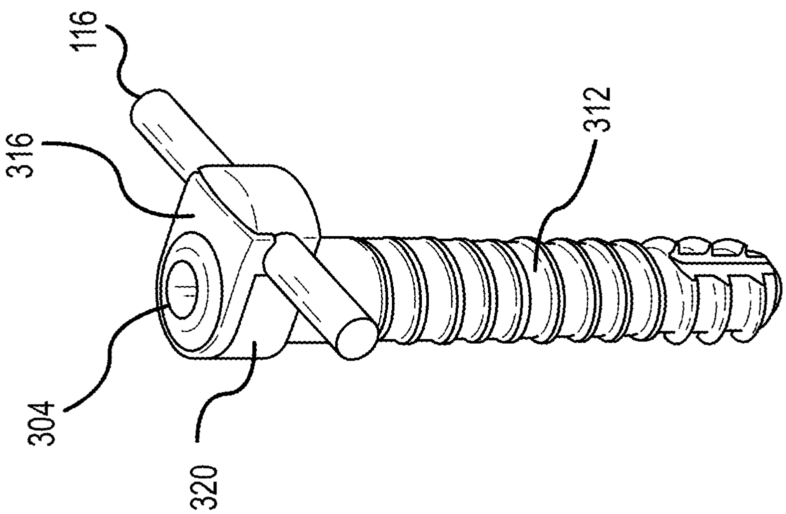


FIG.3G

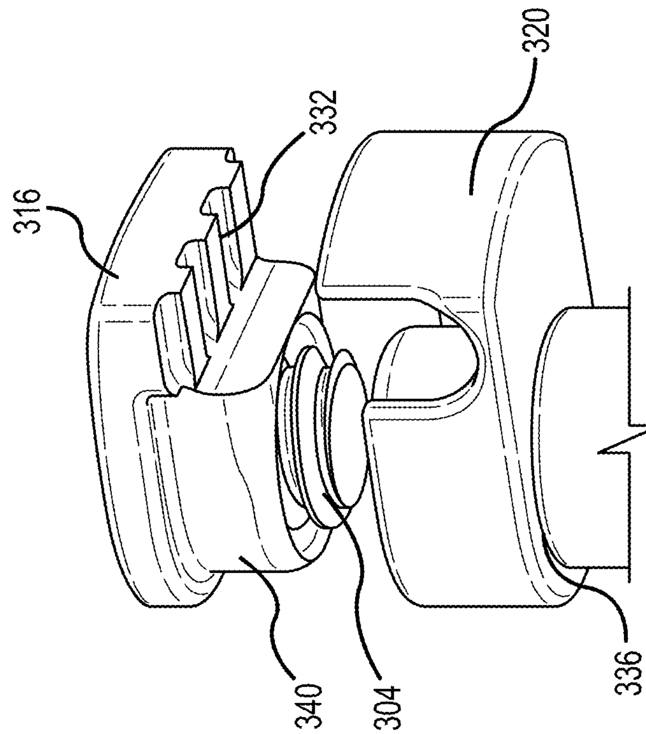


FIG.3H

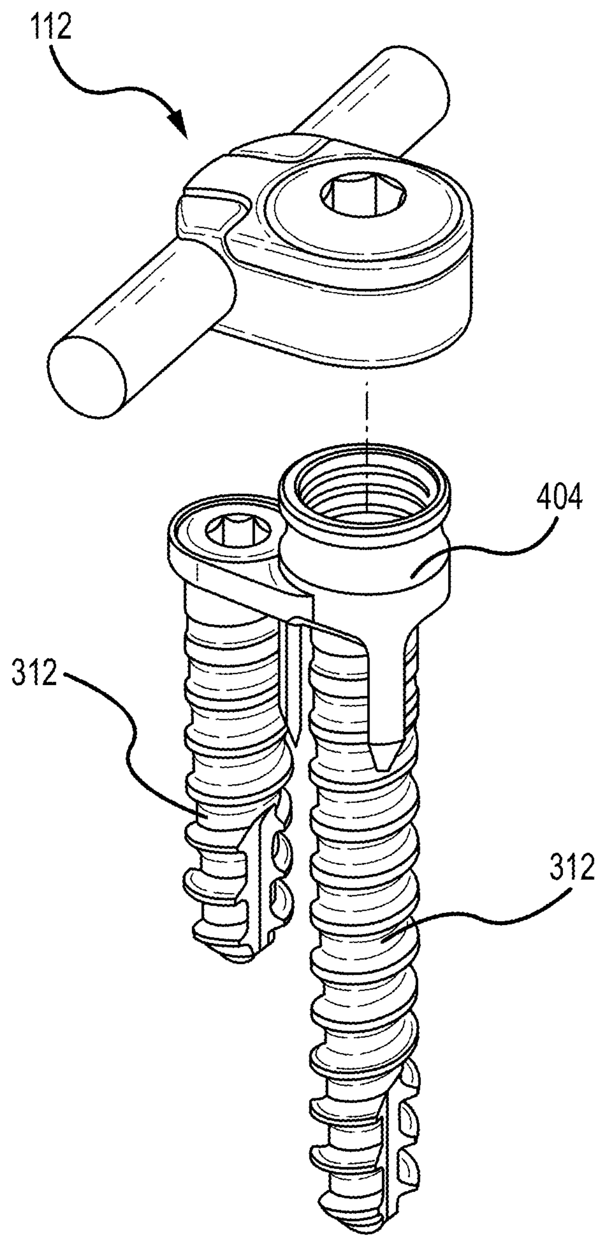


FIG.4

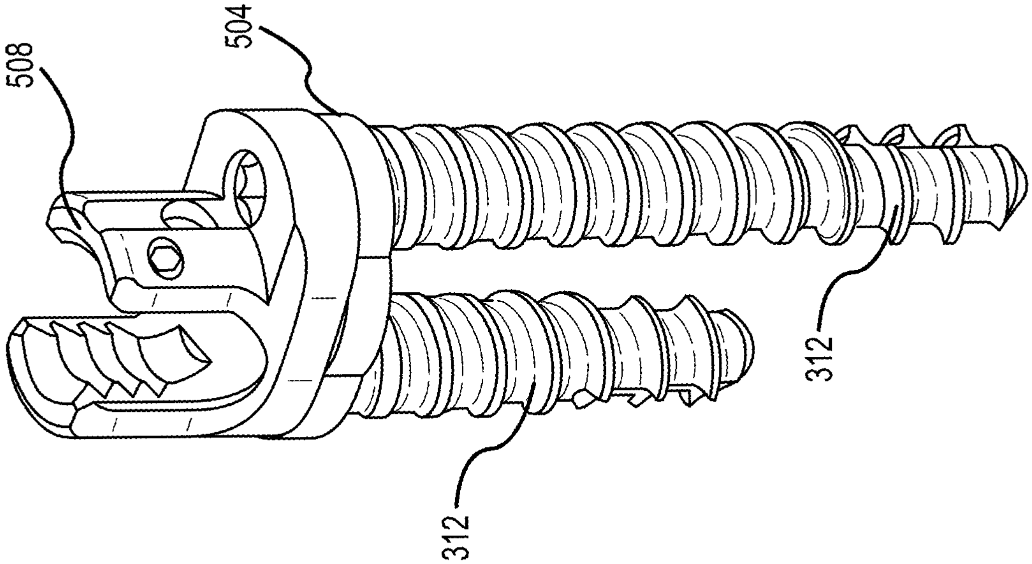


FIG.5D

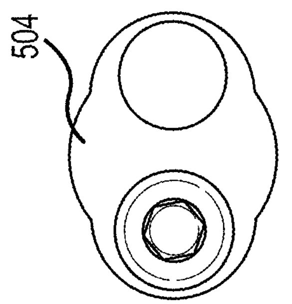


FIG.5B

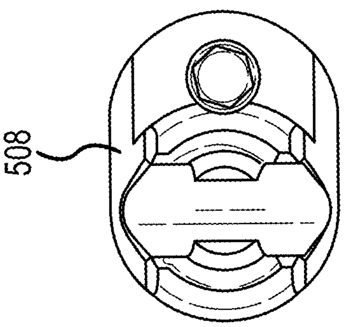


FIG.5C

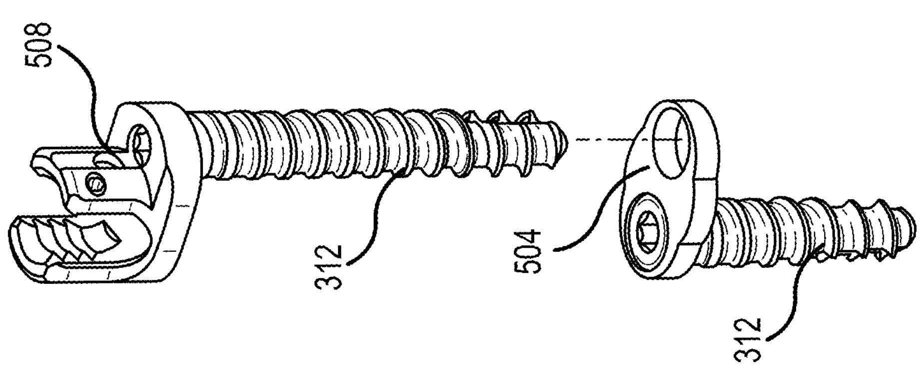


FIG.5A

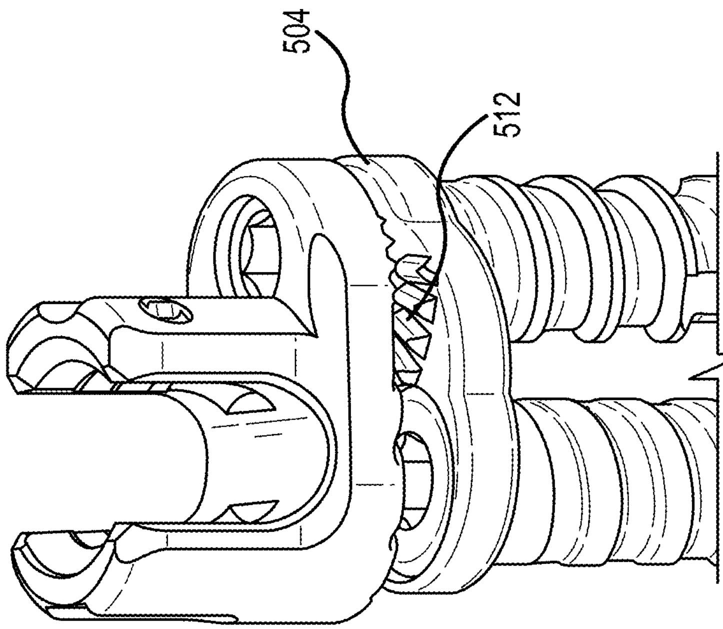


FIG.5F

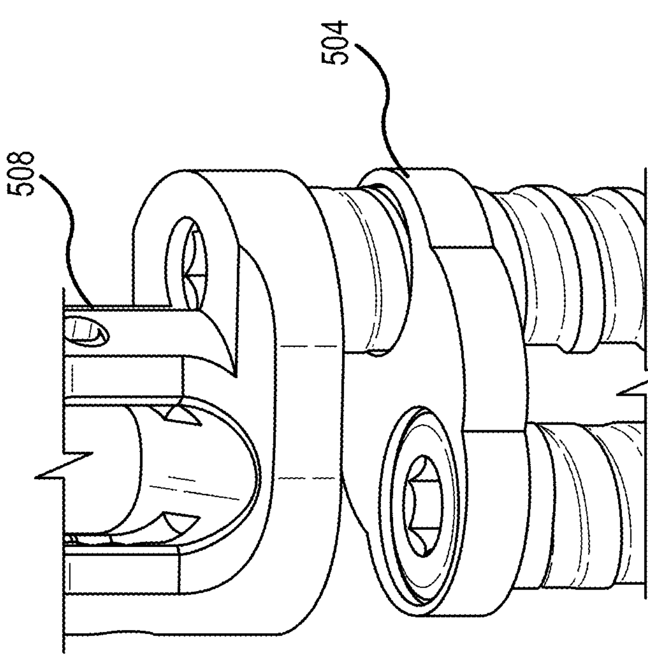


FIG.5E

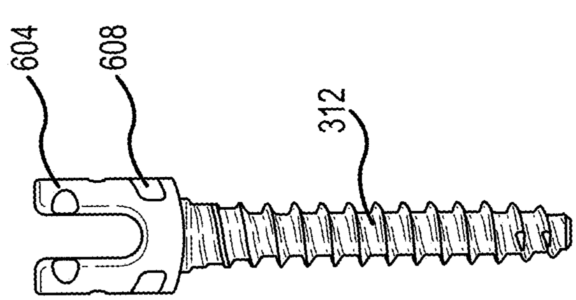


FIG.6A

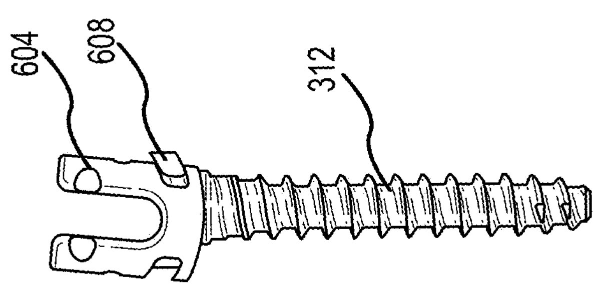


FIG.6B

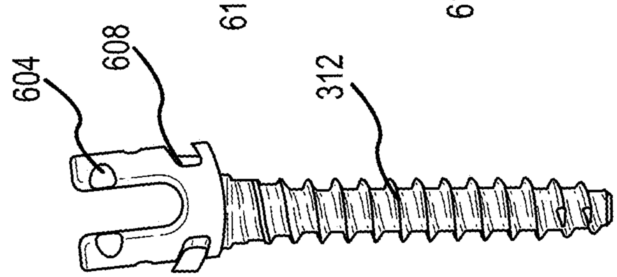


FIG.6C

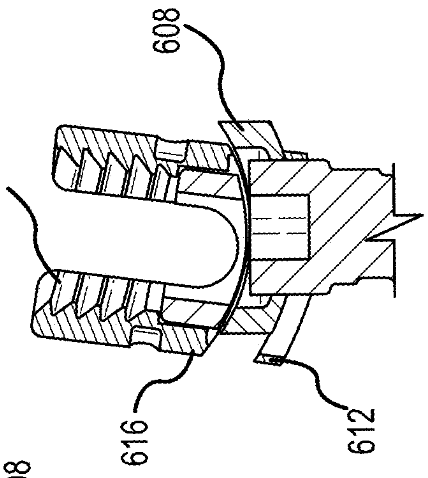


FIG.6D

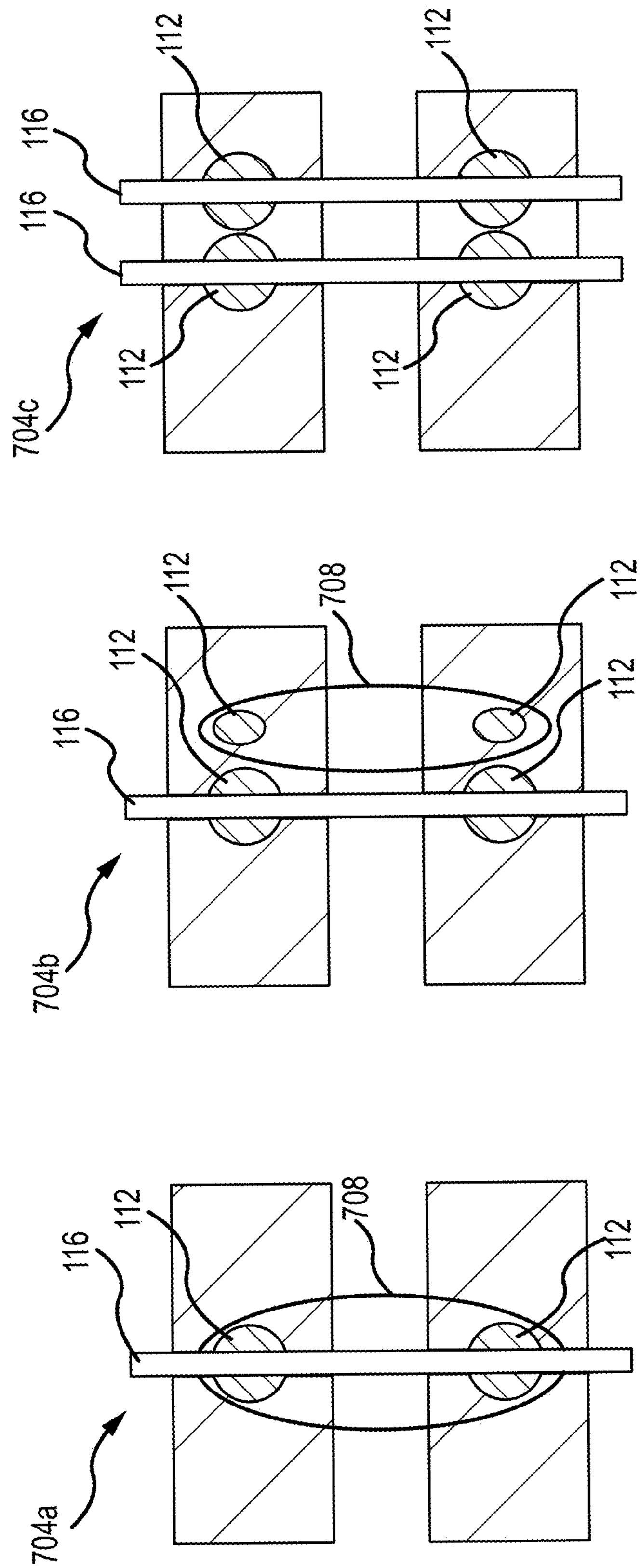


FIG.7

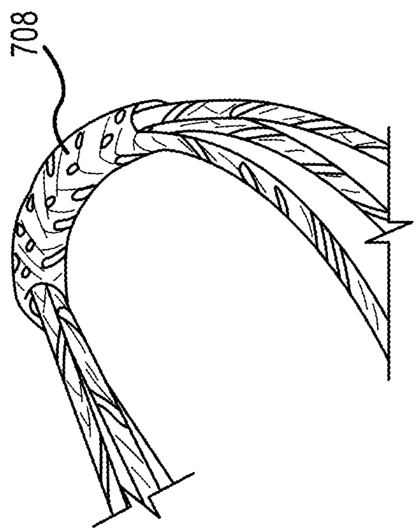


FIG.8

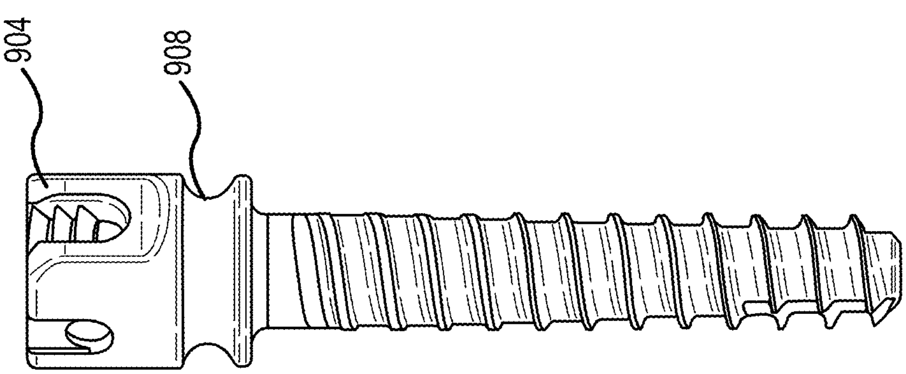


FIG.9A

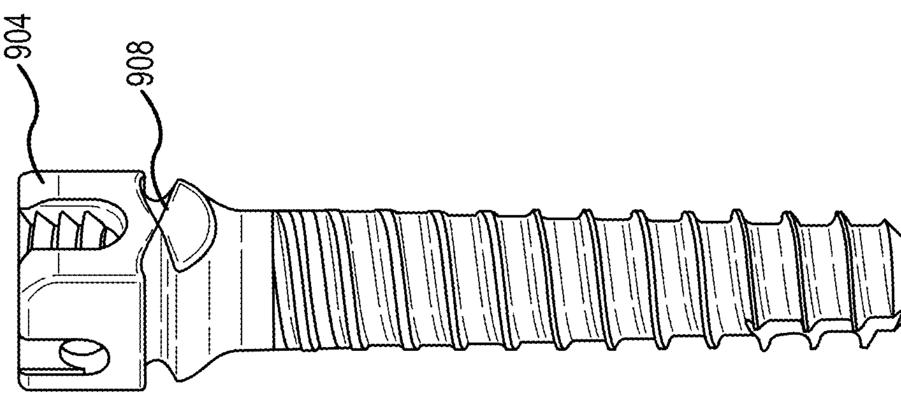


FIG.9B

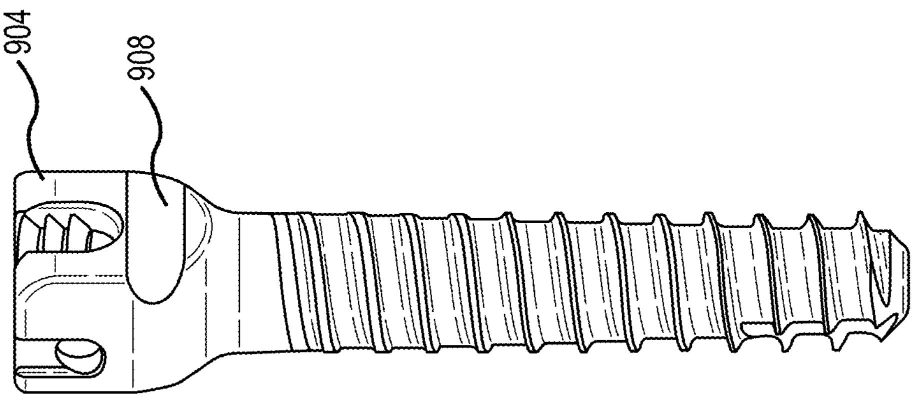


FIG.9C

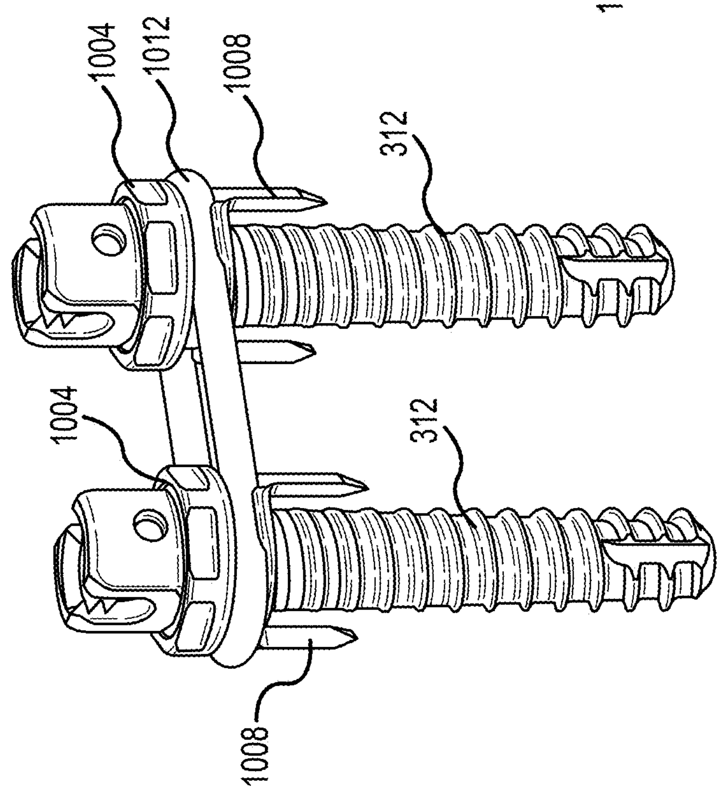


FIG.10A

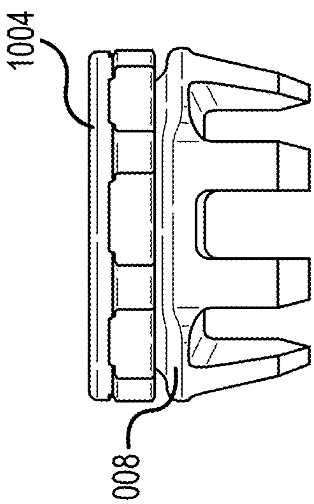


FIG.10B

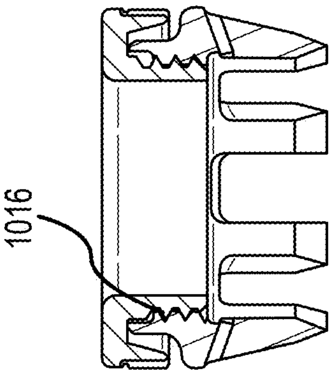


FIG.10C

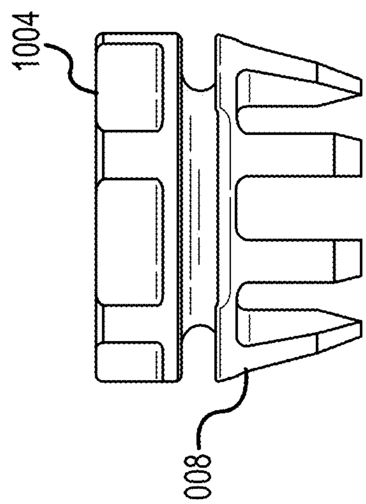


FIG.10D

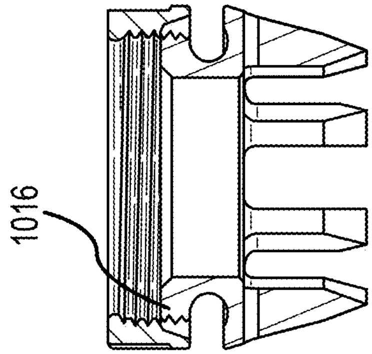


FIG.10E

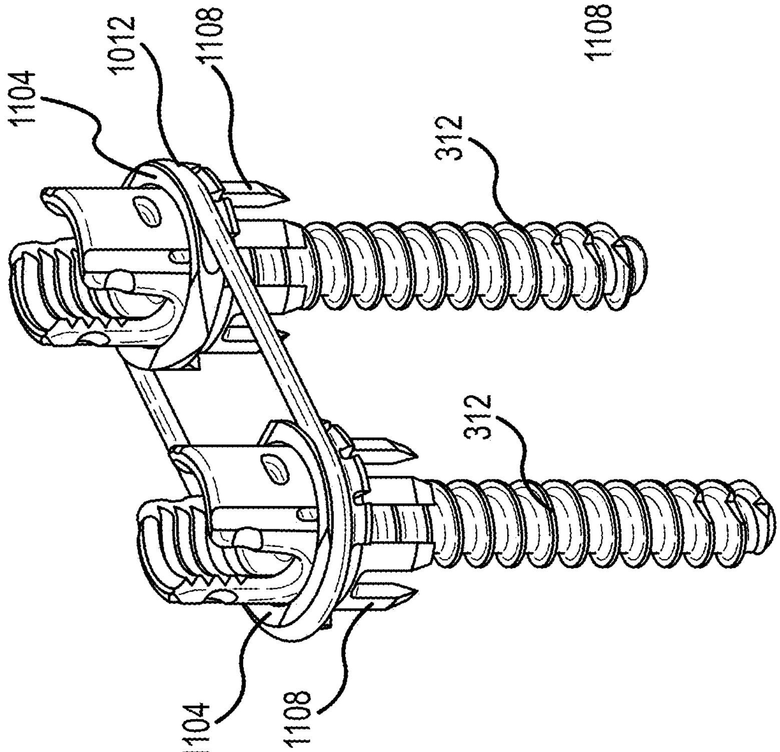


FIG.11A

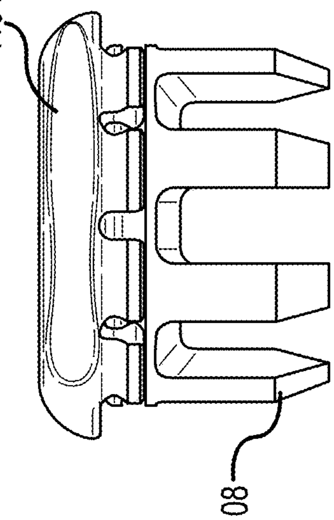
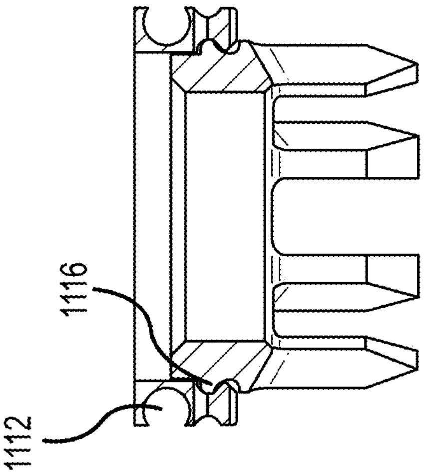


FIG.11B



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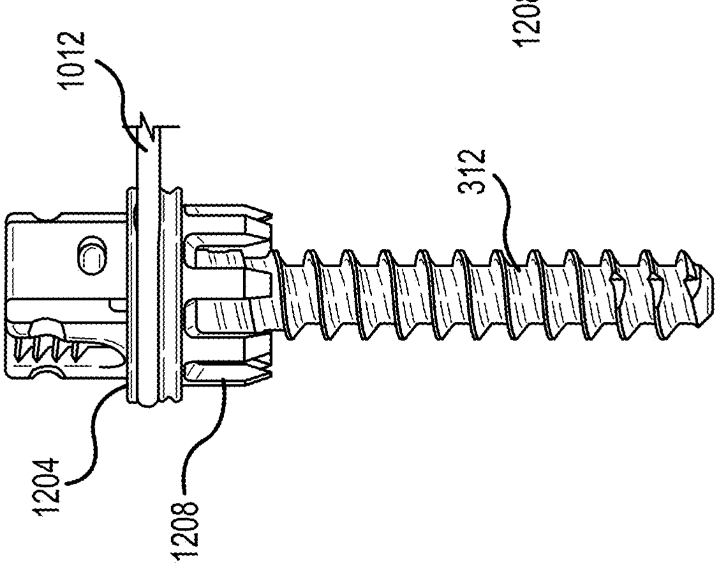

FIG.12A

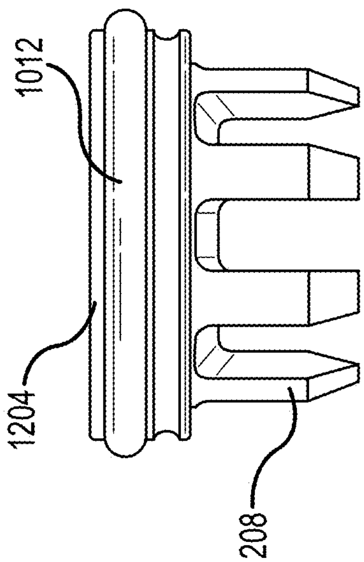

FIG.12B

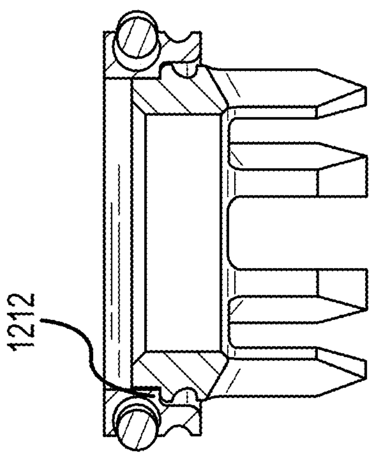

FIG.12C

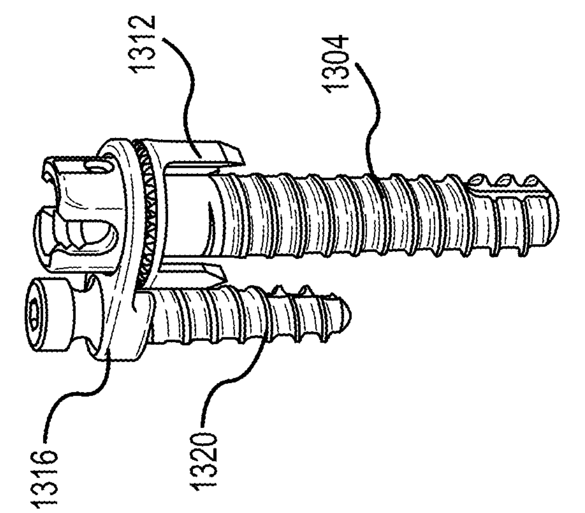

FIG.13C

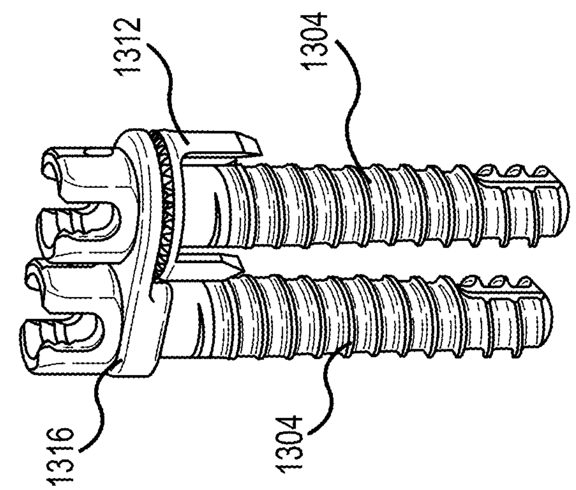

FIG.13B

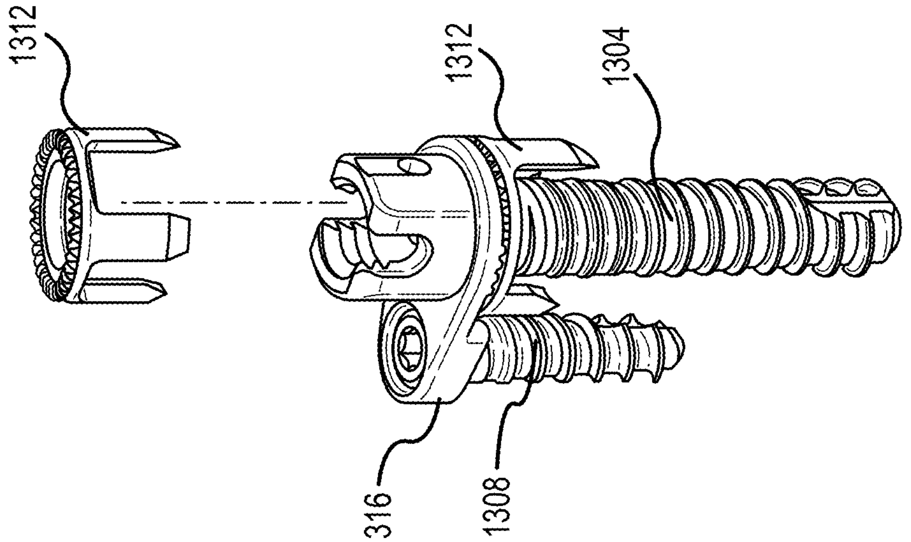

FIG.13A

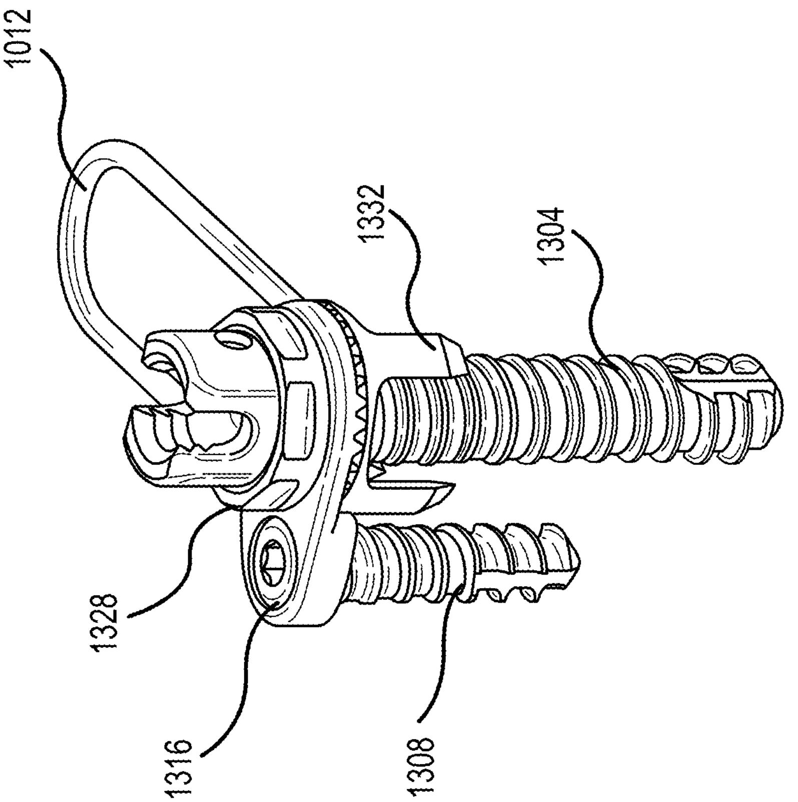

FIG.13E

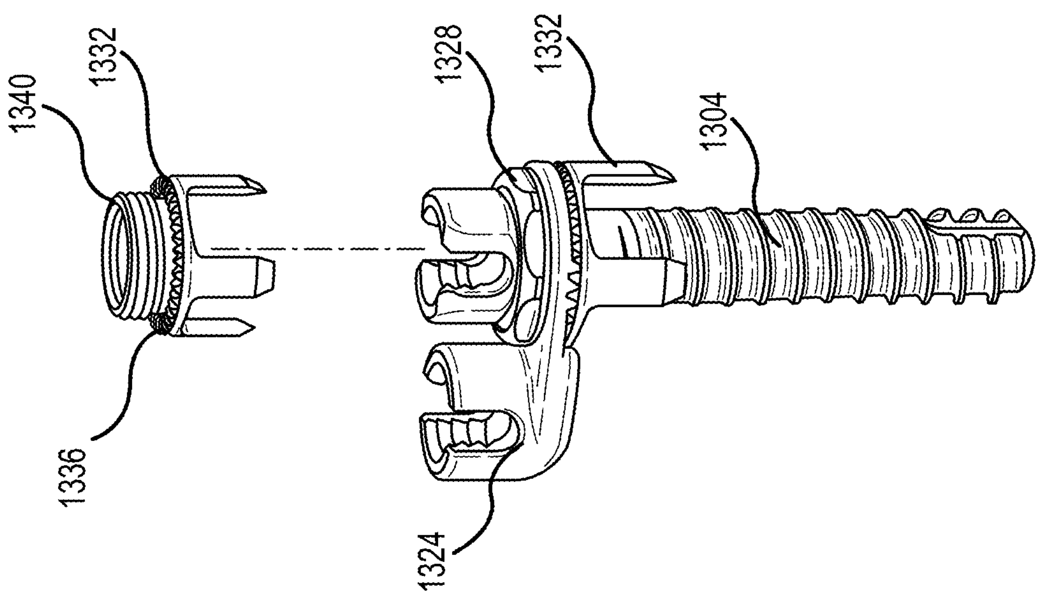

FIG.13D

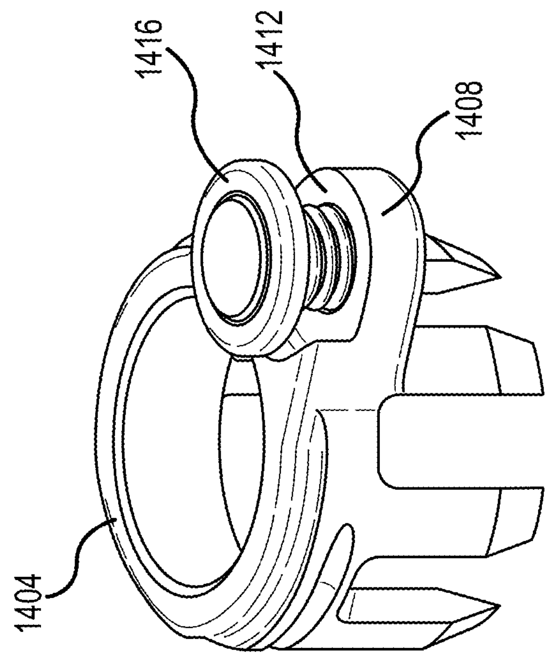

FIG.14A

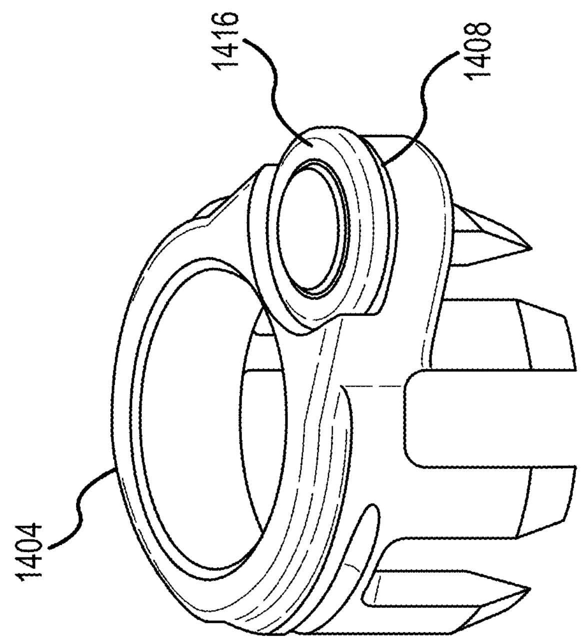

FIG.14B

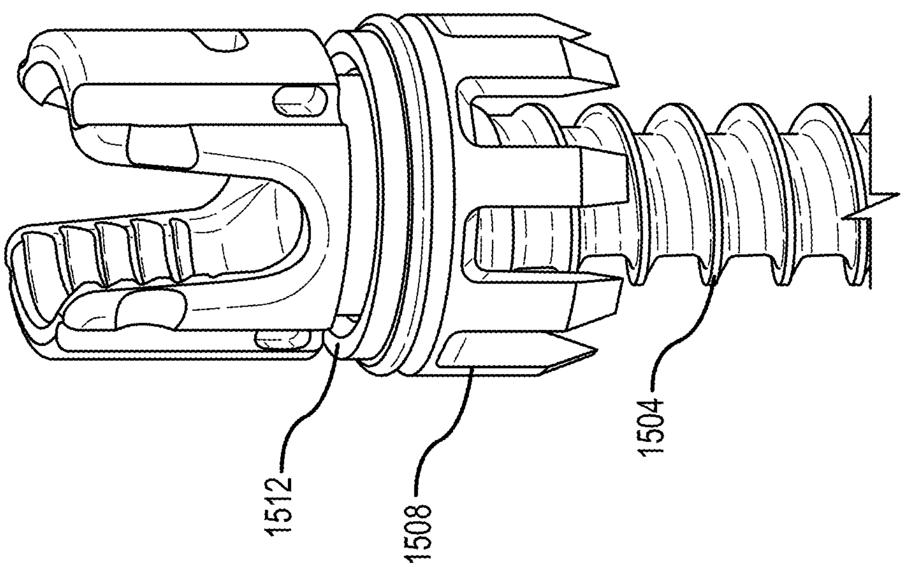

FIG.15

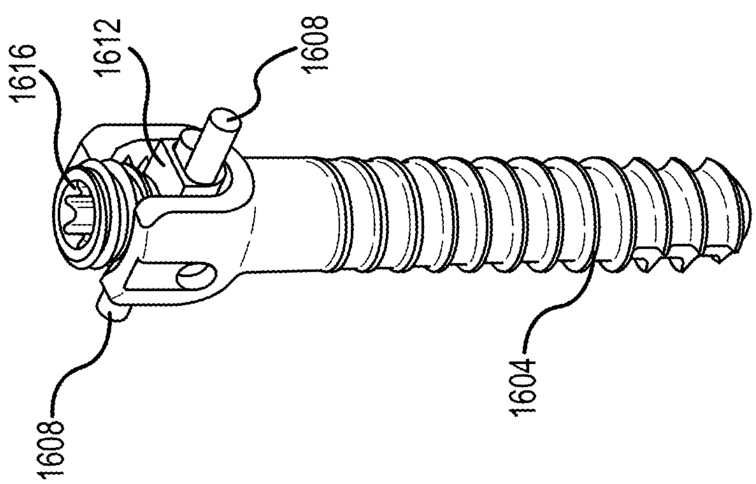

FIG.16A

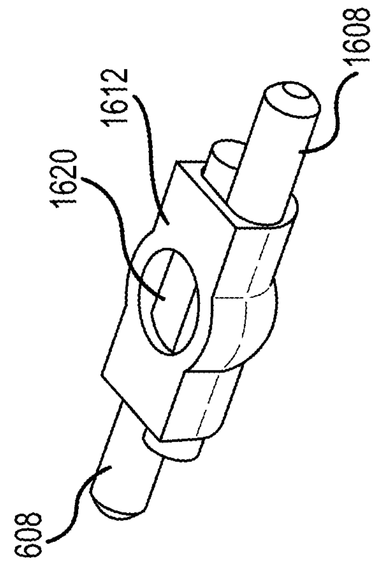

FIG.16B

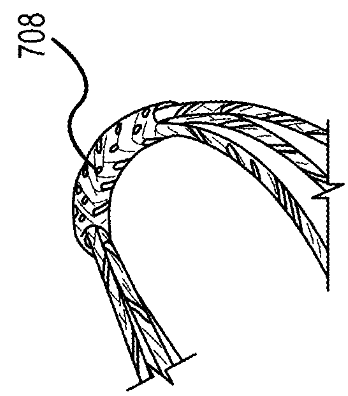

FIG.16C

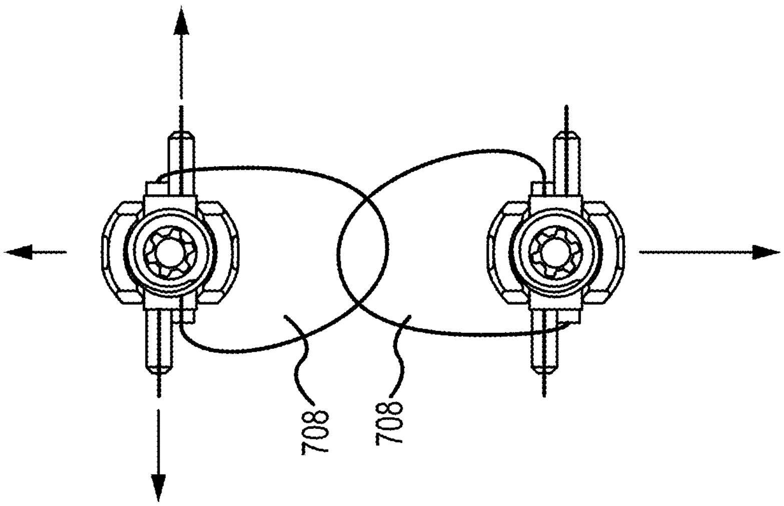

FIG.16D

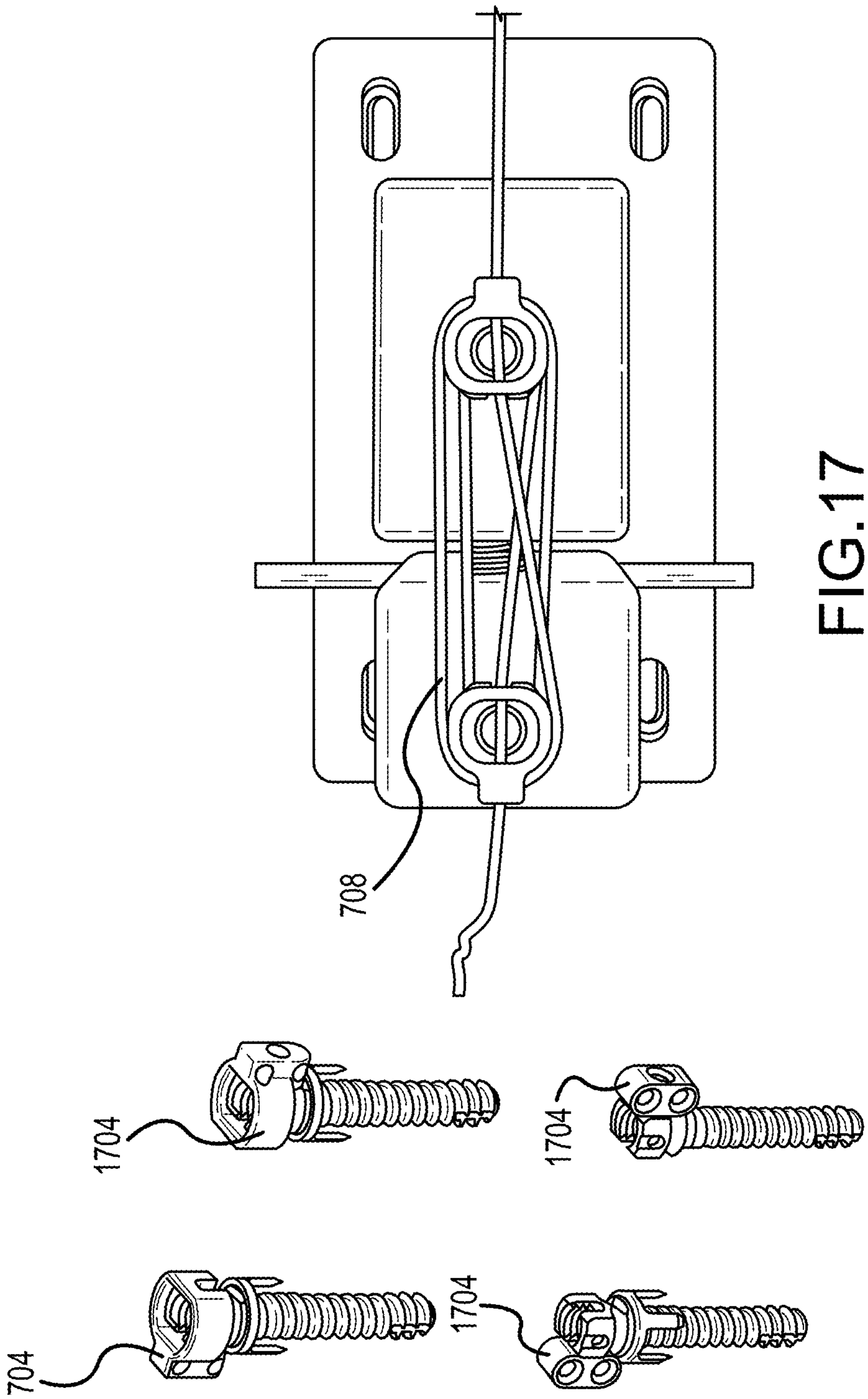

FIG.17

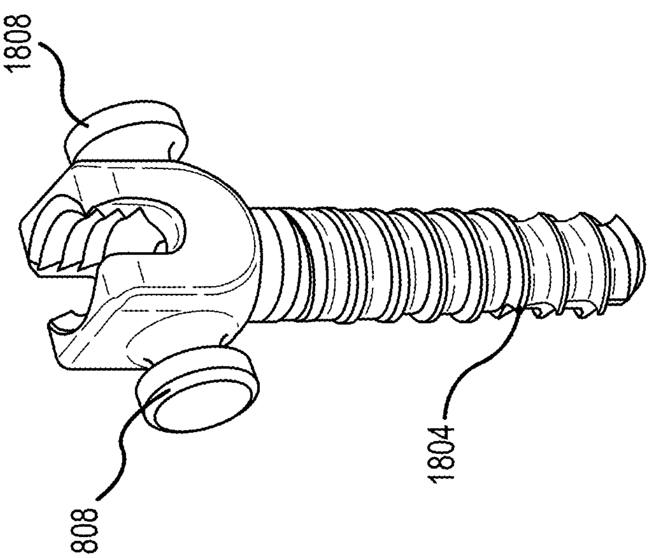

FIG.18A

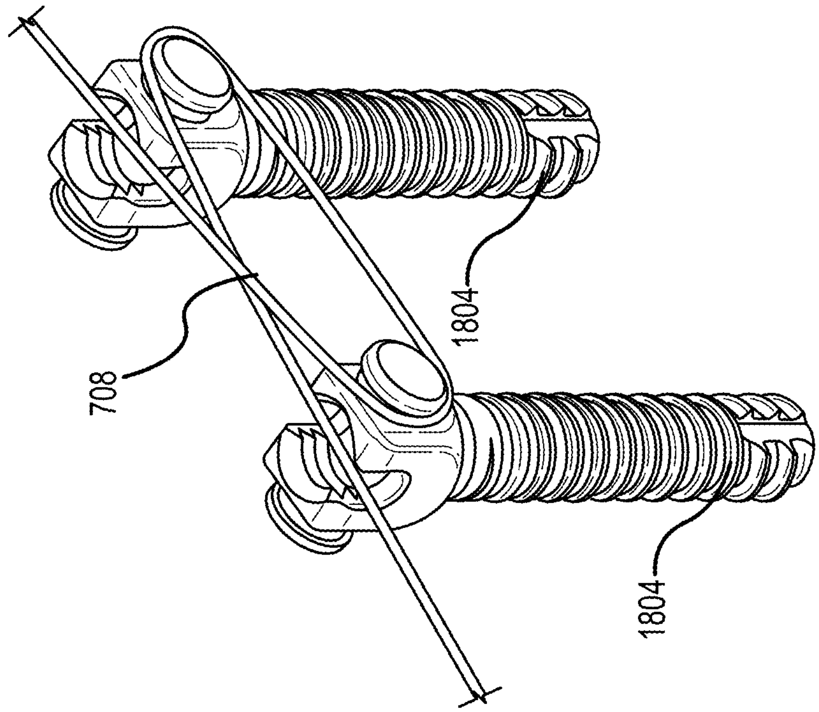

FIG.18B

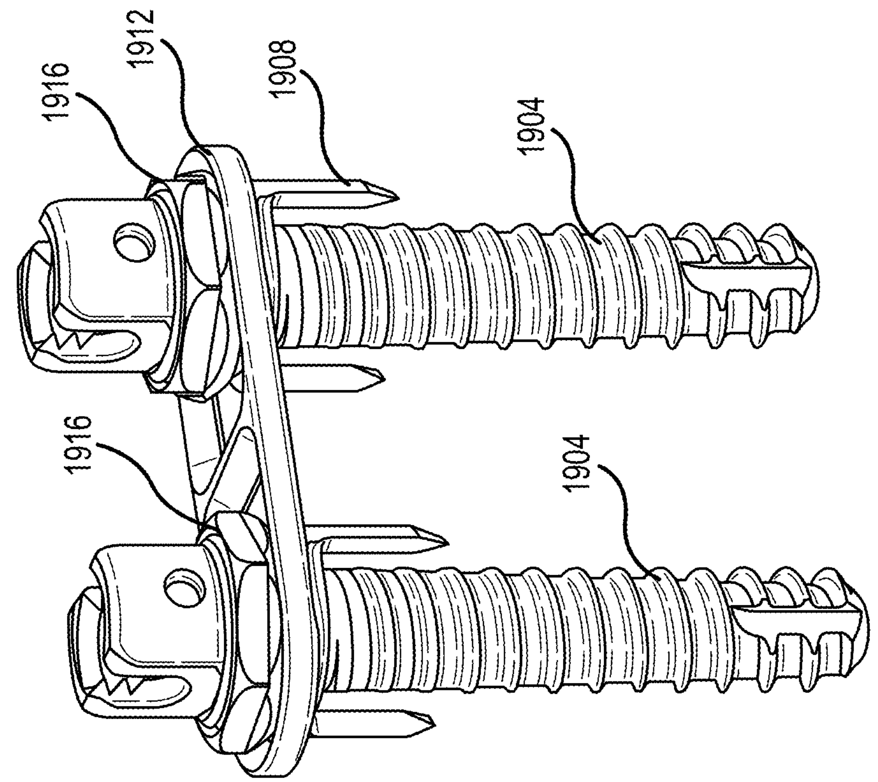

FIG.19

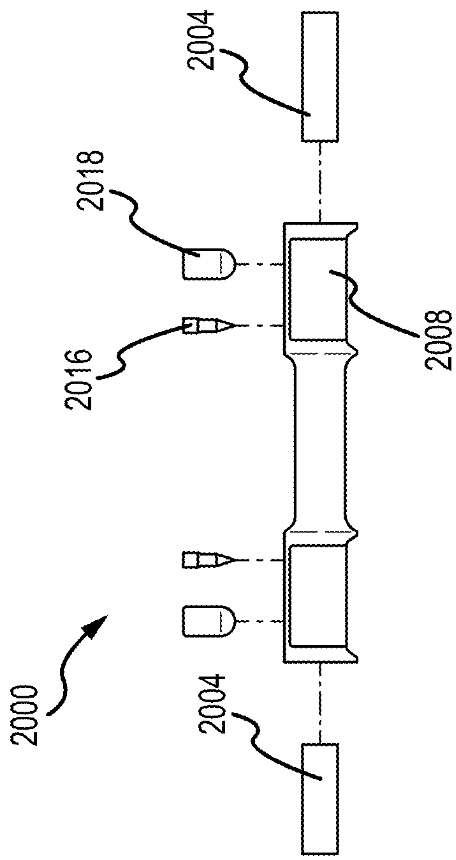

FIG.20A

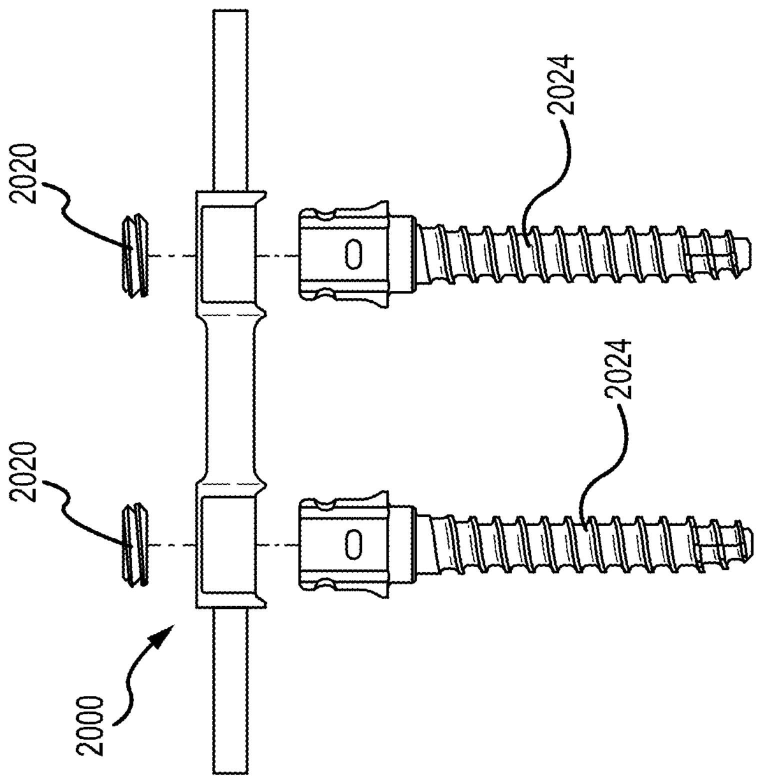

FIG.20B

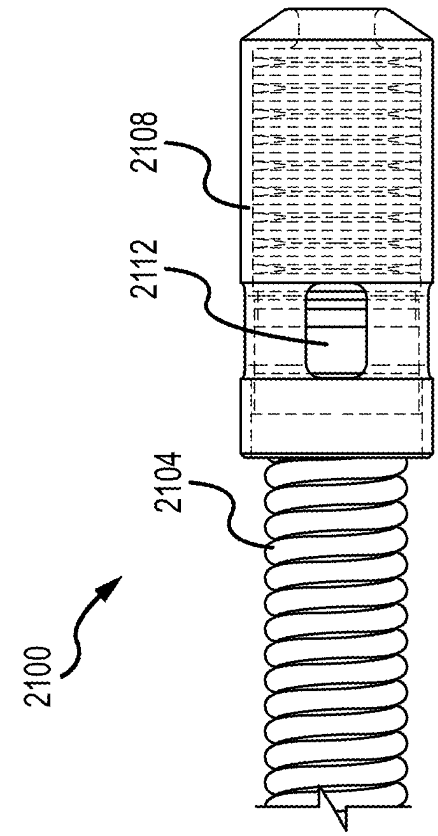

FIG.21B

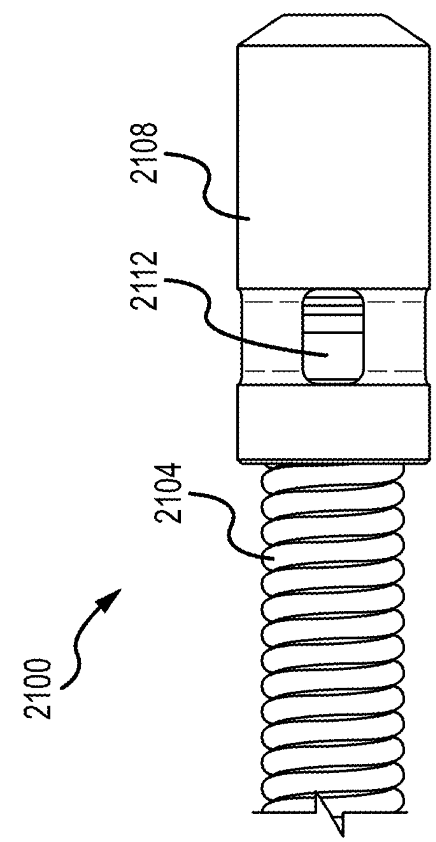

FIG.21A

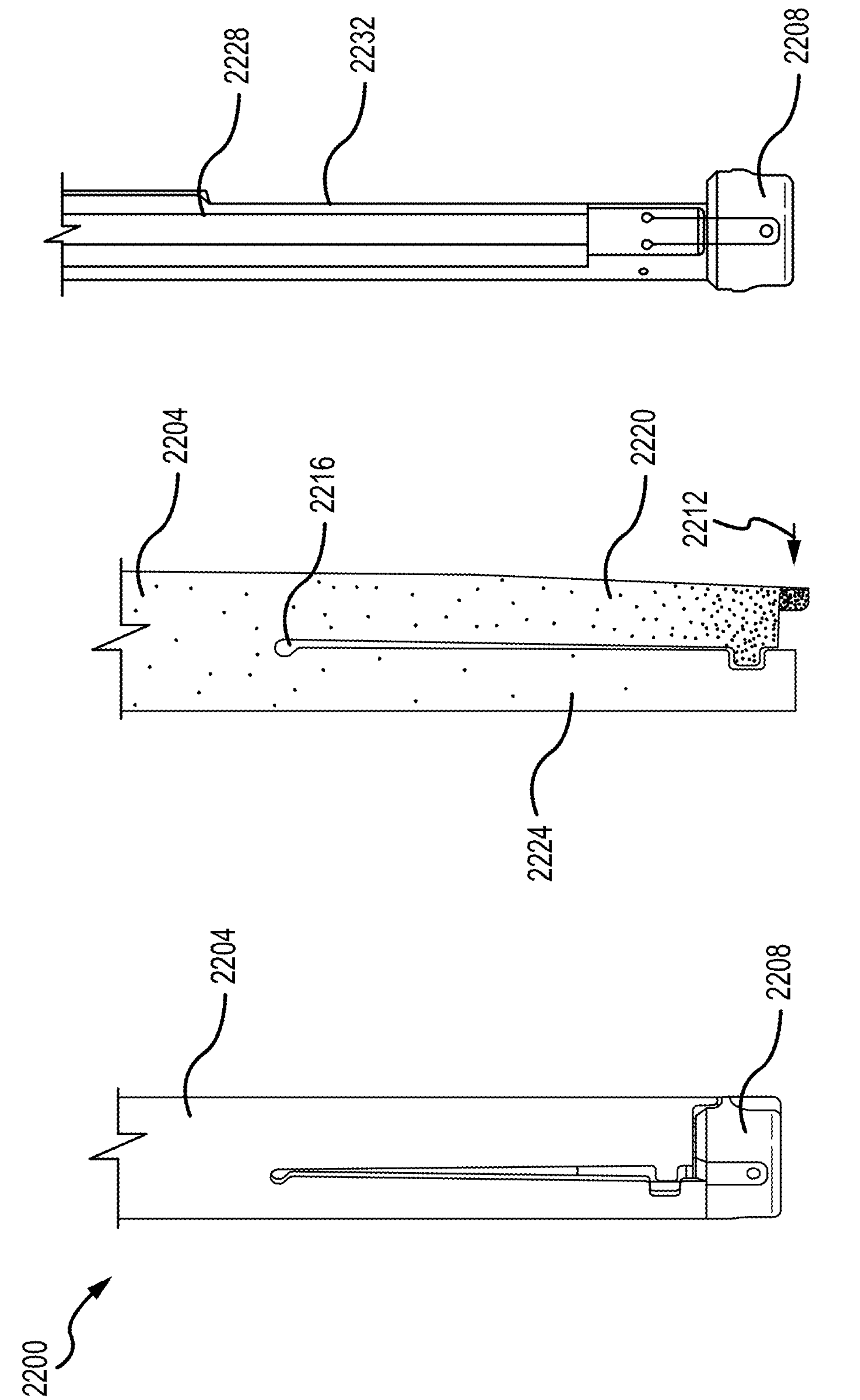

FIG.22C

FIG.22B

FIG.22A

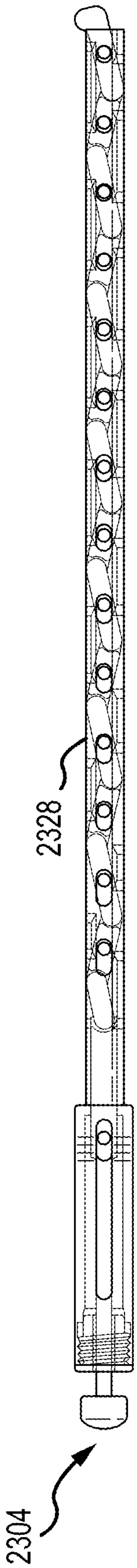

FIG.23A

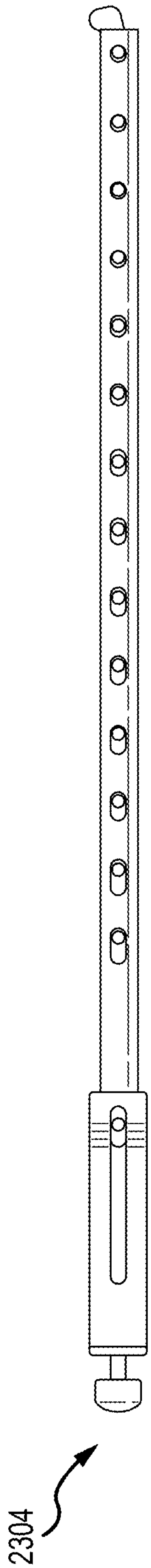

FIG.23B

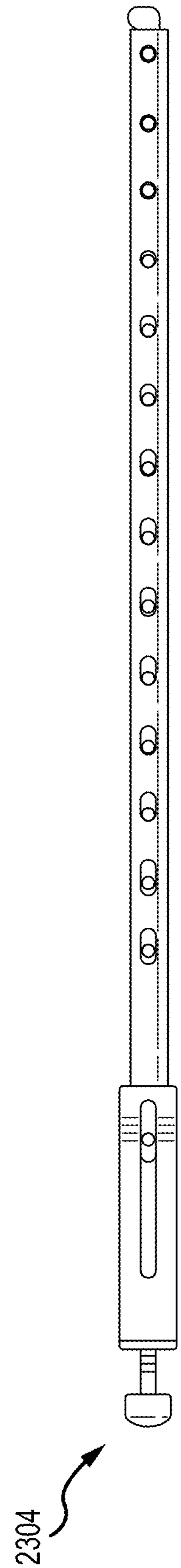

FIG.23C

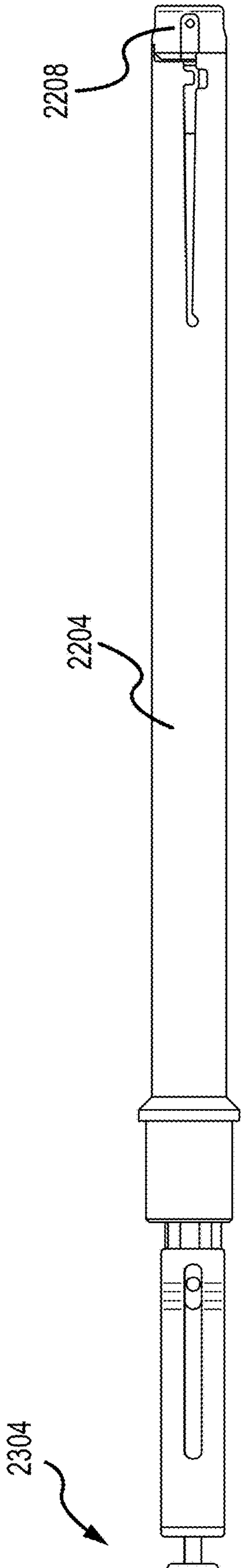

FIG.24A

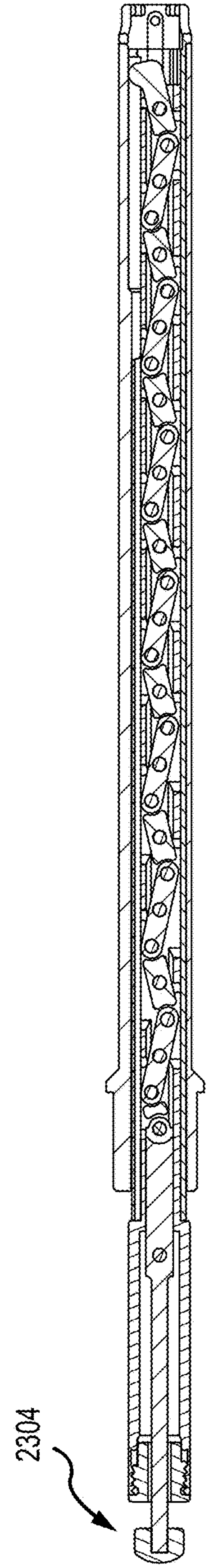

FIG.24B

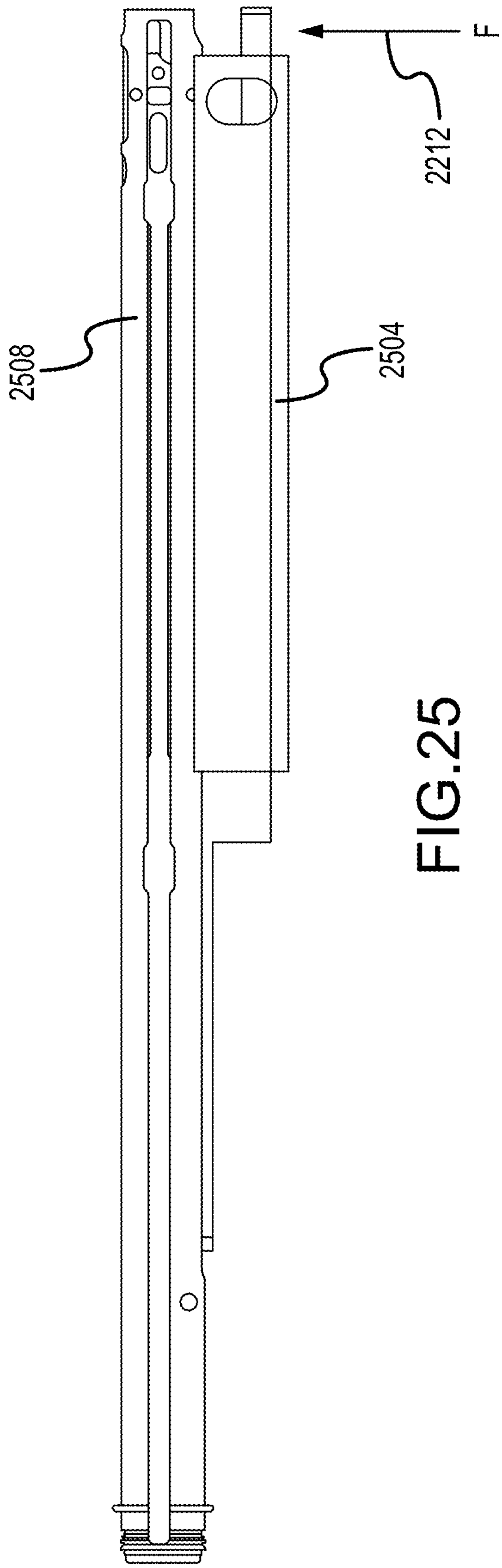

FIG.25

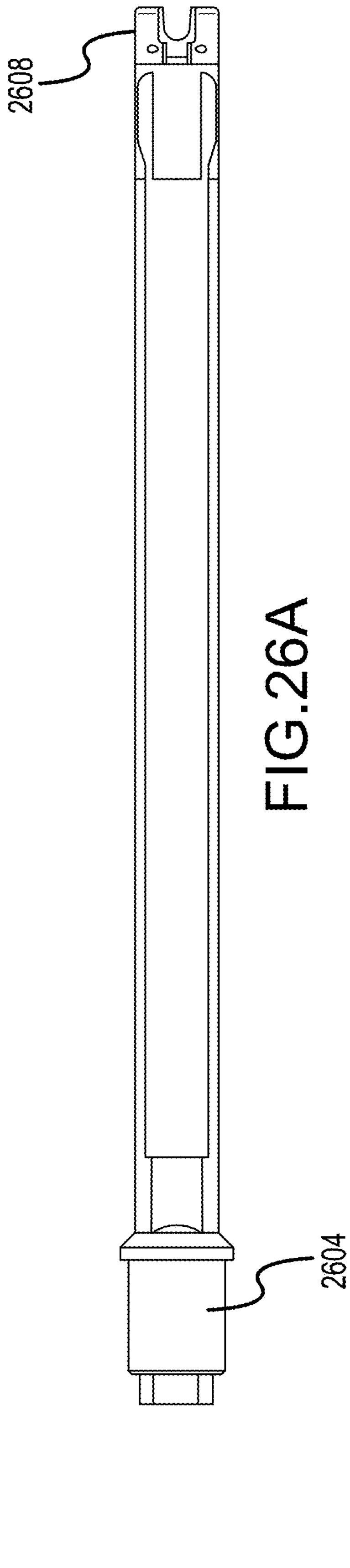

FIG.26A

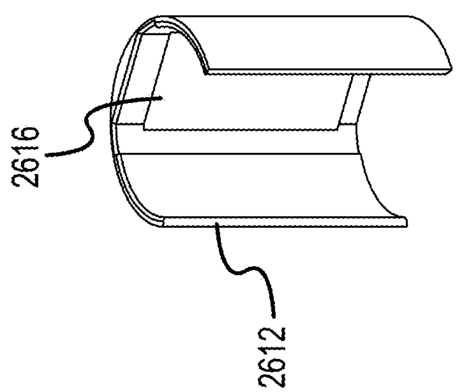

FIG.26B

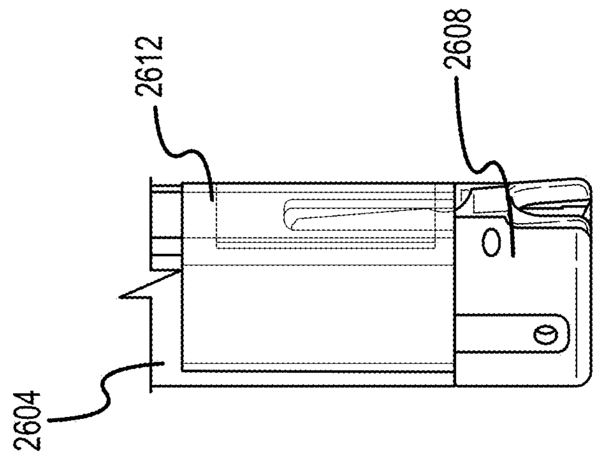

FIG.26C

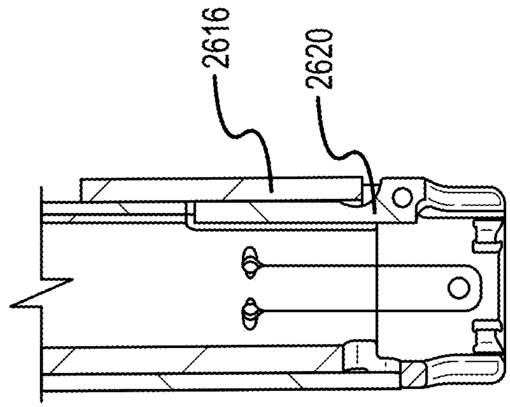

FIG.26D

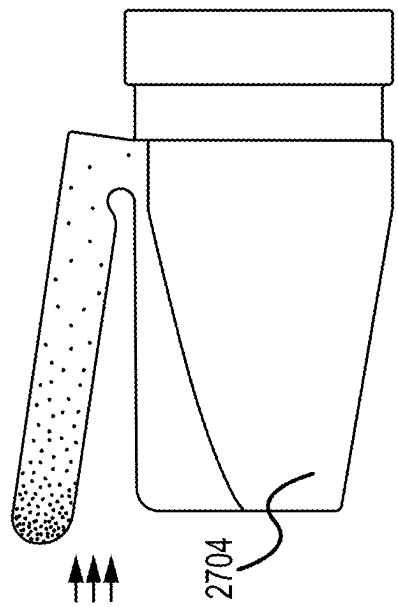

FIG.27B

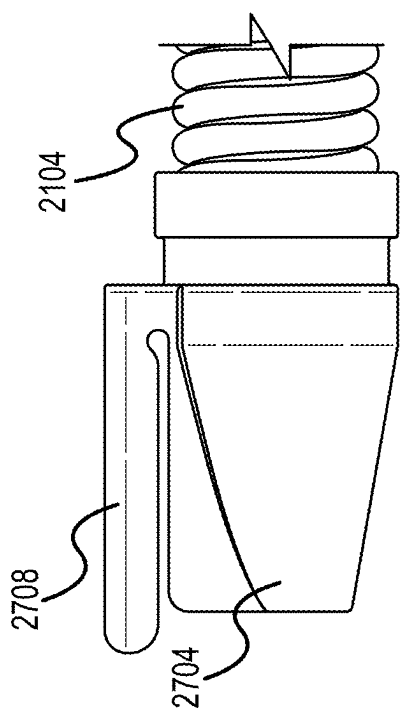

FIG.27A

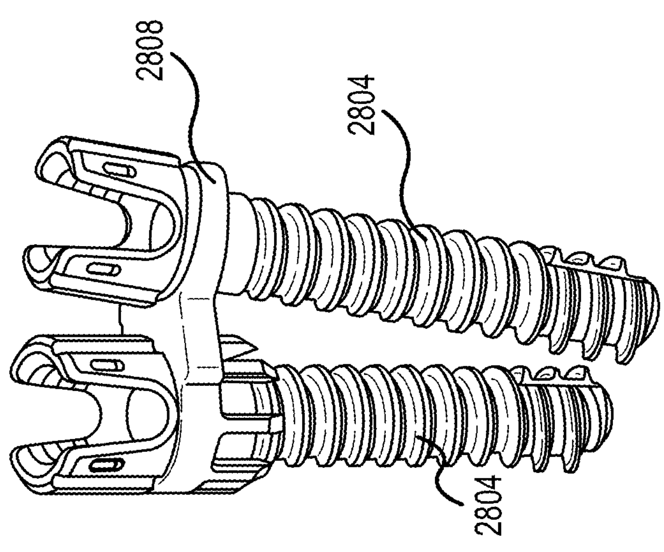

FIG.28A

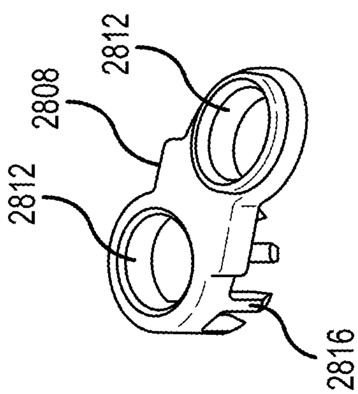

FIG.28B

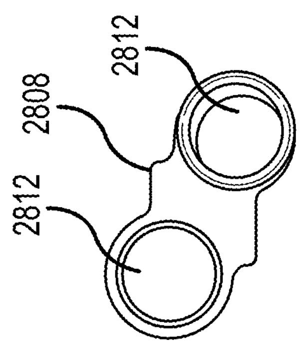

FIG.28C

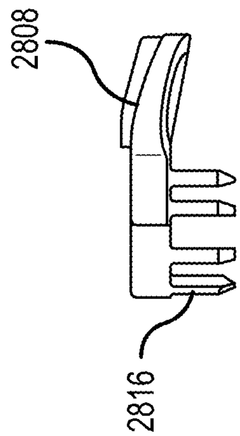

FIG.28D

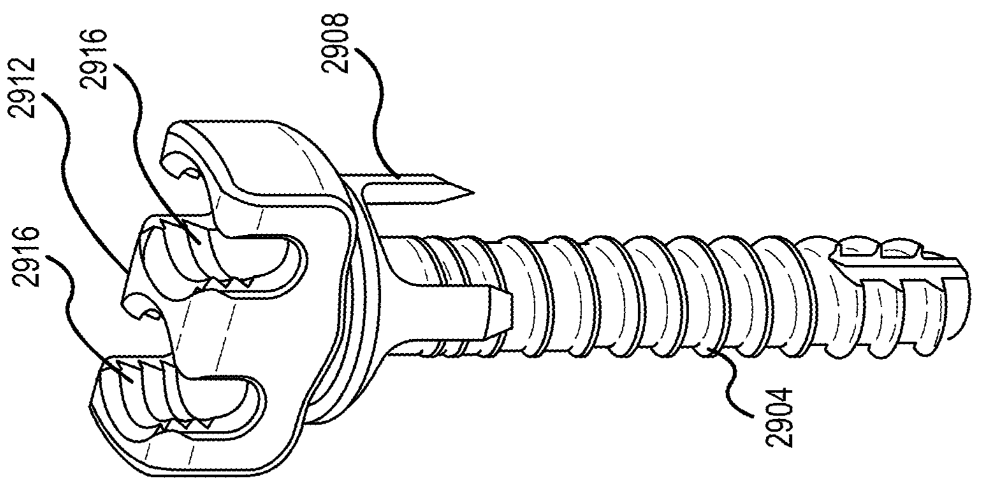

FIG.29

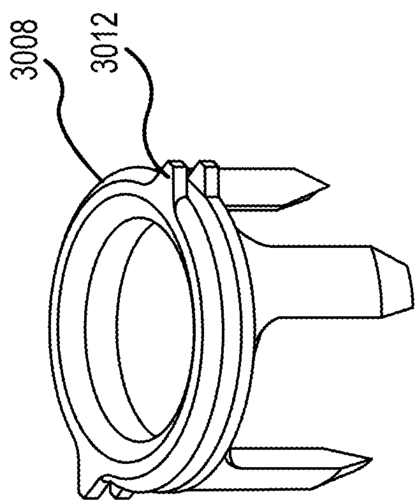

FIG.30A

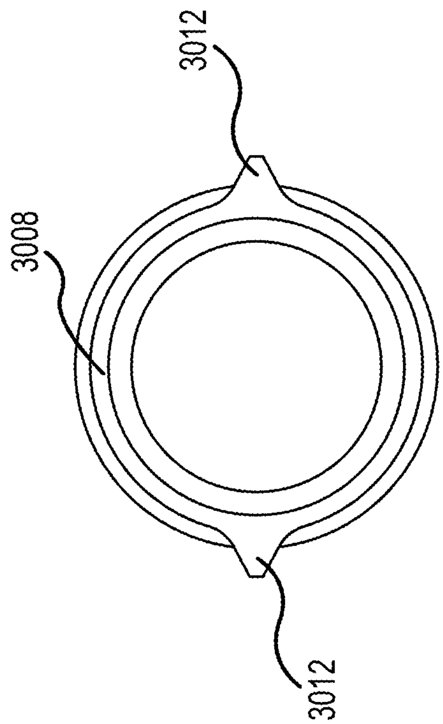

FIG.30B

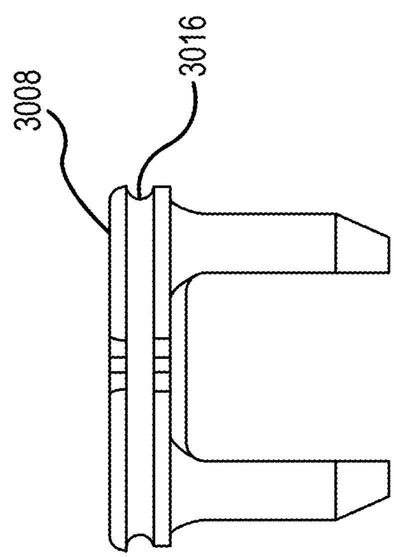

FIG.30C

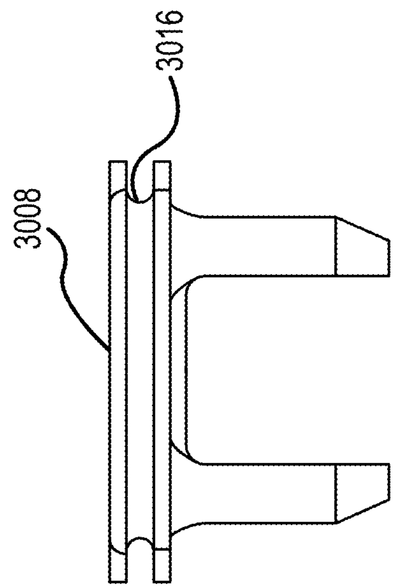

FIG.30D

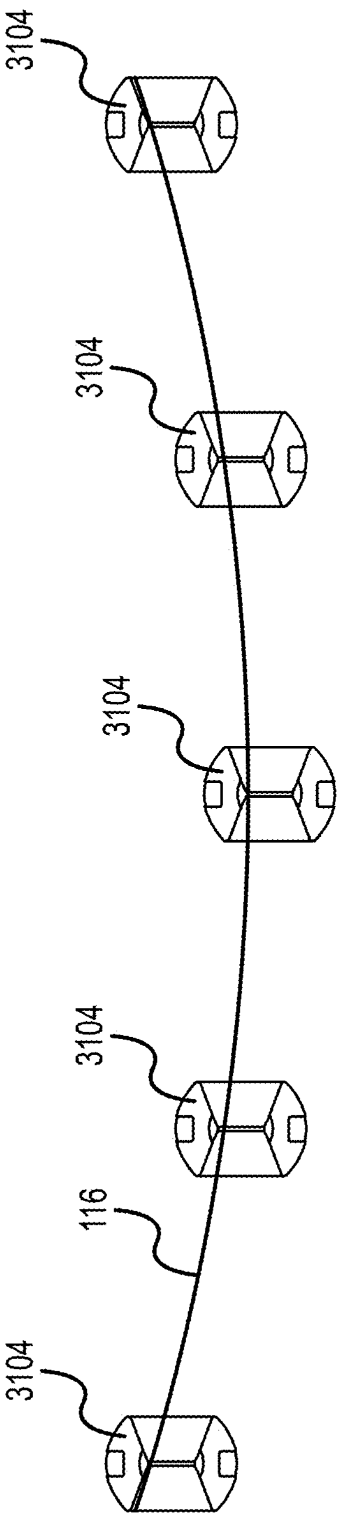

FIG.31A

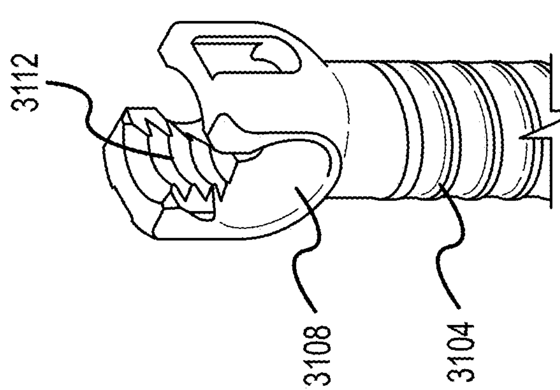

FIG.31B

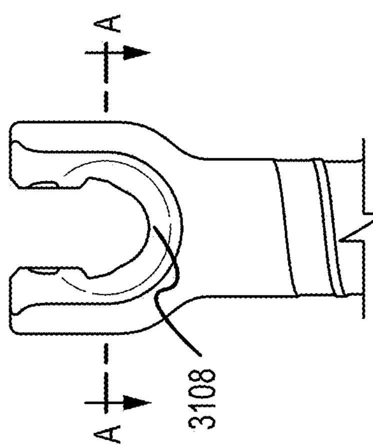

FIG.31C

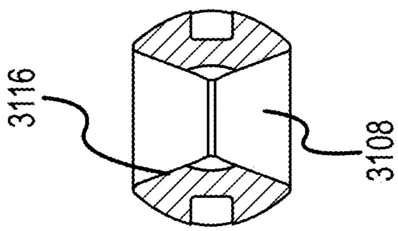

FIG.31D

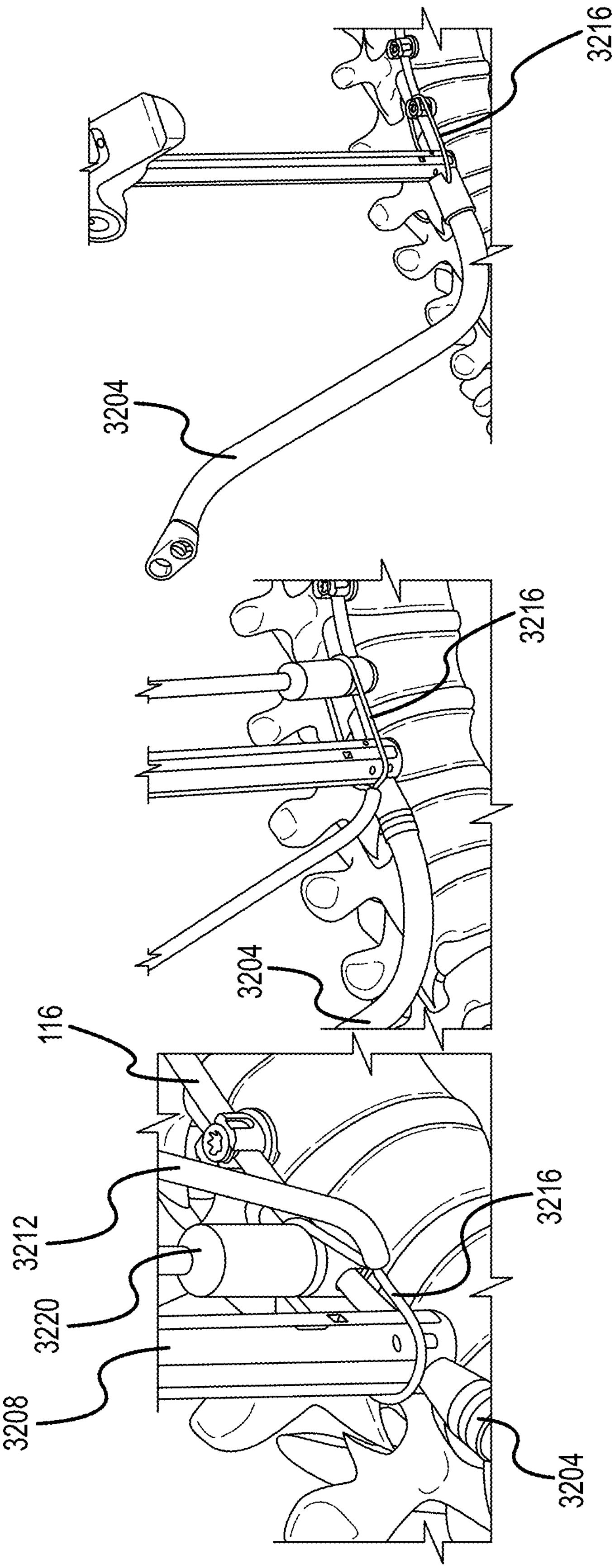

FIG.32

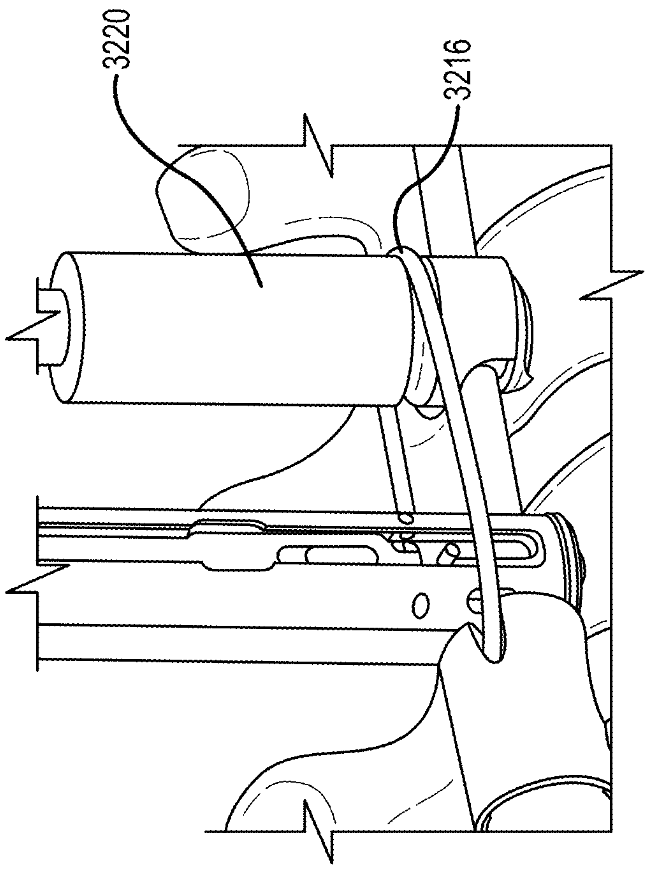

FIG.33A

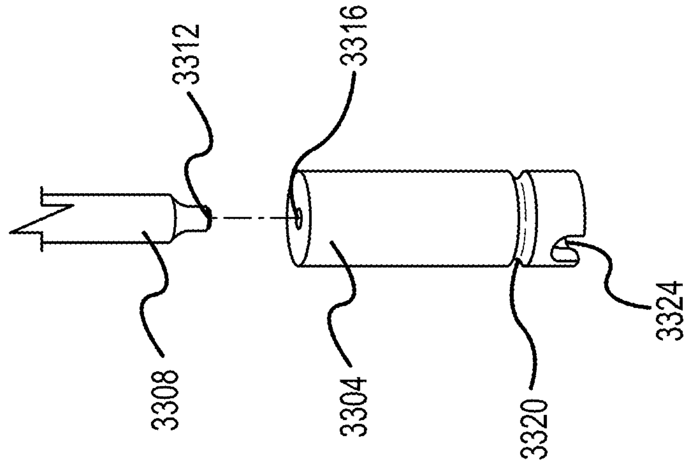

FIG.33B

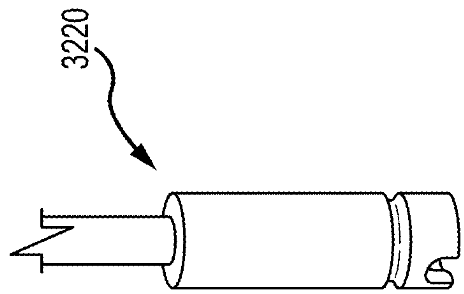

FIG.33C

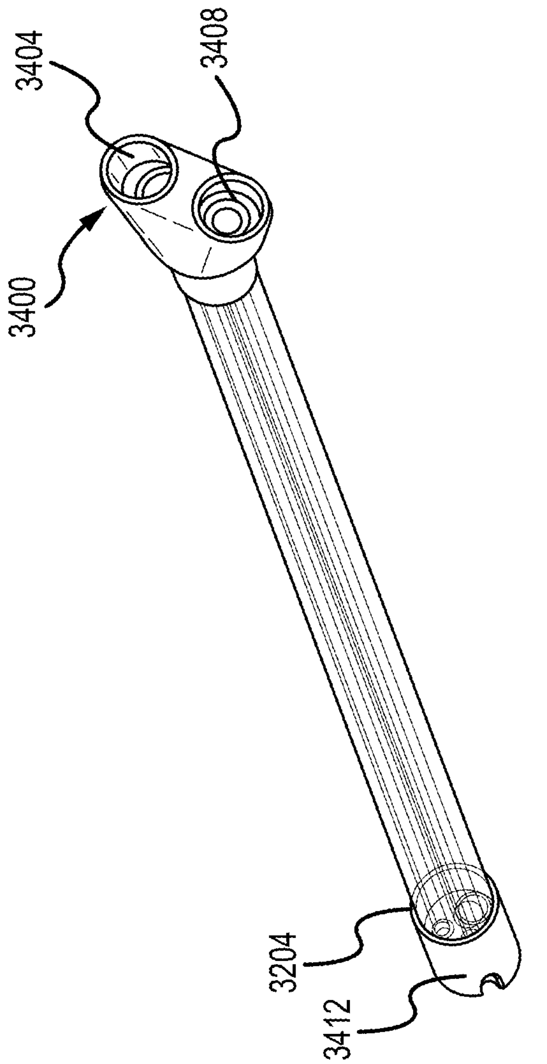

FIG.34A

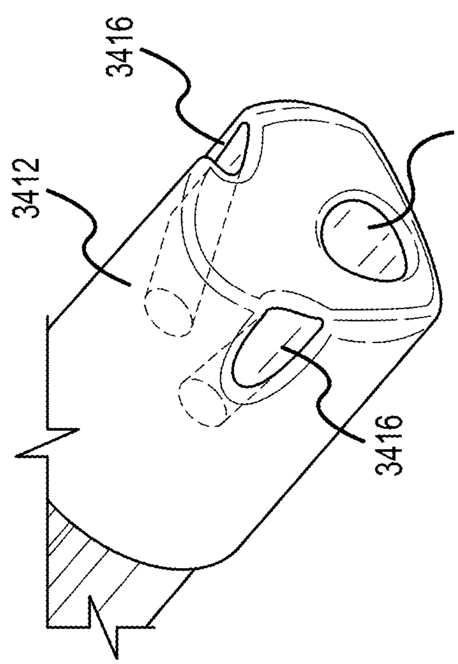

FIG.34B

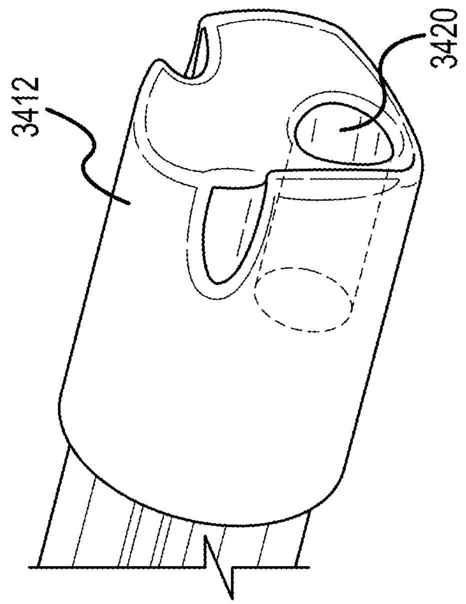

FIG.34C

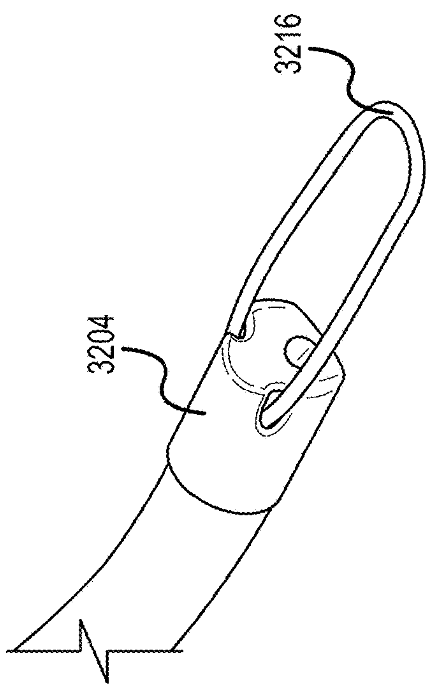

FIG.35A

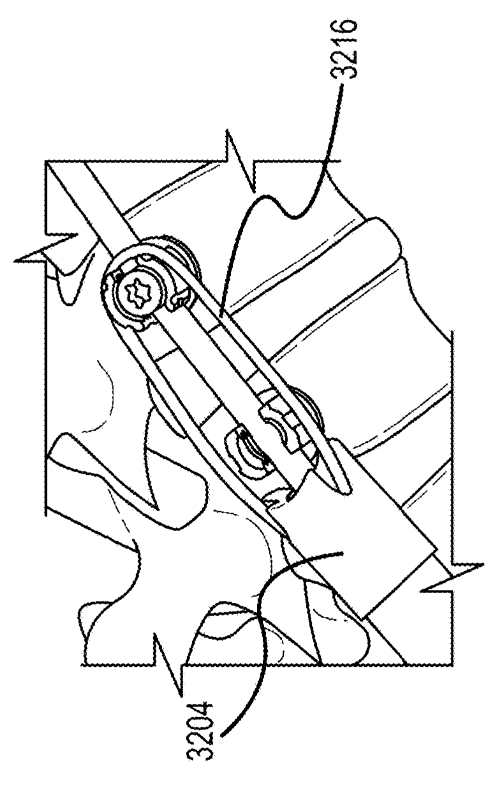

FIG.35B

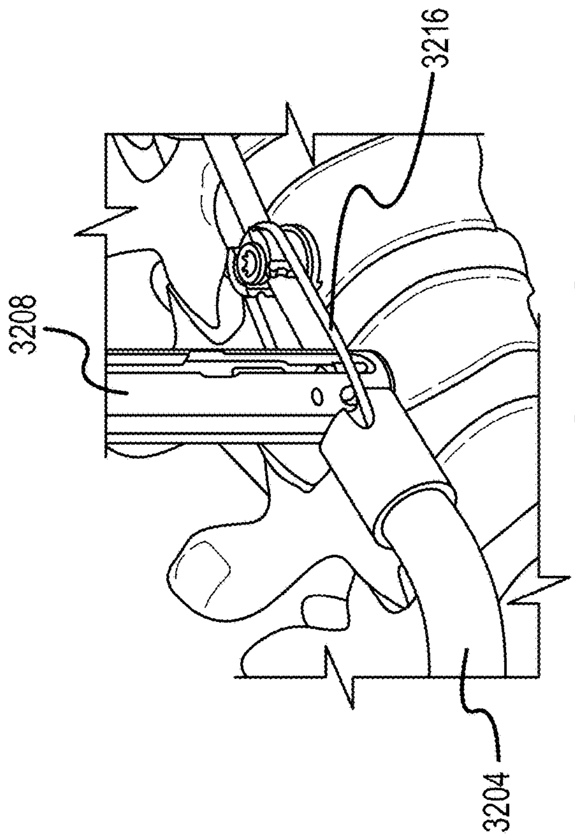

FIG.35C

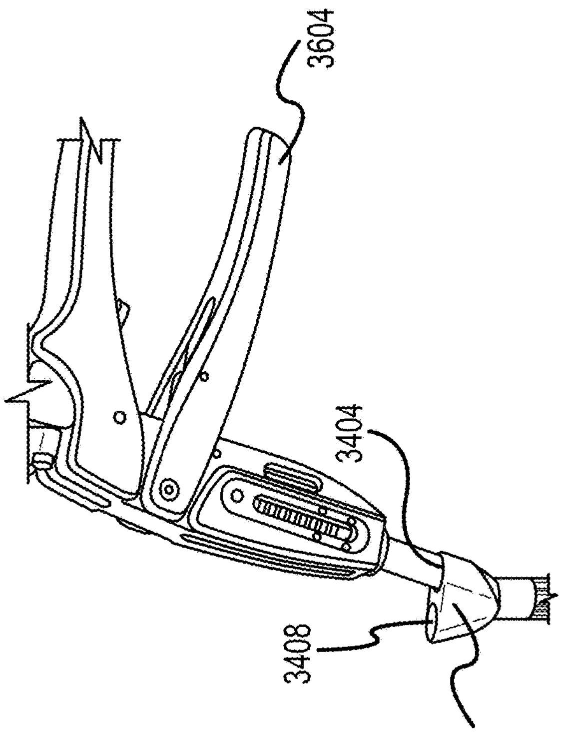

FIG.36A

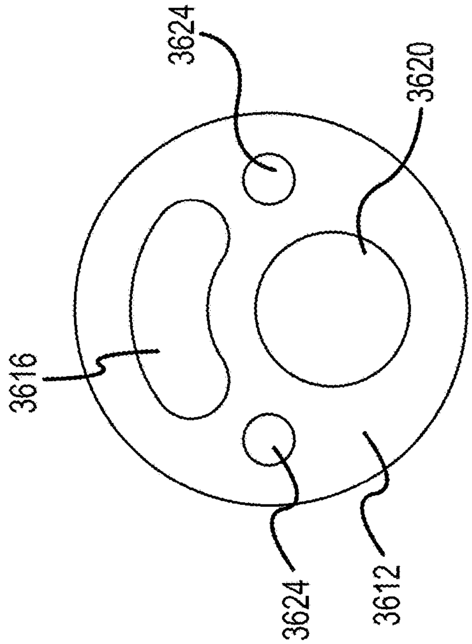

FIG.36C

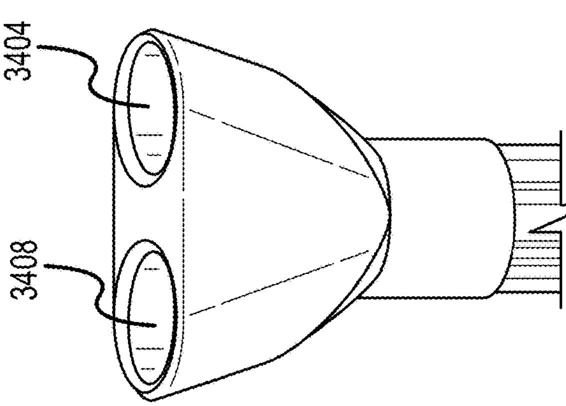

FIG.36B

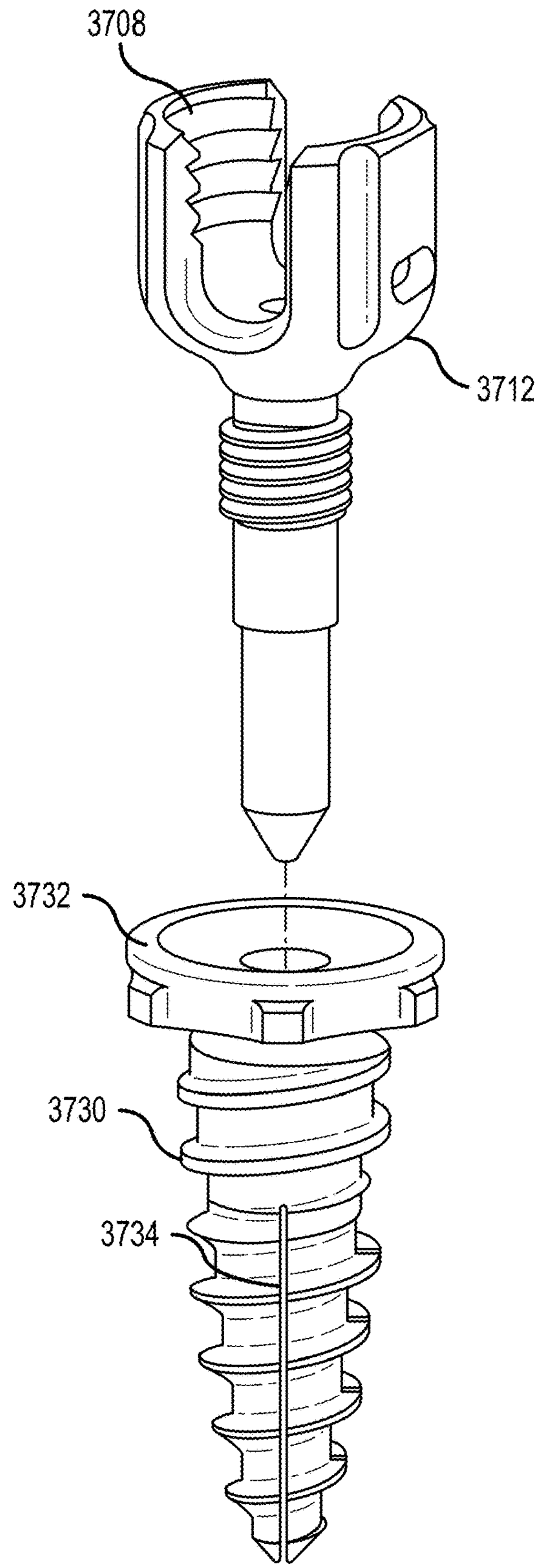

FIG.37A

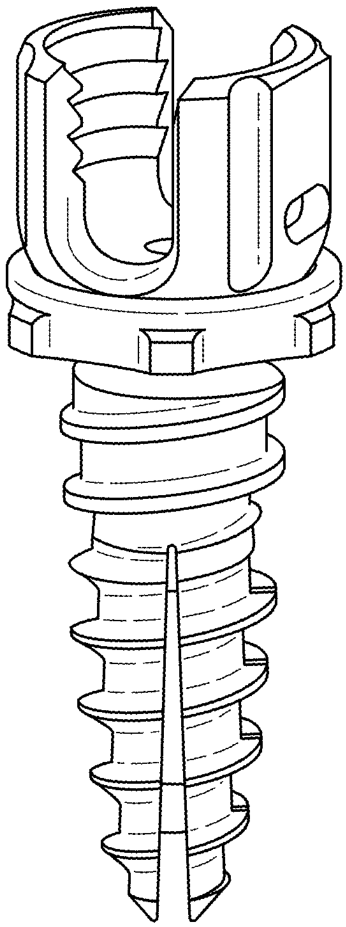

FIG.37B

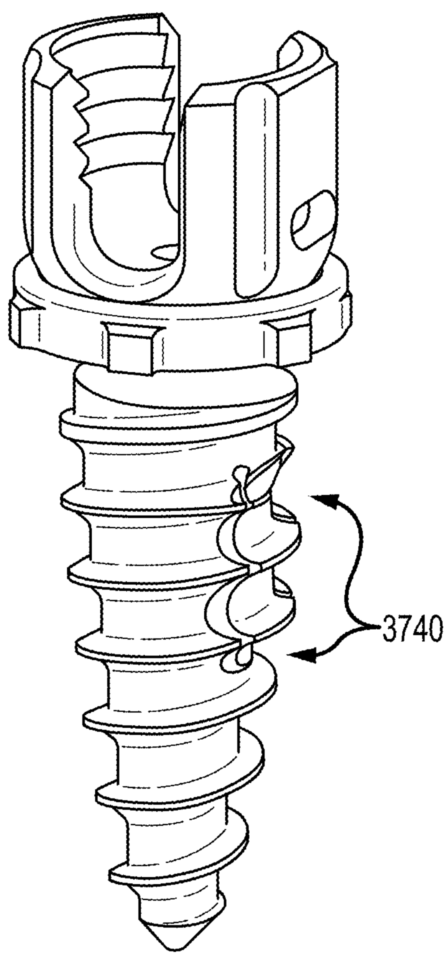

FIG.37C

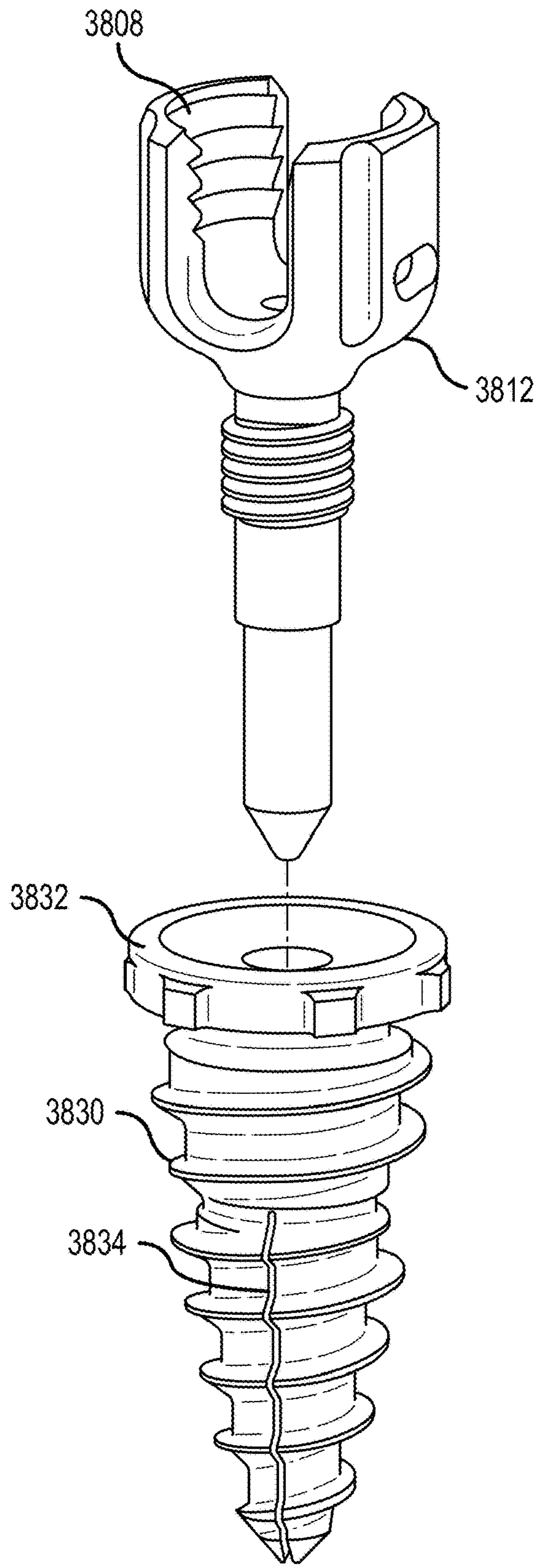

FIG.38A

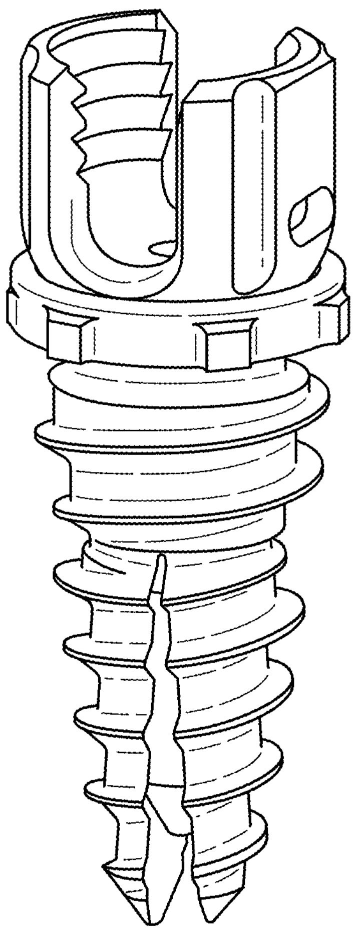

FIG.38B

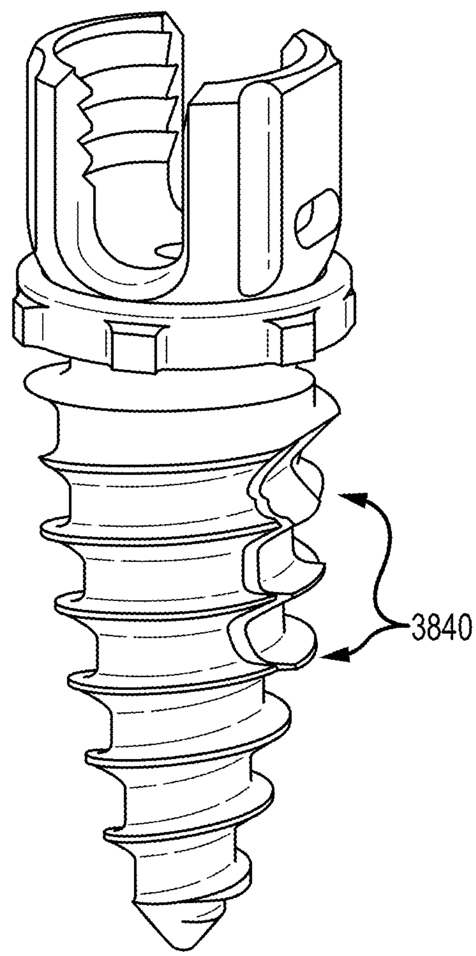

FIG.38C

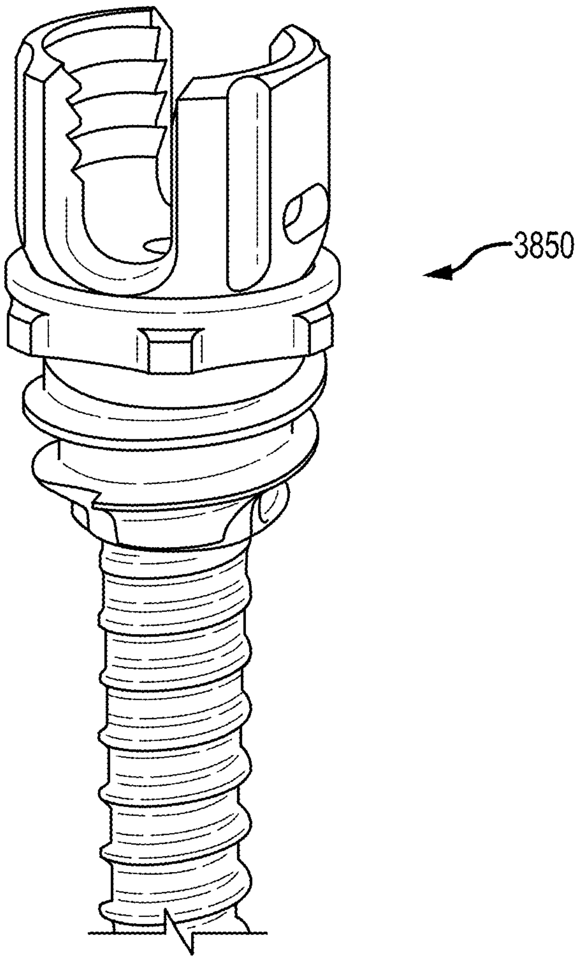

FIG.38D

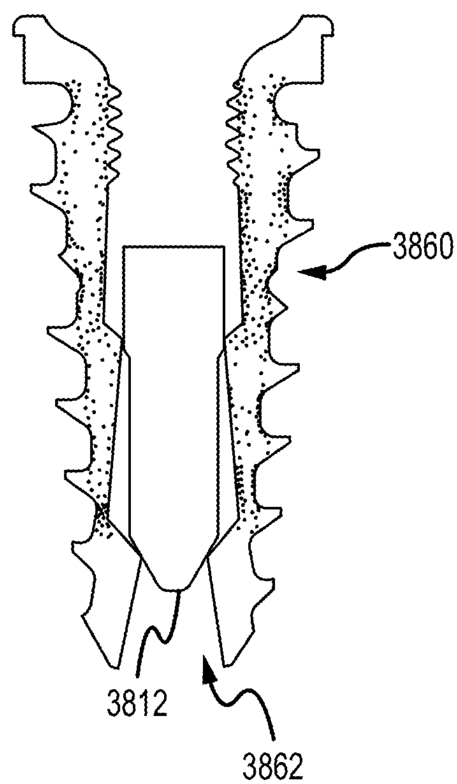

FIG.38E

SPINAL TENSIONING SYSTEM, DEVICE, AND METHOD

CROSS-REFERENCE TO RELATED APPLICATION

[0001] The present application claims the benefit of and priority, under 35 U.S.C. § 119, to U.S. Provisional Application Ser. No. 63/556,278 filed Feb. 21, 2024, entitled "SPINAL TENSIONING SYSTEM, DEVICE, AND METHOD" the entire disclosure of which is hereby incorporated herein by reference, in its entirety, for all that it teaches and for all purposes.

BACKGROUND

[0002] The present disclosure relates to surgical techniques and devices for use in correcting spinal deformities, such as scoliosis. More specifically, this disclosure discusses various vertebral implants for use in securing a flexible elongated member (e.g., tether or cord) between vertebral bodies and techniques for correction of spinal deformities using the disclosed implants.

[0003] Dynamic stabilization techniques, such as vertebral body tethering, are used in spinal treatment procedures for juveniles to permit enhanced mobility of the spine while also providing sufficient counter loading of a spinal curvature to effect treatment through bone growth modulation, particularly during times of rapid growth. Such dynamic stabilization systems may include fixed, uniaxial, or polyaxial bone anchors installed in adjacent or nearby vertebrae of the spine, various cord clamping devices, and a flexible cord secured to the bone anchors that may be tensioned between the bone anchors.

[0004] Current techniques and implants suffer from various deficiencies or potential failure modes as well as difficulties in implantation among other things. The following disclosure discusses various implants and surgical procedures to address these and other short comings with traditional approaches to spinal tethering.

BRIEF SUMMARY

[0005] Embodiments of the present disclosure were contemplated to address the above-noted issues of existing stabilization techniques. This disclosure recognizes, among other things, that improving various aspects of spinal tethering systems can involve improvements such as implant (e.g., bone screw and/or anchor) revisions to mitigate screw migration, cord securing mechanisms (e.g., cord clamping) to reduce stress on the cord or reduce implantation time, construct strengthening to reduce or eliminate construct failure, and construct changes to prevent overcorrection, among others. Details of various concepts are provided below.

[0006] One aspect of the present disclosure provides a bone anchor, which may include a screw comprising a head and a shank, where the shank defines a screw axis, and a connector attachable to the head of the screw, where the connector is configured to receive and secure a cord offset from the screw axis.

[0007] In some embodiments, the connector can comprise a connector body and connector cap that moves relative to the connector body.

[0008] In some embodiments, the bone anchor can include a set screw that threads into the connector body to secure the connector cap to the connector body.

[0009] In some embodiments, the connector body can comprise a cord receiver and wherein a size of the cord receiver changes as the connector cap moves relative to the connector body.

[0010] In some embodiments, the connector body can comprise a cord receiver having an open top end to receive the cord.

[0011] In some embodiments, the connector cap can comprise a clamp that retains the cord between the connector body and the connector cap and that limits the cord from sliding through the clamp when the connector cap is secured into the connector body.

[0012] In some embodiments, the bone anchor can include a staple through which the screw is inserted.

[0013] In some embodiments, the staple can comprise an extending surface having at least one additional opening for a second screw.

[0014] In some embodiments, the connector can align the cord with a screw axis of the second screw.

[0015] In some embodiments, the staple can comprise an extension having a cord support face to receive and secure at least one of a second cord and a second cord between a post and the cord support face.

[0016] In some embodiments, the staple can comprise an alignment feature.

[0017] In some embodiments, the alignment feature can be provided on a ring that is rotatable relative to a bottom portion of the staple.

[0018] In some embodiments, the bone anchor can include an anchor plate having a first opening and a second opening.

[0019] According to at least another embodiment, a bone anchor can be provided that includes: a first screw; a second screw; an anchor plate coupling the first screw with the second screw; and a cord receiver configured to couple a cord or second cord under tension with one or both of the first screw and second screw.

[0020] In some embodiments, the cord receiver can be integrally formed with the anchor plate.

[0021] In some embodiments, the cord receiver can be part of the first screw.

[0022] In some embodiments, the cord receiver can comprise a tulip head having internal threads to receive a set screw.

[0023] In some embodiments, the cord receiver and the anchor plate can comprise teeth that substantially prevent a relative rotation thereof when a face of the anchor plate contacts a face of the cord receiver.

[0024] In some embodiments, the first screw can extend through a first opening of the anchor plate and wherein the second screw extends through a second opening of the anchor plate.

[0025] In some embodiments, the first screw can draw the cord receiver into contact with the anchor plate and wherein the cord receiver abuts the anchor plate to substantially prevent the second screw from withdrawing out of the anchor plate.

[0026] According to at least another embodiment, a bone anchor can be provided that includes: a screw comprising a screw axis; and a cord receiver that moves relative to the screw axis along a track provided adjacent to a head of the screw.

[0027] In some embodiments, the track can comprise a curved track.

[0028] In some embodiments, the track can comprise a linear track.

[0029] In some embodiments, the cord receiver can comprise a slot that mates with the track.

[0030] In some embodiments, the bone anchor can further include: a first set screw that substantially fixes a position of the cord receiver relative to the screw; and a second set screw that substantially holds a cord within a tulip head of the cord receiver.

[0031] In some embodiments, both the first set screw and the second set screw can utilize a common threading in the cord receiver.

[0032] In some embodiments, the second set screw can thread through a center of the first set screw.

[0033] According to at least another embodiment, a system can be provided that includes: two or more bone anchors; and at least one of a second cord and a looped cord that couples the two or more bone anchors under a tensile force.

[0034] In some embodiments, the two or more bone anchors can be coupled with a cord and a second cord.

[0035] In some embodiments, the two or more bone anchors can comprise a first bone anchor, a second bone anchor, a third bone anchor, and a fourth bone anchor.

[0036] In some embodiments, a cord can apply a first tensile force between the first bone anchor and the second bone anchor and wherein the second cord can apply a second tensile force between the third bone anchor and the fourth bone anchor.

[0037] In some embodiments, the first and third bone anchors can be implanted in a first vertebra and wherein the second and fourth bone anchors can be implanted in a second vertebra.

[0038] In some embodiments, a first cord can apply a first tensile force between the first bone anchor and the second bone anchor and wherein a second cord can apply a second tensile force between the third bone anchor and the fourth bone anchor.

[0039] In some embodiments, at least one of the first cord and the second cord can comprise the looped cord.

[0040] In some embodiments, the at least one of a second cord and a looped cord can wrap around a notch in one of the two or more bone anchors.

[0041] In some embodiments, the notch can be provided around an axis of a first bone anchor in the two or more bone anchors.

[0042] According to at least another embodiment, a system can be provided that includes: a screw; a staple; and a looped cord that wraps around the screw and applies a tensile force to the screw.

[0043] In some embodiments, the system may further include a locking nut that engages the staple and secures the looped cord therebetween.

[0044] In some embodiments, the system may further include a ring that engages the staple, wherein the ring is positioned around the screw and directly contacts the looped cord.

[0045] In some embodiments, the ring may comprise a cord receiver to receive and at least partially retain the looped cord therein.

[0046] In some embodiments, the ring may be configured to rotate relative to the staple.

[0047] In some embodiments, the ring can comprise a friction fit to engage the staple.

[0048] In some embodiments, the ring can comprise a ring stop to engage the staple.

[0049] In some embodiments, the system may further include a second screw coupled with the screw via an anchor plate.

[0050] In some embodiments, the screw and the second screw can comprise a same type of screw.

[0051] In some embodiments, the screw and the second screw can comprise a different type of screw.

[0052] In some embodiments, the looped cord may directly contact the screw.

[0053] In some embodiments, the anchor plate and the staple can comprise features that substantially prohibit relative rotation thereof when the anchor plate is contacting the staple.

[0054] In some embodiments, the system may further include a locking nut that secures the looped cord around the screw.

[0055] According to at least another embodiment, a bone anchor can be provided that includes: a staple having at least one opening to receive a screw and at least one feature to receive a second cord or looped cord and to counteract a tensile force therein.

[0056] In some embodiments, the at least one feature can comprise a cord support face and a post that presses the second cord or looped cord into the cord support face.

[0057] In some embodiments, the cord support face can be provided on an extension of the staple.

[0058] In some embodiments, the staple can comprise one or more arms for extending into a bony structure.

[0059] In some embodiments, the staple can comprise a cord support face that presses the second cord or looped cord into the screw.

[0060] According to at least another embodiment, a system can be provided that includes: a screw; and a cord coupler that couples at least two cord portions together and that couples the at least two cord portions with the screw.

[0061] In some embodiments, the screw can comprise a tulip head to receive the cord coupler.

[0062] In some embodiments, the system may further include a set screw that secures the cord coupler into a head of the screw.

[0063] In some embodiments, the cord coupler can comprise a hole that exposes the at least two cord portions to the set screw.

[0064] In some embodiments, the at least two cord portions may belong to a common second cord.

[0065] In some embodiments, the at least two cord portions may belong to different cords.

[0066] In some embodiments, the system may further include a second screw, wherein the cord coupler extends between the screw and the second screw.

[0067] In some embodiments, a first set screw may connect the cord coupler to the screw and wherein the second set screw may connect the cord coupler to the second screw.

[0068] In some embodiments, the first set screw can secure a first cord portion to the cord coupler and wherein the second set screw can secure a second cord portion to the cord coupler.

[0069] According to at least another embodiment, a bone anchor can be provided that includes: a screw shank; and a head that receives at least one cord and at least one second cord.

[0070] In some embodiments, the head can comprise at least one lateral post to receive the at least one second cord.

[0071] In some embodiments, the head can comprise two lateral posts.

[0072] In some embodiments, the at least one lateral post can be integrally formed with the head.

[0073] According to at least another embodiment, a surgical system can be provided that includes: a surgical instrument having: a proximal end; a distal end; and an instrument body coupling the proximal end with the distal end, wherein the distal end comprises a passage to support manipulation of a second cord around at least one bone anchor.

[0074] In some embodiments, the distal end can comprise a first second cord passage, a second cord passage, and a cord passage, wherein the proximal end can comprise a first opening and a second opening, wherein the first opening is coupled with the cord passage via a primary passage lumen in the instrument body, and wherein the second opening can be coupled with both the first second cord passage and the second cord passage via at least one secondary passage lumen in the instrument body.

[0075] In some embodiments, the distal end can interface with a tensioning tower when the tensioning tower is coupled with a first bone anchor.

[0076] In some embodiments, the second cord can wrap around a second bone anchor when the distal end interfaces with the tensioning tower.

[0077] In some embodiments, the second cord can wrap around a screw attachment tower when the screw attachment tower is coupled with a second bone anchor.

[0078] In some embodiments, the screw attachment tower can comprise a second cord notch to substantially prohibit axial movement of the second cord along a body of the tower.

[0079] In some embodiments, the screw attachment tower can further comprise a cord notch to allow a cord to pass from the first bone anchor to the second bone anchor.

[0080] In some embodiments, the tensioning tower can comprise a deflectable member that moves under application of a tensile force against the deflectable member.

[0081] In some embodiments, the tensioning tower can comprise a force sensor that measures the tensile force.

[0082] In some embodiments, the measurement of the tensile force can be displayed to a surgeon via a user interface.

[0083] In some embodiments, the surgical system may further include a tensioning tip having a spring and housing that is configured to be deflected by tension applied to a cord by a cord tensioner.

[0084] In some embodiments, the surgical system may further include a pivot ladder that translates the tensile force to a motion of one or more linkages in the pivot ladder.

[0085] In some embodiments, the bone anchor can comprise a cone implant into which a screw with a cord receiver is threaded into a central threaded lumen of the cone implant.

[0086] In some embodiments, the bone anchor can comprise a cone implant into which a screw with a cord receiver is threaded, further comprising a laser cut at a distal, narrow tip of the cone implant that can allow the tip to splay when the screw with a cord receiver is threaded into a central threaded lumen of the cone implant.

[0087] In some embodiments, the bone anchor can comprise a cone implant into which a screw with a cord receiver is threaded, further comprising one or more U-shaped laser cuts along a side wall of the cone implant that can allow the U-shaped laser cut region to splay outwards from the cone side wall of the cone implant when the screw with a cord receiver is threaded into a central threaded lumen of the cone implant.

[0088] It is to be appreciated that any feature described herein can be claimed in combination with any other feature (s) as described herein, regardless of whether the features come from the same described embodiment.

[0089] The details of one or more aspects of the disclosure are set forth in the accompanying drawings and the description below. Other features, objects, and advantages of the techniques described in this disclosure will be apparent from the description and drawings, and from the claims.

[0090] 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. When each one of A, B, and C in the above expressions refers to an element, such as X, Y, and Z, or class of elements, such as X1-Xn, Y1-Ym, and Z1-Zo, the phrase is intended to refer to a single element selected from X, Y, and Z, a combination of elements selected from the same class (e.g., X1 and X2) as well as a combination of elements selected from two or more classes (e.g., Y1 and Zo).

[0091] The term "a" or "an" entity refers to one or more of that entity. As such, the terms "a" (or "an"), "one or more" and "at least one" can be used interchangeably herein. It is also to be noted that the terms "comprising", "including", and "having" can be used interchangeably.

[0092] The preceding is a simplified summary of the disclosure to provide an understanding of some aspects of the disclosure. This summary is neither an extensive nor exhaustive overview of the disclosure and its various aspects, embodiments, and configurations. It is intended neither to identify key or critical elements of the disclosure nor to delineate the scope of the disclosure but to present selected concepts of the disclosure in a simplified form as an introduction to the more detailed description presented below. As will be appreciated, other aspects, embodiments, and configurations of the disclosure are possible utilizing, alone or in combination, one or more of the features set forth above or described in detail below.

[0093] Numerous additional features and advantages of the present disclosure will become apparent to those skilled in the art upon consideration of the embodiment descriptions provided hereinbelow.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0094] The accompanying drawings are incorporated into and form a part of the specification to illustrate several examples of the present disclosure. These drawings, together with the description, explain the principles of the disclosure.

The drawings simply illustrate preferred and alternative examples of how the disclosure can be made and used and are not to be construed as limiting the disclosure to only the illustrated and described examples. Further features and advantages will become apparent from the following, more detailed, description of the various aspects, embodiments, and configurations of the disclosure, as illustrated by the drawings referenced below.

[0095] FIG. **1** is a block diagram of a system according to at least one embodiment of the present disclosure;

[0096] FIG. **2** is a block diagram illustrating details of the system shown in FIG. **1**;

[0097] FIGS. **3**A-**3**H illustrate a bone anchor according to at least some embodiments of the present disclosure;

[0098] FIG. **4** illustrates another example of a bone anchor according to at least some embodiments of the present disclosure;

[0099] FIGS. **5**A-**5**F illustrate another example of a bone anchor according to at least some embodiments of the present disclosure;

[0100] FIGS. **6**A-**6**D illustrate another example of a bone anchor according to at least some embodiments of the present disclosure;

[0101] FIG. **7** illustrates various examples of coupling bone anchors according to at least some embodiments of the present disclosure;

[0102] FIG. **8** illustrates an example of a second cord according to at least some embodiments of the present disclosure;

[0103] FIGS. **9**A-**9**C illustrate another example of a bone anchor according to at least some embodiments of the present disclosure;

[0104] FIGS. **10**A-**10**E illustrate another example of a bone anchor according to at least some embodiments of the present disclosure;

[0105] FIGS. **11**A-**11**C illustrate another example of a bone anchor according to at least some embodiments of the present disclosure;

[0106] FIGS. **12**A-**12**C illustrate another example of a bone anchor according to at least some embodiments of the present disclosure;

[0107] FIGS. **13**A-**13**E illustrate another example of a bone anchor according to at least some embodiments of the present disclosure;

[0108] FIGS. **14**A-**14**B illustrate another example of a bone anchor according to at least some embodiments of the present disclosure;

[0109] FIG. **15** illustrates another example of a bone anchor according to at least some embodiments of the present disclosure;

[0110] FIGS. **16**A-**16**D illustrate examples of bone anchor coupling according to at least some embodiments of the present disclosure;

[0111] FIG. **17** illustrates an example of coupling bone anchors together according to at least some embodiments of the present disclosure;

[0112] FIGS. **18**A-**18**B illustrate another example of a bone anchor and bone anchor coupling according to at least some embodiments of the present disclosure;

[0113] FIG. **19** illustrate another example of coupling bone anchors together according to at least some embodiments of the present disclosure;

[0114] FIGS. **20**A-**20**B illustrate a cord coupling system according to at least some embodiments of the present disclosure;

[0115] FIGS. **21**A-**21**B illustrate details of a snake tip used in a surgical instrument according to at least some embodiments of the present disclosure;

[0116] FIGS. **22**A-**22**C illustrate components of a surgical instrument according to at least some embodiments of the present disclosure;

[0117] FIGS. **23**A-**23**C illustrate a mechanism to measure tension according to at least some embodiments of the present disclosure;

[0118] FIGS. **24**A-**24**B illustrate an assembled surgical instrument according to at least some embodiments of the present disclosure;

[0119] FIG. **25** illustrates details of a component of a surgical instrument according to at least some embodiments of the present disclosure;

[0120] FIGS. **26**A-**26**D illustrate a force sensor useable in a surgical instrument according to at least some embodiments of the present disclosure;

[0121] FIGS. **27**A-**27**B illustrate details of an alternative snake tip used in a surgical instrument according to at least some embodiments of the present disclosure;

[0122] FIGS. **28**A-**28**D illustrate another example of a bone anchor according to at least some embodiments of the present disclosure;

[0123] FIG. **29** illustrates another example of a bone anchor according to at least some embodiments of the present disclosure;

[0124] FIGS. **30**A-**30**D illustrate an example of a staple useable with a bone anchor according to at least some embodiments of the present disclosure;

[0125] FIGS. **31**A-**31**D illustrate another example of a bone anchor and a system comprising a plurality of bone anchors according to at least some embodiments of the present disclosure;

[0126] FIG. **32** illustrates details of a surgical instrument used to couple and manipulate bone anchors according to at least some embodiments of the present disclosure;

[0127] FIGS. **33**A-**33**C illustrate details of a surgical instrument used to couple and manipulate bone anchors according to at least some embodiments of the present disclosure;

[0128] FIGS. **34**A-**34**C illustrate additional details of a surgical instrument from FIGS. **33**A-**33**C and FIG. **32**;

[0129] FIGS. **35**A-**35**C illustrate additional details of the surgical instrument from FIGS. **34**A-**34**C;

[0130] FIGS. **36**A-**36**C illustrate additional details of the surgical instrument from FIGS. **34**A-**34**C;

[0131] FIGS. **37**A-**37**C illustrate another example of a bone anchor comprising various cone implants according to at least some embodiments of the present disclosure; and

[0132] FIGS. **38**A-**38**E illustrate another example of a bone anchor comprising various cone implants according to at least some embodiments of the present disclosure.

DETAILED DESCRIPTION

[0133] Embodiments will now be described more fully with reference to the accompanying drawings. The present disclosure provides details on concepts for improving various aspects of a spinal tethering system, such as a spinal tethering system detailed in U.S. Pat. No. 10,653,453 titled "DYNAMIC STABILIZATION SYSTEMS AND ASSOCI-

ATED METHODS", which is hereby incorporated by reference in its entirety. The improvements discussed also relate to aspects of the spinal tethering instruments discussed in U.S. Pat. No. 10,905,474 titled "SURGICAL CORD TENSIONING DEVICES, SYSTEMS, AND METHODS" and U.S. Pat. No. 10,939,941 titled "SURGICAL CORD TENSIONING DEVICES, SYSTEMS, AND METHODS", which are both hereby incorporated by reference in their entirety. The improvements discussed also relate to aspects of the spinal tethering devices discussed in U.S. Patent Publication No. 2022/0226023 titled "SPINAL TETHERING DEVICES, SYSTEMS, AND METHODS", which is hereby incorporated by reference in its entirety.

[0134] The following description discusses various implants used in a spinal tethering system, such as bone screws, bone anchors, staples, and the like. Most spinal tethering systems utilize bone screw designs from traditional spinal fixation systems targeting similar portions of the spine, such as fixed head pedicle screws. These traditional bone screws were originally designed to couple solid spinal rods between vertebral bodies, and can induce unwanted stress on a flexible cord or tether when used in a spinal tethering system. Spinal fixation systems often include fixed, uni-axial, and multi-axial bone screws, where the screw head (e.g., tulip or saddle) is fixed or allowed to move (uni-axial or multi-axial) in reference to the shaft of the bone screw. Bone screws from spinal fixation systems were typically designed to receive spinal fusion rods rather than flexible elongate members, such as a cord or tether. The improvements outlined below are discussed in reference to these commonly available bone screw designs. The anchors referenced below involve an implant that is designed to surround at least a portion of a bone screw and engage surrounding bone surface to distribute loads from the bone screw over a greater area of cortical bone. Again, improvements outlined below to anchors are discussed in reference to these anchor or staple designs.

[0135] Bone screw and anchor designs discussed below can provide numerous benefits over traditional pedicle screws for use in spinal tethering. The benefits can include providing a stronger construct, reducing screw plow (e.g., movement/migration of the screw in the vertebral body over time), enhancing cord clamping, reducing cord breakage, reducing surgical procedure steps (eliminate multiple steps for separate anchor and screw placement), and providing for multiple mechanisms for coupling bone anchors to one another (e.g., to increase strength and provide redundancy).

[0136] Other devices discussed below include cord clamping mechanisms that deviate from use of set screws and typical tulip head pedicle screws. The cord clamping mechanisms discussed below provide benefits such as reducing stress points on the flexible cord, increasing holding strength, and allowing for controlled distribution of tension across multiple implant levels, among others. Additional benefits of each different implant is discussed below in reference to the illustrations of the specific designs.

[0137] Before any embodiments of the disclosure are explained in detail, it is to be understood that the disclosure is not limited in its application to the details of construction and the arrangement of components set forth in the following description or illustrated in the drawings. The disclosure is capable of other embodiments and of being practiced or of being carried out in various ways. Also, it is to be understood that the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting. The use of "including," "comprising," or "having" and variations thereof herein is meant to encompass the items listed thereafter and equivalents thereof as well as additional items. Further, the present disclosure may use examples to illustrate one or more aspects thereof. Unless explicitly stated otherwise, the use or listing of one or more examples (which may be denoted by "for example," "by way of example," "e.g.," "such as," or similar language) is not intended to and does not limit the scope of the present disclosure.

[0138] The terms proximal and distal are used in this disclosure with their conventional medical meanings, proximal being closer to the operator or user of the system, and further from the region of surgical interest in or on the patient, and distal being closer to the region of surgical interest in or on the patient, and further from the operator or user of the system.

[0139] Turning initially to FIG. **1**, a system is illustrated that may be used, for example, to correct a spinal deficiency of a patient. The system may include a plurality of bone anchors **112** implanted onto a patient anatomy. Illustratively, a bone anchor **112** may be implanted on one or more vertebra of the patient. Each bone anchor **112** may be implanted on a side of a vertebral body. The bone anchors **112** may be implanted on a lateral side of the vertebral body and, in some embodiments, may be implanted on the anterolateral aspect of the vertebral bodies on the convex side **104** of the curve formed in the patient's spine. Although the bone anchors **112** are illustrated as being implanted on the convex side **104** of the curve, it should be appreciated that one or more bone anchors **112** may be implanted on the concave side **108** of the curve formed in the patient's spine. For instance, a patient's spine may have multiple curves and it may be desirable to implant a plurality of cords **116** along different sides of the patient's spine. Bone anchors **112** may be implanted in the thoracic region and/or lumbar region. Illustratively, a bone anchor **112** may be implanted anywhere from T2-L5. The bone anchors **112** and the cord **116** may be implanted using one or more surgical instruments **120**. The surgical instrument(s) **120** may support a minimally-invasive surgical procedure where multiple, but relatively small, incisions are made in the patient.

[0140] Although the term "cord" is used herein to refer to element **116**, it should be appreciated that the term cord can encompass any element capable of applying tensile forces between two or more bone anchors **112**. Thus, a cord **116** may include a cord, rope, tape, polymer line, or the like. The cord **116** may be capable of elastic deformation under tensile loads.

[0141] Moreover, the system including a plurality of bone anchors **112** and a cord **116** may be configured in a number of different suitable ways. In one example, each bone anchor **112** may fixedly secure a portion of the cord **116** such that the cord **116** is not released from a bone anchor **112** once secured.

[0142] In another example, one or more bone anchors **112** may be configured to flexibly secure a portion of the cord **116** such that if tensile forces applied to the cord **116** exceed a predetermined amount, then the cord **116** may be allowed to "slip" or move relative to the bone anchor **112**. In such a configuration, the ability to allow the cord **116** to "slip" or move relative to the bone anchor **112** enables the entire implant system to share loads between bone anchors **112**

rather than having more loads applied at certain bone anchors **112** than other bone anchors **112**. In this manner, the likelihood of a cord **116** experiencing plastic deformation or total failure is reduced because the tensile forces are spread more evenly across the cord **116** instead of being concentrated at a particular location of the cord **116**.

[0143] As shown in FIG. **2**, the cord **116**, which may also be referred to as a “tether”, can be received at each bone anchor **112** via a tulip head or similar type of cord receiver. The cord **116** may then be attached to the bone anchor **112** with a set screw **204**. The set screw **204** may be placed over top of the cord **116**. Tightening of the set screw **204** within the tulip head or cord receiver of the bone anchor **112** may enable a secure connection between the cord **116** and bone anchor **112**. As tension is placed on the cord **116** then set screws **204** of adjacent bone anchors **112** are secured, a tension may be maintained in the cord **116** thereby causing tensile forces to be placed on adjacent bone anchors **112**. The tensile forces, coupled with patient growth, may help to correct spinal curvature of the patient. As can be appreciated, these tensile forces may place additional stress on the bone anchor(s) **112** and/or the vertebral bodies in which the bone anchor(s) **112** are implanted. Various embodiments provided herein provide solutions to help prevent migration of the bone anchor(s) **112** through the bone and/or decoupling of the bone anchor(s) **112** from the cord **116**.

[0144] With reference now to FIGS. **3**A-**3**H, a first example of a bone anchor **112** will be described in accordance with at least some embodiments of the present disclosure. The bone anchor **112** may be similar or have similar features to the other bone anchors depicted and described herein.

[0145] The bone anchor **112** illustrated in FIGS. **3**A-**3**H exhibit a modular implant design that allows assembly of various implants customized to the patient and procedure. The bone anchor **112** is depicted to include a screw **312**, a connector **308**, and a set screw **304**, The connector **308** may be constructed separately from the screw **312** and may be configured for attachment to the screw **312** even after the screw **312** has been implanted in a bone. In some embodiments, the connector **308** may comprise a modular design that enables different sizes or types of connectors **308** to be paired with different sizes or types of screws **312**.

[0146] The set screw **304** may provide a couple of different functions for the bone anchor **112**. In some embodiments, the set screw **304** comprises a threading that interfaces with threading on the screw **312**. The set screw **304** may also hold the connector **308** onto a top of the screw **312** once the set screw **304** is threaded into the corresponding threading of the screw **312**. The connector **308** may include a connector cap **316** and connector body **320** through which the set screw **304** passes to engage with the threading of the screw **312**. While the threading of the screw **312** to receive the set screw **304** is shown to be internal threading and the threading of the set screw **304** is shown to be external threading, it should be appreciated that alternative configurations are possible where the threading of the screw **312** to receive the set screw is external threading and the threading of the set screw **304** is internal threading.

[0147] The connector **308** also includes a cord receiver **324** that presents a passage for the cord **116**. The cord receiver **324** may be sized with an inner diameter that is larger than an outer diameter of the cord **116**, thereby allowing the cord **116** to slide through the cord receiver **324**. As shown in FIGS. **3**D and **3**E, as the set screw **304** is threaded into the screw **312** (e.g., further engaged and drawn into the body of the screw), the bottom of the set screw **304** may engage an upper surface of the connector cap **316**. The connector cap **316** may be drawn downward (e.g., into the connector body **320** and toward the screw **312**). Motion of the connector cap **316** as the set screw **304** is tightened may cause the connector cap to engage the cord **116** inside of the cord receiver **324**. In other words, tightening of the set screw **304** may cause the connector cap **316** to clamp down onto the cord **116**, thereby coupling the cord **116** with the bone anchor **112**. When the set screw **304** is fully tightened into the screw **312**, the diameter of the cord receiver **324** may be reduced and the cord **116** may be held between the connector cap **316** and the lower part of the cord receiver **324**. The cord **116** may be pinched within the cord receiver **324** to prevent the cord **116** from moving relative to the bone anchor **112**.

[0148] FIGS. **3**F-**3**H illustrate an alternative configuration of a connector **308** whereby the connector **308** is capable of receiving the cord **116** via a top opening **328** in the cord receiver **324**. This particular configuration of connector **308** still exhibits a connector body **320** and connector cap **316**; however, the connector cap **316** in this particular configuration also comprises a clamp **332** to complete the cord receiver **324**. The clamp **332** may also include a number of ribs or teeth that help engage the cord **116** when the cord **116** is positioned within the cord receiver **324**. Tightening of the set screw **304** may cause the connector cap **316** to move downward, thereby closing the size of the cord receiver **324** and pinching the cord **116** within the cord receiver **324**. Utilization of a connector **308** with a top opening **328** may facilitate easier access for the cord **116** into the cord receiver **324** since the cord **116** is no longer required to be threaded through the cord receiver **324**. Instead, the screw **312** can be implanted and the connector body **320** can be attached to the top of the screw **312** before the cord **116** is placed into position in the cord receiver **324**.

[0149] The connector body **320** may rest atop a body-screw interface **336** of the screw **312**. In particular, the screw **312** may be provided with a shoulder or similar face for the body-screw interface **336** that supports the bottom surface of the connector body **320**. Thus, tightening of the set screw **304** will not cause the connector body **320** to move relative to the screw **312**. Instead, tightening of the set screw **304** will cause the connector cap **316** to move downward into the connector body **320** as the connector cap **316** also moves downward into the screw **312**. The connector cap **316** may be retained within the connector body **320** with a cap fitting **340** that substantially prevents the connector cap **316** from rotating within the connector body **320**. Thus, the connector cap **316** is only moving translationally (e.g., upward or downward) with respect to the connector body **320** while the set screw **304** is turned.

[0150] As tension is placed on the cord **116** (e.g., during installation) and a predetermined amount of tension is present in the cord **116**, then the set screw **304** may be tightened to secure the cord **116** relative to the bone anchor **112**. The connector **308** is configured to offset the cord receiver **324** from the axis of the screw **312**. Offsetting the cord **116** from the axis of the screw **312** may help to relieve certain forces that might otherwise urge the screw **312** out of the vertebral body or cause the screw **312** to migrate through the vertebral body.

[0151] FIG. **4** illustrates another example of a modular bone anchor **112** according to at least some embodiments of the present disclosure. The bone anchor **112** is shown to include a plurality of screws **312** coupled together with an extending staple **404**. In the illustrated configuration, the extending staple **404** includes a primary staple for interfacing with one of the screws **312** as well as an extension that interfaces with the other of the screws **312**. In some embodiments, the portion of the extending staple **404** that includes the primary staple may also include a threaded receiver for connection with a connector **308**. The illustrated configuration also shows that the connector **308**, when attached to the threaded receiver of the extending staple **404**, places the cord receiver substantially over top of the second screw **312**. In this way, the connector **308** is provided with a connection strength of two screws **312** with a bony structure, thereby counteracting ploughing and other screw migration issues.

[0152] In some embodiments, the connector **308** may be placed over top of the extending staple **404**, then the set screw **304** of the connector **308** may attach the connector **308** with the extending staple **404**. Utilization of the extending staple **404** may also enhance the connection between the bone anchor **112** and the bony structure into which the anchor **112** is placed.

[0153] FIGS. **5**A-**5**F illustrate still further possible configurations of a bone anchor **112** in accordance with at least some embodiments of the present disclosure. The bone anchor **112** illustrated herein is shown to include a first screw **312** connected with a cord receiver **508** and a second screw **312** connected with an anchor plate **504**. FIG. **5**D illustrates a configuration where the first screw **312** is placed through one hole of the anchor plate **504** to situate the cord receiver **508** on the anchor plate **504**.

[0154] In some embodiments, the anchor plate **504** may include a piece of material having at least two holes, each of which is configured to receive a different screw **312**. The cord receiver **508** may be similar to other cord receivers **324** or connectors **308** depicted and described herein. For instance, the cord receiver **508** may include a tulip head having an opening for receiving a cord **116**. The tulip head of the cord receiver **508** may also include a threaded receiver to accept a set screw **304**. As the set screw **304** is tightened into the threaded receiver of the cord receiver **508**, the set screw **304** may substantially fix a position of the cord **116** relative to the cord receiver **508**.

[0155] The first screw **312** that interfaces with the cord receiver **508** may be positioned within the cord receiver **508** such that axial motion of the screw **312** translates directly to axial motion of the cord receiver **508**. The first screw **312** may be separate from the cord receiver **508** or may be integrally formed with the cord receiver **508**.

[0156] The second screw **312** that interfaces with the anchor plate **504** may be positioned within the anchor plate **504** such that axial motion of the screw **312** translates directly to axial motion of the anchor plate **504**. The second screw **312** may be separate from the anchor plate **504** or may be integrally formed with the anchor plate **504**. Moreover, when the cord receiver **508** is positioned over the anchor plate **504**, the second screw **312** may be substantially prohibited from being removed from the anchor plate **504**. In other words, the cord receiver **508**, when overlapping and abutting the anchor plate **504**, may vertically fix the second screw **312** into the anchor plate **504**.

[0157] FIGS. **5**E and **5**F illustrate two possible configurations of the anchor plate **504** and cord receiver **508**. In one configuration, the anchor plate **504** may include a substantially planar top surface and the cord receiver **508** may include a substantially planar bottom surface for interfacing with and contacting the substantially planar top surface of the anchor plate **504**. In another configuration, the anchor plate **504** and/or cord receiver **508** may be provided with interface features or locking features that help prohibit relative rotation between the anchor plate **504** and the cord receiver **508** when the two components abut one another. In particular, one or both of the anchor plate **504** and cord receiver **508** may be provided with teeth **512** that substantially help to secure a lateral connection between the anchor plate **504** and cord receiver **508**.

[0158] In some embodiments, the anchor plate **504** includes a first set of teeth and the cord receiver **508** includes a second set of teeth that are designed to mate with (e.g., interlock, mesh, etc.) the first set of teeth provided on the anchor plate **504**. Peaks of one set of teeth may be designed to mate with valleys of the other set of teeth when the anchor plate **504** abuts the cord receiver **508**.

[0159] In some embodiments, the footprint of the anchor plate **504** and/or cord receiver **508** may be designed to fit within a vertebra. As an example, the footprint of the anchor plate **504** and/or cord receiver **508** may have a maximum width of 14.00 mm or less, thereby enabling the entire structure to be inserted through a Minimally Invasive Surgical (MIS) port or instrument.

[0160] FIGS. **6**A-**6**D illustrate another configuration of a bone anchor **112** in accordance with at least some embodiments of the present disclosure. The bone anchor **112** is shown to facilitate minor translations (e.g., lateral movements) of the cord **116**. Specifically, and without limitation, the bone anchor **112** may include a screw **312**, a cord receiver **604**, and a track **608**. The geometries of the cord receiver **604** and track **608** may create a cord housing that is capable of translating relative to the screw **312** shank to allow for 'misalignment' of screws while maintaining a straight cord **116** path. In this design, the cord receiver **604** moves on a curved surface (e.g., the track **608**) within the medial lateral plane of the patient for a posterior approach to the spine, but it is the anteroposterior plane for the lateral approach described herein.

[0161] It may also be possible to design the track **608** with a flat configuration rather than an arcuate configuration. An advantage to using an arcuate track **608** is that translation of the cord **116** is enabled, but the instrument used to insert the screw **312** into bone can be inserted through the same port as the cord receiver **604**. If not intended to be inserted separately then access to cord receiver **604** for instrument interface and set screw insertion can be achieved through the same port used to insert screw **312**. It could also translate on a flat surface, but the benefit of the curve is that the set screw instrument could be inserted thru the same port.

[0162] During installation of the bone anchor **112**, the screw **312** and cord receiver **604** may be driven together into the bony structure. Even with the screw **312** fully inserted into bone, the cord receiver **604** may be allowed to translate by moving along the track **608**. As shown in FIG. **6**D, the cord receiver **604** may have a feature that mates with the track **608** and slides along the track. In particular, the cord receiver **604** may have a slot with a top portion **616** positioned above the slot and a bottom portion **612** positioned below the slot. The dimensions of the slot separating the portions of the cord receiver **604** may be larger than the width of the track **608**, thereby facilitating motion of the cord receiver **604** along the track **608**.

[0163] The track **608** may be provided as a movable member of the cord receiver **604** and may have tabs that limit the amount of movement the track **608** can have relative to the cord receiver **604**. The track **608** may include a hole therein that fits over top of the head of the screw **312**. The track **608** may be assembled by sliding through slide slot and holding it in place over the head of the screw **312** by means of a compression saddle insert (not shown) that is inserted through the top cord receiver of the tulip head, or alternatively through a side slot of the tulip head and held in place by a shoulder or other engagement feature on the head of the screw **312**. The interaction between the hole in the track **608** and the shoulder on the screw **312** head may hold the two components together.

[0164] The cord receiver **604**, configured with a tulip head, may further include threading **620** to receive one or more set screws. For example, a first set screw may be used to push on the tulip head to secure the assembly (e.g., substantially fix a relative position of the cord receiver **604**, track **608**, and screw **312**). A second set screw (either thru the center of the first set screw, or using the same housing threads **620**) would lock the cord **116** within the tulip head of the cord receiver **604**. Once the first and second set screws are tightened, the cord receiver **604** may stop translating relative to the screw **312** and the cord **116** may be substantially fixed within the cord receiver **604**.

[0165] Referring now to FIGS. **7** and **8**, additional details of other mechanisms for coupling two or more bone anchors **112** together will be described in accordance with at least some embodiments of the present disclosure. Up to now, a cord **116** has been described as the mechanism for coupling two or more bone anchors **112** via tensile forces. FIGS. **7** and **8** illustrate another coupling mechanism that can be used to apply tensile forces between two or more bone anchors **112**.

[0166] Embodiments of the present disclosure contemplate use of a second cord **708** as a coupling mechanism. A second cord **708** may be used alone to couple two or more bone anchors **112** or a second cord **708** may be used in combination with another coupling mechanism (e.g., another second cord **708**, a cord **116**, combinations thereof, etc.).

[0167] A second cord **708** may be provided, in some embodiments, as a component to supplement a cord **116**. A second cord **708** may be provided as a bundled second cord as shown in FIG. **8**, or the second cord **708** may be constructed similarly to the cord **116**. In some embodiments, a cord **116** may be used to couple all bone anchors **112** within a system, whereas a second cord **708** may be used as a supplement to the cord **116** to couple only particular bone anchors **112** in the system. Said another way, a second cord **708** may be provided to help increase tensile strength between bone anchors **112** at specific levels or segments of the patient's spine where increased forces are anticipated. The second cord **708** may be left in the system along with the cord **116**. Alternatively, the second cord **708** may be used to aid in construction of the system (e.g., to provide a method of tensioning specific levels), but the second cord **708** may not be left in the patient after surgery. For instance, a second cord **708** may be used to hold correction of two adjacent bone anchors **112** during surgery, but may be removed during surgery as well.

[0168] A construct with supplemental fixation (e.g., a second cord **708** and a cord **116** coupled to common bone anchors **112**) is shown as one example of fixation in FIG. **7**. Other possible constructs of supplemental fixation are shown where two coupling mechanisms are connected to separate bone anchors **112** on the same vertebra. The two coupling mechanisms may include a cord **116** and second cord **708** or two cords **116**.

[0169] Because the present disclosure contemplates use of two different coupling mechanisms attaching to a single bone anchor **112**, embodiments of the present disclosure also contemplate various examples of bone anchors **112** that accommodate multiple coupling mechanisms. A first example of a bone anchor **112** that accommodates two or more coupling mechanisms will be described in connection with FIGS. **9**A-**9**C. In this particular configuration, the bone anchor **112** is shown to include a shank with a cord receiver **904** and notch **908**. The notch **908** may be positioned between the shank and the cord receiver **904**. In the illustrated embodiments, the notch **908** may wrap entirely around the circumference of the bone anchor **112** (see FIG. **9**A). In another configuration, the notch **908** may wrap around the circumference of the bone anchor **112**, but the cord receiver **904** may include one or more planar surfaces that interrupt a portion of the notch **908** (see FIG. **9**B). In another configuration, two or more non-continuous notch features **908** may be provided at different sides of the cord receiver **904** (see FIG. **9**C).

[0170] FIGS. **10**A-**10**E illustrate an alternative configuration of bone anchors **112** that facilitate coupling by two or more coupling mechanisms. In particular, a bone anchor **112** is depicted with a modular configuration where a staple **1008** is provided with a receiver for a second cord **708**, which may also be referred to as a looped cord **1012**. The staple **1008** may comprise an annular ring to have a screw **312** pass therethrough. The staple **1008** may also include threads **1016** that interface with a locking nut **1004**. The locking nut **1004** may also include threads **1016** to couple with threads **1016** of the staple **1008**.

[0171] In some embodiments, the locking nut **1004**, when screwed onto the staple **1008**, may secure a looped cord **1012** therebetween. In particular, a looped cord **1012** may be used to couple two different screws **312** together and may be substantially secured to each screw **312** via the locking nut **1004** and staple **1008**. FIG. **10**A illustrates an example where each screw **312** is provided with its own locking nut **1004** and staple **1008**, then the looped cord **1012** is configured to be secured between each the locking nut **1004** and staple **1008**. The looped cord **1012** may be first secured to one of the screws **312**, then tension may be placed on the looped cord **1012**. After a predetermined amount of tension has been placed on the looped cord **1012**, the locking nut **1004** around the other screw **312** may be tightened to secure the assembly of two screws **312** via the looped cord **1012**.

[0172] Each screw **312** may be configured to pass through the staple **1008**, meaning that an outer diameter of the screw **312** is less than an inner diameter of the staple. The screw **312** may interface with an inner surface of the staple **1008** (e.g., via a complimentary thread) or the inner surface of the staple **1008** may be substantially planar such that the staple **1008** freely passes over the shank of the screw **312** without interfacing with the threads **1016**.

[0173] The locking nut **1004** may comprise an inner diameter that is less than a shoulder of the tulip head of the screw **312**, thereby prohibiting the locking nut **1004** from passing above the tulip head of the screw **312**. In some embodiments, the staple **1008** may be first implanted on the bony structure, then the locking nut **1004** may be placed over the shank of the screw **312**. After the locking nut **1004** is placed over the shank of the screw **312**, the screw **312** may be implanted in the bony structure through the staple **1008**. A looped cord **1012** may be placed between the locking nut **1004** and staple **1008**, then placed under tension before the locking nut **1004** is finally threaded down onto the staple **1008**. Alternatively, or additionally, a different order of operations could be followed where screw **312** is not fully inserted/implanted into the bony structure (e.g., such that the tulip head of the screw **312** does not fully abut the locking nut **1004** in a locked position) until the looped cord **1012** is placed in its desired position. After placement of the looped cord **1012**, the screw **312** may be fully inserted/implanted into the bony structure.

[0174] As shown in FIGS. **10**B-**10**E, the threads **1016** may be realized in a number of different ways. In one example (e.g., FIGS. **10**B and **10**C), the locking nut **1004** may have threads **1016** on its outer diameter and the staple **1008** may have threads **1016** on its inner diameter. In another example (e.g., FIGS. **10**D and **10**D), the locking nut **1004** may have threads **1016** on its inner diameter and the staple **1008** may have threads **1016** on its outer diameter. Both the locking nut **1004** and staple **1008** may have platforms for pinching the looped cord **1012** therebetween.

[0175] FIGS. **11**A-**11**C illustrate another possible example of a staple **1108** that may be used to help limit an axial motion of a looped cord **1012** relative to a screw **312**, in accordance with at least some embodiments. The embodiment of FIGS. **11**A-**11**C exhibit a ring **1104** that retains the looped cord **1012**. The ring **1104** may be assembled onto a top of the staple **1108** via a snap fit or friction fit **1116**. The ring **1104** may be initially separate from the staple **1108** or may be assembled with the staple **1108**. When the ring **1104** is snapped into place of the staple **1108**, the ring **1104** may still be allowed to rotate about the staple **1108**, but axial movement of the staple **1108** and ring **1104** may be substantially minimized or prohibited.

[0176] The configuration using a snap fit or friction fit **1116** enables the ring **1104** to be pressed into a mating configuration with the staple **1108** via the screw **312**. In other words, as the screw **312** is inserted through the staple **1108**, the shoulder of the tulip head of the screw **312** may drive the ring **1104** down onto the staple **1108**. After the screw **312** has been driven into the staple **1108** enough, the ring **1104** may snap into place via the friction fit **1116**. This snapping may secure the assembly of the screw **312**, ring **1104**, and staple **1108** from further axial movement. The ring **1104** may still rotate about the staple **1108** as the looped cord **1012** is placed around a cord receiver **1112** of the ring **1104**.

[0177] The cord receiver **1112** may correspond to a notch or opening that is sufficiently sized to receive the looped cord **1012**. The cord receiver **1112** may also include a geometry that snaps around the looped cord **1012**. For example, the cord receiver **1112** may include a notch with lips that secure the looped cord **1012** within the notch of the cord receiver **1112**. The notch and lips may prohibit the looped cord **1012** from leaving the cord receiver **1112** unless a substantial amount of force is placed thereon. Otherwise, the looped cord **1012** may slide around the ring **1104** in a relatively free range of motion, while still maintaining some contact with the ring **1104**. In this particular configuration, the looped cord **1012** may be inserted after screw **312** insertion, but prior to an additional cord **116** being inserted and fixed between the tulip heads of the screw **312**.

[0178] Referring now to FIGS. **12**A-**12**C, yet another possible anchor configuration will be described in accordance with at least some embodiments of the present disclosure. The configuration of FIGS. **12**A-**12**C is similar to the configuration of the bone anchor in FIGS. **11**A-**11**C, except that the ring **1204** does not include a snap fit or friction fit with the staple **1208**. The bone anchor is shown to include a ring **1204** having a cord receiver and a staple **1208** configured to receive the ring **1204**. The ring **1204** and staple **1208** may include a ring stop feature **1212** that substantially prohibits the ring **1204** from passing beyond the staple **1208**. The ring stop feature **1212** is different from a snap fit or friction fit **1116** in that the ring stop feature **1212** limits relative motion of the ring **1204** and staple **1208** in only one axial direction. Even when resting against the staple **1208**, the ring **1204** may still be removed from the staple **1208** in an upward direction, unless a shoulder of the tulip head of screw **312** exists and screw **312** is inserted through anchor **1208**.

[0179] FIGS. **13**A-**13**E illustrate further possible configurations of a bone anchor in accordance with at least some embodiments of the present disclosure. In particular, FIG. **13**A is shown to include a first screw type **1304** and second screw type **1308** that are coupled to one another via a staple **1312** and anchor plate **1316** assembly. The first screw type **1304** is shown to include a tulip head for receiving a cord **116** whereas the second screw type **1308** is shown to include a flat top and does not directly interface with a cord **116**. The second screw type **1308** may be provided to improve connectivity between the bone anchor and the bony structure and to limit migration of the bone anchor through the bony structure (e.g., to prevent ploughing).

[0180] The staple **1312** may be configured to have one of the screws (e.g., the first screw type **1304**) pass therethrough. The staple **1312** may further include one or more features on its top surface that interface with mating features of the anchor plate **1316**. The features on the top surface of the staple **1312** and the bottom surface of the anchor plate **1316** may substantially prohibit rotation of the two elements, when the features mate with one another.

[0181] The anchor plate **1316** may include two holes or openings. The first hole or opening may be configured to align with the opening of the staple **1312**. The second hole or opening of the anchor plate **1316** may be configured to receive the second screw type **1308** or **1320**. In the configuration of FIG. **13**A, the head of the second screw type **1308** may sit below a top surface of the anchor plate **1316**, but the head of the second screw type **1308** may not pass through the second hole or opening of the anchor plate **1316**. In the configuration **13**C, the head of the second screw type **1320** may sit above the top surface of the anchor plate **1316** but should not extend above the head of the first screw type **1304**. The anchor plate **1316** helps to couple the two screws together as well as interface with the staple **1312**.

[0182] While the first screw type **1304** is shown to have a larger shank diameter than the second screw type **1308** and **1320**, it should be appreciated that such a configuration is not required. For instance, the first screw type **1304** and second screw type **1308** or **1320** may have the same shank diameters or the second screw type **1308** or **1320** may have a shank diameter that is greater than the shank diameter of the first screw type **1304**.

[0183] FIG. **13**B illustrates an embodiment where two screws of the same type are coupled to one another with the anchor plate **1316**. In this particular embodiment, two screws of the first screw type **1304** are coupled to one another via the anchor plate **1316**. Both screws **1304** may be configured to receive a cord **116**, second cord **708**, or the like.

[0184] FIG. **13**D illustrates another embodiment where a first screw type **1304** is inserted through a staple **1332**, but a different type of staple **1332** is used as compared to previous configurations. The staple **1332** is designed to interface with an anchor plate having an integrated tulip head **1324**. The anchor plate with integrated tulip head **1324** may be axially fixed relative to the staple **1332** via a locking nut **1328**. The locking nut **1328** may be used to tighten the anchor plate onto the top surface of the staple **1332**. More specifically, the staple **1332** may include threads **1340** that interface with the locking nut **1328** and ribs **1336** that interface with the anchor plate. As the locking nut **1328** is tightened onto the threads **1340**, the anchor plate with integrated tulip head **1324** may be pressed down onto the staple **1332**. Ribs **1336** on the staple **1332** may help secure the anchor plate in rotation relative to the staple **1332**.

[0185] In some embodiments, the first screw type **1304** may be inserted through the staple **1332** and anchor plate. In other embodiments, it may be suitable to use other screw types (e.g., a second screw type **1308** or third screw type **1320**) in connection with the anchor plate having the integrated tulip head **1324** to achieve the embodiment illustrated in FIG. **13**D.

[0186] FIG. **13**E illustrates another embodiment where a looped cord **1012** is wrapped around the first screw type **1304**. This particular configuration again shows the first screw type **1304** and second screw type **1308** coupled to one another via an anchor plate **1316**. A locking nut **1328** is also shown to secure a looped cord **1012** onto a top surface of the anchor plate **1316**.

[0187] With reference now to FIGS. **14**A and **14**B, an improved staple **1404** will be described in accordance with at least some embodiments of the present disclosure. The staple **1404** is shown to include a feature that enables cooperation with a second cord **708** or looped cord **1012**. In particular, the staple **1404** is shown to include an extension **1408** having a cord support face **1412**. The extension **1408** may also include a threaded hole into which a post **1416** can be inserted and tightened.

[0188] A second cord **708** or looped cord **1012** may be configured to wrap around the shank of the post **1416** and then be pinched between a head of the post **1416** and the cord support face **1412**. The extension **1408** may be integrally formed with the rest of the staple **1404**. In some embodiments, the post **1416** may include a feature that prohibits the post **1416** from being completely removed from the extension **1408**. In other words, the post **1416** may be a movable part of the staple **1404**, but may not be configured to be removed from the staple **1404** unless unnecessary or undesired forces are placed thereon.

[0189] With reference now to FIG. **15**, another example of a bone anchor will be described in accordance with at least some embodiments of the present disclosure. The bone anchor is shown to include a screw **1504** with a shank. The screw **1504** may also include a tulip head having a lower surface configured to interface with a second cord **708** or looped cord **1012**. In some embodiments, the bone anchor may further include a staple **1508** that can receive the screw **1504** and that can secure a second cord **708** or looped cord **1012** between its cord support face **1512** and the tulip head of the screw **1504**.

[0190] In some embodiments, the second cord **708** or looped cord **1012** may wrap around the head of screw **1504** and mate with the neck of the screw before the screw is fully seated. The second cord **708** or looped cord **1012** may then be tensioned, at which point the screw **1504** is fully seated (e.g., further driven into the bony structure and into the staple **1508**). Fully screwing the screw **1504** into the staple **1508** may help to secure the second cord **708** or looped cord **1012** between the screw **1504** and staple **1508**, thereby locking the second cord **708** or looped cord **1012** in place therebetween.

[0191] With reference now to FIGS. **16**A-**16**D, additional details of coupling cords will be described in accordance with at least some embodiments of the present disclosure. FIG. **16**B specifically illustrates a cord coupler **1612** that can be used to couple different cord portions **1608** to one another. The cord coupler **1612** can be configured to be received within a tulip head of a screw **1604**. The cord coupler **1612** may also be configured to secure multiple cord portions **1608** together and to the screw **1604**. The cord portions **1608** may correspond to independent pieces of a cord **116**. Alternatively, or additionally, one cord portion **1608** may correspond to a cord **116** while another cord portion **1608** may correspond to a piece of a looped cord **1012** or to a second cord **708**. Alternatively, or additionally, one cord portion **1608** may correspond to a piece of a looped cord **1012** or second cord **708** while another cord portion **1608** may correspond to another piece of a looped cord **1012** or second cord **708**. Alternatively, or additionally, both cord portions **1608** may correspond to different sections of the same looped cord **1012** or second cord **708**.

[0192] In the illustrated configuration, the cord coupler **1612** is shown to fit within the tulip head of the screw **1604** while also receiving both cord portions **1608**. The cord coupler **1612** may include a two-piece plastic fitting that snaps together around two cord portions **1608**. Once the cord coupler **1612** is positioned around the cord portions **1608**, the cord coupler **1612** may be inserted into the tulip head of the screw **1604** and set therein with a set screw **1616**.

[0193] The cord coupler **1612** may also include a hole **1620** on an upper surface thereof. The hole **1620** may provide access for the set screw **1616** to directly contact both cord portions **1608**. The hole **1620** may be sized to expose at least half of each cord portion **1608** and to receive the bottom of the set screw **1616**.

[0194] In some embodiments, the cord coupler **1612** provides an ability to daisy-chain multiple cords or second cords together. The cord portions **1608** can be locked into place at each screw **1604** with a set screw **1616**. As shown in FIG. **16**D, second cords **708** could be locked into screws **1604** which are rotated 90 degrees from standard configurations. Said another way, the passages in the tulip head of each screw **1604** may not be required to face one another. Rather, the passages in the tulip head of each screw **1604** may be directed orthogonally (or in some other non-facing arrangement) such that tightening of the loops against a side of the tulip head provides the desired tension to the screw **1604**. This particular configuration may help to prohibit the cord **116** from slipping out of the tulip head of the screw (e.g., because the set screw **1616** loosened).

[0195] FIG. **16**D also illustrates that the directionality of the cord portions **1608** within the screw **1604** are orthogonal to the direction of force/tension placed onto the head of the screw **1604**. By utilizing a configuration of this type, it becomes possible to utilize stronger and redundant second cord **708** configurations. One example of a redundant second cord configuration is shown in FIG. **17**. More specifically, primary cord could be routed into loops for supplemental strength and/or to correct spine thru tensioning. The routing of the cord could provide a mechanical advantage for tensioning. Screw caps **1704** could be designed so that cords are pre-routed and then dropped over screws for ease of insertion. Examples of such screw caps **1704** are shown in FIG. **17** as well.

[0196] FIGS. **18**A and **18**B exhibit an alternative configuration of screw **1804** where a separate screw cap **1704** is not required. Instead, according to the examples of FIGS. **18**A and **18**B, the screw **1804** may be provided with one or more lateral posts **1808** on the head thereof. The lateral post(s) **1808** may function similarly to the screw caps **1704** in that the lateral post(s) **1808** support the looping of one or more second cords **708** onto the screw **1804**. In some embodiments, a primary cord **116** or second cord **708** could be routed over the lateral posts **1808** in a way that provides a mechanical advantage for tensioning as well as supplemental fixation/strength. In the embodiment depicted in FIGS. **18**A and **18**B, the lateral posts **1808** may be oriented orthogonally to the channel passing through the tulip head of the screw **1804**. Such a configuration allows the tensile forces applied to the screw **1804** by a second cord **708** to supplement a tensile force applied by a cord **116** fixed in the tulip head of the screw **1804**.

[0197] Although the lateral post(s) **1808** are shown as being integrally formed with the screw **1804**, it should be appreciated that the lateral post(s) **1808** may also be modular. In other words, the lateral post(s) **1808** may be provided as a modular component, similar to the screw caps **1704** illustrated in FIG. **17**.

[0198] With reference now to FIG. **19**, yet another example of a bone anchor or system of bone anchors will be described in accordance with at least some embodiments of the present disclosure. The bone anchors are illustrated to include two or more screws **1904** that are coupled to one another with an anchor plate **1912**. The anchor plate **1912** is similar to other anchor plates depicted and described herein except that the anchor plate **1912** includes holes therein that are substantially larger in one dimension than the outer diameter of the screws **1904**. Such a configuration allows the screws **1904** to be inserted and then the position of the anchor plate **1912** can be adjusted (e.g., slid, translated, etc.) relative to one or both screws **1904**. This configuration also affords some flexibility when connecting two screws **1904**.

[0199] The configuration of FIG. **19** also provides an ability to rigidly connect (e.g., fuse) two screws **1904**. In some embodiments, the screws **1904** may accept the anchor plate **1912** to support a hybrid (e.g., fusion+tether construct) or revision. The specific level with the plate **1912** would be fused but a single primary cord **116** could pass over the length of the construct (e.g., between the screws **1904**). In some embodiments, spherical or cylindrical features on the bottom of the locking nut **1916** may interface with the slot-like channel of the anchor plate **1912**. As the locking nut **1916** is tightened, the anchor plate **1912** may be pressed against a top surface of the staple **1908**, but the rounded feature on the bottom of the locking nut **1916** may allow for the screws to sit at varying angles. In other words, the rounded bottom of the locking nut **1916** may allow the screws **1904** to have some substantial separation from one another and may avoid the requirement that both screws **1904** be co-planar with one another. In particular, one of the screws **1904** may be provided at an angle other than parallel with the other screw **1904** thanks to the rounded bottom of the locking nut **1916**.

[0200] With reference now to FIGS. **20**A and **20**B, an alternative configuration of a cord coupler **2008** will be described in accordance with at least some embodiments of the present disclosure. The configuration illustrated in these figures enables a cord-rod connector (e.g., cord coupler **2008**) that allows two different cord portions **2004** to be coupled together as part of the stabilization system **2000**. Rather than coupling the cord portions **2004** at the same screw as shown in previous figures, this particular embodiment utilizes the cord coupler **2008** to couple one cord portion **2004** above one screw **2024** and to couple another cord portion **2004** above another screw **2024**. In this configuration, adjacent screws **2024** can be coupled with the cord coupler **2008**.

[0201] In some embodiments, the cord coupler **2008** may be constructed of a metal or metallic alloy. In some embodiments, the cord coupler **2008** may be constructed of a flexibly-resilient material such as a polymer, rubber, or the like. The cord coupler **2008** may also include notches that align and fit within the tulip head of a screw **2024**. The cord coupler **2008** may be fixed within a screw **2024** with a set screw **2020** that engages threading in the tulip head of the screw **2024**.

[0202] The cord coupler **2008** may also include one or more cord-securing members to connect the cord portion **2004** to the cord coupler **2008**. In some embodiments, the cord-securing member(s) may include a needle **2016**. In some embodiments, the cord-securing member(s) may include a pin **2018** (e.g., a blunt-tipped element) that secures the cord portion **2004** into the cord coupler **2008**. Alternatively, or additionally, the cord portion(s) **2004** may be secured in the cord coupler **2008** with the set screws **2020**, meaning that a cord-securing member may not be necessary.

[0203] Referring now to FIGS. **21**A-**27**B, details of an instrument and components thereof that may be used during a tensioning step. It should be appreciated, however, that the various techniques and devices could also be used during other surgical steps (e.g., to implant one or more bone anchors, tension a cord, tension a second cord, or otherwise implant the tensioning system). More specifically, and as will be described in further detail herein, a surgical instrument may be provided to implant the bone anchors and to apply tension to a cord **116**, looped cord **1012**, or second cord **708**. The instrument may be referred to as a tensioner, counter tensioner, or tensioning instrument. Moreover, while various components of an instrument will be described herein, it should be appreciated that various components may be omitted or exchanged with other components.

[0204] FIGS. **21**A and **21**B illustrate a tensioning tip **2100**. The tensioning tip **2100** is illustrated as a two-piece design with stacked washers (e.g., Belleville washers) placed between the pieces. The two pieces may include a housing **2108** and spring **2104**. Although spring **2104** is illustrated and described as having a particular configuration, it should be appreciated that other devices or components could be used. For instance, the spring **2104** may include or be replaced with any suitable flexible tubing with a lumen running through it large enough to accommodate cord **116**.

[0205] The housing **2108** may include a window **2112** that allows a relative motion between the housing **2108** and spring **2104** to be indicated. The cord **116** may be allowed to pass through the center of the tensioning tip **2100** (e.g., passing through the lumen of the spring **2104** and a hole in the tip of the housing **2108**). The end of the housing **2108** may interface with a counter tensioner **2200** as will be described in further detail.

[0206] More specifically, compression of stacked washers will indicate (through an indicator shown in the window **2112**) the amount of tension applied to a cord **116**. As the tensioning tip **2100** is pressed against the counter tensioner **2200**, an indicator may move laterally within the window **2112**.

[0207] The counter tensioner **2200** may also include a number of components to help apply tension to a cord **116** while securing to a bone anchor (e.g., to pull a cord **116** through a bone anchor prior to fixing the cord **116** within the bone anchor). FIGS. **22**A-**25** illustrate details of the components of the counter tensioner **2200**. In some embodiments, the counter tensioner **2200** comprises an outer sleeve **2204** and inner sleeve **2208**. The outer sleeve **2204** may include a slot cut therein to separate a bottom portion of the outer sleeve **2204** into a first arm **2220** and second arm **2224**. The first arm **2220** and second arm **2224** may meet at a slot apex **2216**, that includes an enlarged feature to facilitate relative movement of the arms **2220**, **2224**. As a force **2212** is applied against the first arm **2220** during cord **116** tensioning, the first arm **2220** may deflect toward the second arm **2224**. In some embodiments, the force **2212** is applied against the first arm **2220** by the tensioning tip **2100** when the tensioning tip **2100** is connected to the cord **116**.

[0208] The inner sleeve **2208** is shown to include a passage **2228** for additional components of the counter tensioner **2200**, The passage **2228** may include a cut **2232** to provide clearance for compression of the outer sleeve **2204**. Said another way, the cut **2232** may be dimensioned to enable deflection of the first arm **2220** when the outer sleeve **2204** is positioned over the inner sleeve **2208** as shown in FIG. **22**A.

[0209] FIGS. **24**A and **24**B illustrate additional details of the counter tensioner **2200** with a pivot ladder **2304** inserted therein. The pivot ladder **2304** may extend through the passage **2228** of the inner sleeve **2208** to a point where the end of the pivot ladder **2304** contacts the end of the inner sleeve **2208**. The pivot ladder **2304** may also include an outer sleeve, having an outer diameter less than an inner diameter of the passage **2228**. The pivot ladder **2304** may further include a series of pivoting linkages each which rotate about a center pin. The subsequent pins ride in a slot along the centerline of the linkages. In such a configuration, lateral displacement of each linkage is additive. Therefore, while there may be a small amount of movement at the tip (~2 mm), the last linkage can move ~5 mm or more, depending upon the geometry used for the pivot ladder **2304**.

[0210] In some embodiments, a piston and spring are provided at the distal end of the instrument pivot ladder **2304**. The piston and spring may push on the linkages so that they sit in a rotated state, until force is applied at the tip by force **2212**. The spring piston provides space for a spring and also markings to indicate displacement and how it relates to force (e.g., tension) on the counter tensioner's **2200** deflection beam (e.g., the deflection of the first arm **2220** under application of force **2212**).

[0211] An alternative configuration of the counter tensioner **2508** is shown in FIG. **25** where it can be seen that the deflection beam **2504** is positioned external to the main channel of the inner sleeve **2208**. In particular, rather than using an outer sleeve **2204** as shown in FIGS. **22**A and **22**B, a deflection beam **2504** is positioned on a component part that attaches to a side of the instrument **2508**. In this configuration, the deflection beam **2504** may flex across some or the entire length of the deflection beam **2504**. A force **2212** will be applied to the deflection beam **2504** as tension is applied to the cord **116** passing through the tip of the instrument **2508**, while the instrument **2508** holds or is secured to a bone anchor.

[0212] FIGS. **26**A-**26**D illustrate another configuration of the counter tensioner **2604** where a force sensor **2616** (which may also be provided as a pressure sensor, displacement sensor, or the like) is provided at a distal end of the counter tensioner **2604**. The counter tensioner **2604** may also include an anchor interface **2608** for releasably attaching to a bone anchor when the bone anchor is secured to a bony structure. Like other instruments described herein, the counter tensioner **2604** may be configured to pass through an MIS tube or similar delivery device to facilitate a minimally invasive surgical procedure.

[0213] The force sensor **2616** may include an outer sleeve **2612** that is secured to an outer portion of the counter tensioner at the distal end (e.g., near the anchor interface **2608**). The counter tensioner **2604** may also include a pivoting member **2620** that contacts the force sensor **2616**. Pivoting member **2620** is actuated by the force **2212**, which contacts and causes compression of the force sensor **2616**. In some embodiments, the force sensor **2616** may be calibrated to display an amount of force **2212** at the anchor interface **2608**, and provide a digital readout of the same. In other words, the sensor **2616** may be configured to communicate a force reading via a wired or wireless signal (e.g., via an antenna) to a user interface device provided at a proximal end of the counter tensioner **2604**.

[0214] As can be seen in FIGS. **27**A and **27**B, the tensioning tip **2100** may be modified to include additional or alternative features for measuring or interpreting forces applied by (or to) the tensioning tip **2100**. Specifically, but without limitation, the tensioning tip **2100** may include a deflection beam **2708** that is offset from the slot in which the cord **116** passes. The deflection beam **2708** may be integrally formed with the housing **2704**. The deflection beam **2708** may interface with an outer diameter of a counter tensioner **2200**, **2508**, **2604**. In some embodiments, as forces are applied against the deflection beam **2708**, the deflection beam **2708** will displace (e.g., move outwardly). Displacement of the deflection beam **2708** may indicate an amount of tension that is being pulled on the cord **116** by the tensioning tip **2100**. Like other configurations of the tensioning tip **2100**, the cord **116** may still be configured to pass through the center of the tensioning tip **2100** such that the tensioning tip **2100** interfaces with the counter tensioner as tensile forces are applied to the cord **116**.

[0215] Referring now to FIGS. **28**A-**28**D, another example of a bone anchor will be described in accordance with at least some embodiments of the present disclosure. The bone anchor is similar to at least some other bone anchors depicted and described herein, in that the bone anchor may include two or more screws **2804** that are coupled via an anchor plate **2808**. The anchor plate **2808** is shown to include two non-planar openings **2812**. Each non-planar opening **2812** of the anchor plate **2808** is sized to receive a screw **2804**. The inner diameter of each non-planar opening **2812** may be greater than an outer diameter of the screw **2804** but less than a diameter of the shoulder of the tulip head of the screw **2804**.

[0216] The anchor plate **2808** may have a width that enables the anchor plate **2808** to be delivered through an MIS tube. In some embodiments, the anchor plate **2808** may comprise a width of no more than 15 mm, thereby enabling the anchor plate **2808** to be delivered through an MIS tube of 15 mm. The anchor plate **2808** may then be flipped or rotated at the distal end of the MIS tube and then pressed into the bony structure before screws **2804** are delivered thereto.

[0217] As can be seen in FIG. **28**D, one of the openings **2812** may be provided in a first plane while another of the openings **2812** may be provided in a second plane that is angled at more than zero degrees relative to the first plane. The anchor plate **2808** may comprise a rigid member that substantially fixes the orientation of the first plane and the second plane. In other embodiments, the anchor plate **2808** may comprise a flexible material (e.g., plastic) that allows some amount of bending to occur between the openings **2812**.

[0218] The anchor plate **2808** is also depicted to include an integral staple. More specifically, one or both of the openings **2812** may be provided with one or more staple arms **2816** that extend downwardly from the opening **2812**. The arms **2816** may be configured to press into a bony structure to at least partially secure the anchor plate **2808** to the bony structure while screws **2804** are driven through the anchor plate **2808** and into the bony structure. In some embodiments, the openings **2812** may be tilted relative to each other in at least two dimensions such that screws **2804** extending through both opening **2812** do not intersect or collide with one another.

[0219] The bone anchor of FIGS. **28**A-**28**D may be configured to support a two-cord configuration. Said another way, each screw **2804** may be provided with a tulip head to receive a cord **116**, second cord **708**, or a combination thereof. It may be possible, however, to utilize a screw of a different type (e.g., not both screws in the bone anchor need to be provided with tulip heads).

[0220] With reference now to FIG. **29**, another example of a bone anchor that supports a two-cord configuration will be described in accordance with at least some embodiments of the present disclosure. The bone anchor is shown to include a screw **2904** and staple **2908**. The screw **2904** is further shown to include a dual-slot head **2912** in which two cord slots **2916** are provided. In some embodiments, the dual-slot head **2912** is integrally formed with the shank of the screw **2904** (e.g., the screw **2904** and dual-slot head **2912** are a single piece of material). In some embodiments, the dual-slot head **2912** may correspond to a modular element that is attachable to a top of the screw **2904**.

[0221] A bottom surface of the dual-slot head **2912** may include one or more ribs that interface with one or more ribs on a top surface of the staple **2908**. The ribs may help to substantially preclude rotation of the dual-slot head **2912** relative to the staple **2908** (and therefore the bony structure). In some embodiments, the staple **2908** may first be inserted into the bony structure and then the screw **2904** may be driven through the staple **2908**. Once the ribs of the staple **2908** interface corresponding ribs of the dual-slot head **2912**, the screw **2904** may be prohibited from further rotation and insertion.

[0222] With reference now to FIGS. **30**A-**30**D, additional details of staple **3008** having an alignment feature **3012** will be described in accordance with at least some embodiments of the present disclosure. The staple **3008** may be similar to other staples depicted and described herein. Moreover, the staple **3008** may be used with any of the bone anchors depicted and described herein.

[0223] In some embodiments, the staple **3008** may include one or more arms and an alignment feature **3012**. The arms may be configured to pierce and hold a bony structure. The alignment feature **3012** may include one or more features of the staple **3008** that are visible from above (see FIG. **30**B) and that help determine an orientation of the staple **3008** when being inserted from above.

[0224] The staple **3008** may further include a cord receiver **3016** that is similar to other cord receivers of other staples depicted and described herein. The cord receiver **3016** may be configured to receive a cord **116**, a looped cord **1012**, or a second cord **708**. In some embodiments, the alignment feature **3012** may be provided as a rotatable sleeve that is configured to rotate relative to the inner portion of the staple **3008** that includes the arms. In other words, the alignment feature **3012** may be freely rotatable relative to other portions of the staple **3008**. During implantation, a surgeon may place a ring having the alignment feature **3012** over the top of the base portion of the staple **3008**. After the ring is placed on the base portion of the staple **3008**, the surgeon can rotate the ring and its alignment features relative to the rest of the staple **3008**. This freedom of rotation may allow the surgeon to align the ring as desired, then use the alignment features **3012** to align screws inserted through the staple **3008**. For example, the surgeon may insert a screw into the staple **3008** until a feature of the screw (e.g., a post, a tulip head, a cord receiver, etc.) is aligned with the alignment feature **3012**.

[0225] Referring now to FIGS. **31**A-**31**D, additional details of a system having a plurality of bone anchors coupled with a cord **116** will be described in accordance with at least some embodiments of the present disclosure. The system may be provided as an implanted construct that helps to apply tensile forces between multiple vertebrae, in which the screws **3104** are implanted.

[0226] In some embodiments, one or more screws **3104** may include an angled sidewall **3116** in the tulip head. More specifically, the tulip head of the screws **3104** may include a cord receiver **3108** and threading **3112** for a set screw, like many of the other screws depicted and described herein. This particular screw **3104** may also include at least one angled sidewall that forms part of the cord receiver **3108**. The angled sidewall **3116** may have an hourglass shape that allows the cord **116** to follow a natural curvature without creating contact stress between the cord **116** and cord receiver **3108**.

[0227] In other words, by tapering the entry way into the cord receiver **3108**, the angled sidewall helps minimize pinching or other stresses that might cause damage to a cord

116, especially as the cord **116** is placed under tension and secured in the tulip head. FIG. **31**D, which corresponds to a cross-sectional view along line A-A, helps to illustrate the hourglass figure of the angled sidewall **3116** at the center of the cord receiver **3108**. FIG. **31**B helps illustrate that the angled sidewall **3116** creates a tapered threading **3112** into the screw **3104**, meaning that more threading exists higher up on the screw.

[0228] With reference now to FIGS. **32**-**36**C, additional systems and methods for applying tension to a second cord **3216** between two or more bone anchors will be described in accordance with at least some embodiments of the present disclosure. FIG. **32** illustrates an example of a system and the components thereof that can be used to place and utilize a second cord **3216**. The system is shown to include a snake **3204**, a tensioning tower **3208**, a screw attachment tower **3220**, and a second cord placement instrument **3212**. Each of the instruments depicted as part of the system may help facilitate MIS procedures for the placement and tensioning of the second cord **3216**. The second cord **3216** may be similar or identical to other second cords or looped cords depicted and described herein.

[0229] In some embodiments, the second cord **3216** may be looped around both a tensioning tower **3208** and the screw attachment tower **3220**. Both the tensioning tower **3208** and screw attachment tower **3220** may be coupled with a bone anchor (e.g., a top of a screw) prior to positioning the second cord **3216**. The snake **3204** may be used to apply a tension to the cord **116** traversing the bone anchors. In some examples, the snake **3204** may correspond to an example of the tensioning tip and the tensioning tower **3208** may correspond to an example of the counter tensioner. In other words, the snake **3204** may include the spring and housing assembly that allows the cord **116** to pass therethrough. The tensioning tower **3208** may be designed to interact with the snake **3204** to apply tension to the cord **116** prior to locking the cord in the bone anchors with set screws.

[0230] Additional details of the screw attachment tower **3220** are depicted in FIGS. **33**A-**33**C. In the illustrated but non-limiting examples, the screw attachment tower **3220** may include a tower body **3304** and an inserter **3308**. The tower body **3304** may include a recess **3316** that cooperates with a coupling pin **3312** of the inserter **3308**. The tower body **3304** may also include a second cord notch **3320** and a cord notch **3324**. The second cord notch **3320** may be configured to retain the second cord **3216** and substantially prohibit the second cord **3216** from sliding axially along the tower body **3304**.

[0231] The cord notch **3324** may provide a passageway for the cord **116** to pass underneath the screw attachment tower **3220**. The tower body **3304** may further include features for interfacing with a top of a bone anchor (e.g., to retain a connection with a top of a bone anchor or screw) while tension is applied to the second cord **3216** and/or cord **116**. In some embodiments, the screw attachment tower **3220** may set upon a top of a bone anchor. In some embodiments, the screw attachment tower **3220** may releasably connect to a top of the bone anchor, thereby substantially prohibiting axial movement relative to the bone anchor until released. The two-piece configuration of the screw attachment tower **3220** may allow the instrument to remain in place without requiring use of a separate port/incision.

[0232] FIGS. **34**A-**36**C illustrate additional details of the snake **3204** according to at least some embodiments. The snake **3204** is shown to include a distal end **3412** and a proximal end **3400**. The distal end **3412** may be configured to interface with a distal end of the tensioning tower **3208**. In some embodiments, the distal end **3412** of the snake **3204** may have a tensioning tip extending therefrom to support tensioning of a cord **116**.

[0233] As shown in FIGS. **34**B and **34**C, the distal end **3412** may include a primary cord passage **3420** and two or more second cord passages **3416**. The primary cord passage **3420** may be connected with a first opening **3404** at the proximal end via a primary passage lumen **3620** while the two or more second cord passages **3416** may be connected with the second opening **3408** via one or more secondary passage lumen **3616**. In some embodiments, as shown in FIGS. **35**A-**35**C, the second cord **3216** may have one portion passing through one of the second cord passages **3416** and another portion passing through the other of the second cord passages **3416**. Free ends of the second cord **3216** may be accessible via the second opening **3408** and can be pulled to apply tension on bone anchors via the second cord **3216**. The primary cord passage **3420** and lumen **3620** may be sized to allow a cord **116** to pass therethrough. In some embodiments, a diameter of the primary cord passage **3420** and lumen **3620** may be greater than a diameter of either second cord passage **3416**.

[0234] By providing independent passages and lumen through the snake **3204**, different tensions can be applied to the cord **116** as compared to the second cord **3216**. Additionally, separate tensioning guns **3604** can be used independently and possibly simultaneously to apply different tensile forces to adjacent bone anchors via the second cord **3216** and the cord **116**. In some embodiments, the second cord **3216** may extend from the distal end **3412** of the snake **3204** as a loop. The loop can be extended and manipulated over the bone anchor(s) at the adjacent level(s). The second cord **3216** may interface with features on the bone anchor (or an additional instrument placed on the bone anchor, such as an attachment tower **3220**) and is retained on these features while under tension.

[0235] FIG. **36**C illustrates a cross-sectional view in a middle portion of the snake **3204**. As shown in FIG. **36**C, the snake body **3612** may include multiple lumens through which different surgical elements can pass. The primary passage lumen **3620** may allow the cord **116** to pass therethrough, the secondary passage lumen **3616** may allow the second cord **3216** to pass therethrough, other lumen **3624** may permit other implants, cords or instruments to pass therethrough.

[0236] FIGS. **37**A-**37**C illustrate a bone anchor **3712** that includes a screw **3708** with a cord receiving head with internal threads capable of receiving a set screw **204**. The bone anchor **3712** further comprises an anchor cone implant **3730** that comprises instrument engagement features **3732** at the wider, proximal end of the anchor cone implant **3730**. The instrument engagement features **3732** may comprise notches, slots, grooves, ridges, or other features that enable an instrument to engage with the anchor cone implant **3730** in a manner that enables the instrument to thread or screw **3708** the anchor cone implant **3730** into a vertebral body **104**. A pilot hole may be predrilled at the location the anchor cone implant **3730** is to be implanted.

[0237] The anchor cone implant **3730** may be fabricated of titanium, tantalum or other biocompatible metal or other biocompatible material that is sufficiently capable of being screwed into bone. The anchor cone implant **3730** may further include a split **3734** at the tip end of the cone. The split **3734** may be fabricated by laser cutting the split or by means of cutting with a diamond tip saw or other know cutting methods. The split **3734** is completely through the tip of the cone and goes up the cone a sufficient distance that when the screw **3708** is threaded into the anchor cone implant **3720**, the tip of the cone is forced to splay outward. The anchor cone implant may further include one or more U-shaped cuts **3740** in a side wall of anchor cone implant **3730**. The U-shaped cuts extend through the side wall of the anchor cone implant **3730**, such that when the screw **3708** is threaded into the anchor cone implant **3730**, the U-shaped cut areas of the sidewall will splay away from the sidewall of the anchor cone implant **3730**.

[0238] The bone anchor **3712** may be implanted by creating a pilot hole into a vertebral body **104**; utilizing an instrument to engage instrument engagement features **3732** on the head of the anchor cone implant **3730**; threading the anchor cone implant **3730** into the pilot hole in the vertebral body **104**; engaging engagement features on the tulip head of the screw **3708** with an instrument; threading the screw **3708** into a central threaded lumen in the anchor cone implant **3730**; inserting a cord **116** into the cord receiver of the screw **3708**; tensioning the cord **116** with a cord tensioner; and threading a set screw **204** into the internal threads of the cord receiver of the screw **3708**. A bone anchor **3712** that includes an anchor cone implant **3730** may be used to improve bone purchase or mitigate screw migration. A bone anchor **3712** that includes an anchor cone implant **3730** may be utilized when a revision surgery is necessary or if the bone quality is poor.

[0239] FIGS. **38**A-**38**C illustrate a bone anchor **3812** that includes a screw **3808** with a cord receiving head with internal threads capable of receiving a set screw **204** (not shown). The bone anchor **3812** further comprises an anchor cone implant **3830** that comprises instrument engagement features **3832** at the wider, proximal end of the anchor cone implant **3830**. The instrument engagement features **3832** may comprise notches, slots, grooves, ridges, or other features that enable an instrument to engage with the anchor cone implant **3830** in a manner that enables the instrument to thread or screw the anchor cone implant **3830** into a vertebral body **104**. Additionally, a pilot hole may be predrilled at a predetermined location the anchor cone implant **3830** is to be implanted.

[0240] The anchor cone implant **3830** may be fabricated of titanium, tantalum or other biocompatible metal or other biocompatible material that is sufficiently capable of being screwed into bone. The anchor cone implant **3830** may further include a split **3834** at the tip end of the conc. The split **3834** may be fabricated by laser cutting the split or by means of cutting with a diamond tip saw or other know cutting methods. The split **3834** is completely through the tip of the cone and goes up the cone a sufficient distance that when the screw **3808** is threaded into the anchor cone implant **3830**, the tip of the cone is forced to splay outward. The anchor cone implant **3830** may further include one or more U-shaped cuts **3840** in a side wall of anchor cone implant **3830**. The one or more U-shaped cuts extend through the side wall of the anchor cone implant **3830**, such that when the screw **3808** is threaded into the anchor cone implant **3830**, the one or more U-shaped cut areas of the sidewall will splay away from the sidewall of the anchor cone implant **3830**.

[0241] The bone anchor **3812** may be implanted by creating a pilot hole into a vertebral body **104**. Next, utilizing an instrument to engage instrument engagement features **3832** on the head of the anchor cone implant **3830**. The anchor cone implant **3830** may then be threaded into the pilot hole in the vertebral body **104**. After which, the engagement features on the tulip head of the screw **3808** may be engaged with an instrument and the screw **3808** may be threaded into a central threaded lumen in the anchor cone implant **3830**. Then a cord **116** may be inserted into the cord receiver of the screw **3808**. Next, the cord **116** may be tensioned with a cord tensioner. After the cord is sufficiently tensioned, a set screw **204** may be threaded into the internal threads of the cord receiver of the screw **3808**.

[0242] A bone anchor **3812** that includes an anchor cone implant **3830** may be utilized to improve bone purchase or mitigate screw migration. Alternatively, a bone anchor **3812** that includes an anchor cone implant **3830** may be utilized when a revision surgery is necessary or if the bone quality is poor. It will be understood that the bone anchor **3812** is similar to the bone anchor **3712**, with wider, thicker walls on the cone, especially near the proximal end of the cone. As will be readily appreciated, a thicker cone may be utilized in larger vertebral bodies **104** or where there is poorer bone quality or other situations as determined by a surgeon that such a thicker anchor cone implant **3830** is appropriate.

[0243] FIG. **38**D illustrates a bone anchor with an anchor cone implant **3850** that is shorter and includes a threaded lumen. The lumen of anchor cone implant **3850** extends through the distal end of the cone implant **3850** and is sized to permit the screw to exit the distal end of the cone implant **3850**. A shorter anchor cone implant **3850** may be determined by a surgeon to be appropriate in certain situations, such as smaller vertebral bodies **104** or similar situations. The anchor cone implant **3850** may be fabricated of titanium, tantalum or other biocompatible material that is sufficiently capable of being screwed into bone. Anchor cone implant **3850** may include slits at the narrow end or U-shaped slits in the sidewall to cause additional splay when a screw is threaded into the internal threaded lumen of the anchor cone implant **3850**. Anchor cone implant **3850** may be implanted in a similar manner as anchor cone implants **3730** and **3830**.

[0244] It should be understood that anchor cone implants **3730**, **3830**, or **3850** may be used instead of or in combination with a staple in situations in which anchor cone implants are considered appropriate, such as to improve bone purchase, to lower the likelihood of screw migration, poor bone quality, and similar situations.

[0245] FIG. **38**E illustrates a side cut away view of the tip of a screw **3812** that has been threaded into an anchor cone implant **3860** with a resulting splayed tip **3862** at the distal, narrow end of the anchor cone implant **3860**. It will be readily appreciated that anchor cone implants **3730**, **3830**, and **3850** that comprise laser cut slits at the distal, narrow tip of the cone would have similar splay, flare or spread at the distal, narrow end of the cone when a screw is threaded therein, as shown in FIG. **38**E. Likewise, it will be appreciated that there would be a similar U-shaped splay, flare or spread away from the side walls of the anchor cone implants

3740, **3840** or **3850** having U-shaped laser cuts or slits therein when a screw **3712** or **3812** is threaded into the central threaded lumen.

[0246] It will be appreciated that the various configurations of bone anchors **3712** or **3812** as illustrated in FIGS. **37**A-**38**D may be appropriate to improve bone purchase, mitigate implant migration, mitigate implant backout, or similar surgical procedure plan objectives as determined appropriate by a surgeon. Moreover, the bone anchors **3712** or **3812** may be used in combination with other embodiments disclosed in the disclosure.

[0247] The foregoing is not intended to limit the disclosure to the form or forms disclosed herein. In the foregoing Detailed Description, for example, various features of the disclosure are grouped together in one or more aspects, embodiments, and/or configurations for the purpose of streamlining the disclosure. The features of the aspects, embodiments, and/or configurations of the disclosure may be combined in alternate aspects, embodiments, and/or configurations other than those discussed above. This method of disclosure is not to be interpreted as reflecting an intention that the claims require more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive aspects lie in less than all features of a single foregoing disclosed aspect, embodiment, and/or configuration. Thus, the following claims are hereby incorporated into this Detailed Description, with each claim standing on its own as a separate preferred embodiment of the disclosure.

[0248] Moreover, though the foregoing has included description of one or more aspects, embodiments, and/or configurations and certain variations and modifications, other variations, combinations, and modifications are within the scope of the disclosure, e.g., as may be within the skill and knowledge of those in the art, after understanding the present disclosure. It is intended to obtain rights which include alternative aspects, embodiments, and/or configurations to the extent permitted, including alternate, interchangeable and/or equivalent structures, functions, ranges or steps to those claimed, whether or not such alternate, interchangeable and/or equivalent structures, functions, ranges or steps are disclosed herein, and without intending to publicly dedicate any patentable subject matter.

What is claimed is:

1. A bone anchor, comprising:

a screw comprising a head and a shank, wherein the shank defines a screw axis; and

a connector attachable to the head of the screw, wherein the connector is configured to receive and secure a cord offset from the screw axis.

2. The bone anchor of claim **1**, wherein the connector comprises a connector body and connector cap that moves relative to the connector body.

3. The bone anchor of claim **2**, further comprising a set screw that threads into the connector body to secure the connector cap to the connector body.

4. The bone anchor of claim **3**, wherein the connector body comprises a cord receiver and wherein a size of the cord receiver changes as the connector cap moves relative to the connector body.

5. The bone anchor of claim **3**, wherein the connector body comprises a cord receiver having an open top end to receive the cord.

6. The bone anchor of claim **5**, wherein the connector cap comprises a clamp that retains the cord between the connector body and the connector cap and that limits the cord from sliding through the cord receiver when the connector cap is secured into the connector body.

7. The bone anchor of claim **1**, further comprising a staple through which the screw is inserted.

8. The bone anchor of claim **7**, wherein the staple comprises an extending surface having at least one additional opening for a second screw.

9. The bone anchor of claim **8**, wherein the connector aligns the cord with a screw axis of the second screw.

10. The bone anchor of claim **7**, wherein the staple comprises an extension having a cord support face to receive and secure at least one of a first cord and a second cord between a post and the cord support face.

11. The bone anchor of claim **7**, wherein the staple comprises an alignment feature.

12. The bone anchor of claim **11**, wherein the alignment feature is provided on a ring that is rotatable relative to a bottom portion of the staple.

13. The bone anchor of claim **1**, further comprising an anchor plate having a first opening and a second opening.

14. A bone anchor, comprising:

a first screw;

a second screw;

an anchor plate coupling the first screw with the second screw; and

a cord receiver configured to couple a cord or second cord under tension with one or both of the first screw and second screw.

15. The bone anchor of claim **14**, wherein the cord receiver is integrally formed with the anchor plate.

16. The bone anchor of claim **14**, wherein the cord receiver is part of the first screw.

17. The bone anchor of claim **14**, wherein the cord receiver comprises a tulip head having internal threads to receive a set screw.

18. The bone anchor of claim **14**, wherein the cord receiver and the anchor plate comprise teeth that substantially prevent a relative rotation thereof when a face of the anchor plate contacts a face of the cord receiver.

19. The bone anchor of claim **14**, wherein the first screw extends through a first opening of the anchor plate and wherein the second screw extends through a second opening of the anchor plate.

20. The bone anchor of claim **19**, wherein the first screw draws the cord receiver into contact with the anchor plate and wherein the cord receiver abuts the anchor plate to substantially prevent the second screw from withdrawing out of the anchor plate.

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