

(12) **United States Patent**
Donner et al.

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(54) **IMPLANT ASSEMBLY FOR LOW PROFILE SPINOPELVIC FIXATION AND SACROILIAC JOINT FUSION**

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(72) Inventors: **Edward Jeffrey Donner**, Fort Collins, CO (US); **Christopher Thomas Donner**, Fort Collins, CO (US)

(73) Assignee: **JCBD, LLC**, Fort Collins, CO (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 15 days.

This patent is subject to a terminal disclaimer.

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(65) **Prior Publication Data**

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Related U.S. Application Data

(60) Division of application No. 14/216,975, filed on Mar. 17, 2014, now Pat. No. 9,757,154, which is a (Continued)

(51) **Int. Cl.**
A61B 17/68 (2006.01)
A61F 2/30 (2006.01)

(Continued)

(52) **U.S. Cl.**
CPC **A61B 17/68** (2013.01); **A61B 17/1757** (2013.01); **A61B 17/7044** (2013.01); (Continued)

(58) **Field of Classification Search**
CPC A61B 17/7044; A61B 17/7055; A61B 17/7035; A61B 17/025; A61F 2002/30995
See application file for complete search history.

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Primary Examiner — Lynnsy M Summitt

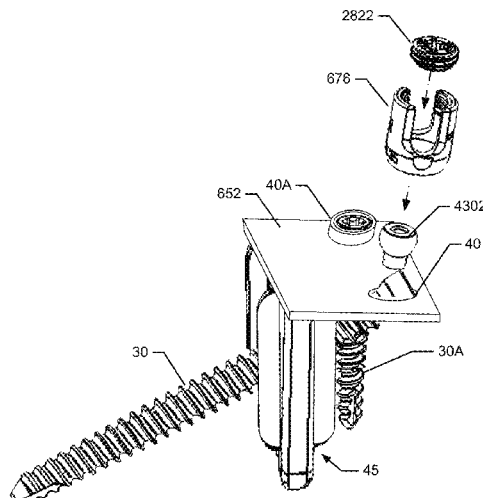
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(57) **ABSTRACT**

An orthopedic anchoring system for attaching a spinal stabilization system and concomitantly fusing a sacroiliac joint is disclosed that includes a delivery tool and an implant assembly for insertion into a joint space of a sacroiliac joint. The implant assembly may be secured using anchors inserted through bores within the implant body and into the underlying sacrum and/or ilium. The implant body may also include an attachment fitting reversibly attached to a guide to provide attachment fittings for elements of the spinal stabilization system. The implant assembly may be releasably coupled to an implant arm of the delivery tool such that the implant arm is substantially aligned with the insertion element of the implant assembly. An anchor arm used to insert the anchor may be coupled to the implant arm in a fixed and nonadjustable arrangement such that the anchor is generally aligned with a bore within the implant assembly.

21 Claims, 144 Drawing Sheets



Related U.S. Application Data

continuation-in-part of application No. 13/475,695, filed on May 18, 2012, now Pat. No. 9,381,045, which is a continuation-in-part of application No. 13/236,411, filed on Sep. 19, 2011, now Pat. No. 9,017,407, which is a continuation-in-part of application No. 12/998,712, filed as application No. PCT/US2011/000070 on Jan. 13, 2011, now Pat. No. 8,979,928.

(60) Provisional application No. 61/335,947, filed on Jan. 13, 2010, provisional application No. 61/798,225, filed on Mar. 15, 2013.

(51) **Int. Cl.**

A61B 17/17 (2006.01)
A61F 2/46 (2006.01)
A61B 17/70 (2006.01)
A61B 17/02 (2006.01)
A61F 2/44 (2006.01)
A61B 17/86 (2006.01)
A61B 17/00 (2006.01)

(52) **U.S. Cl.**

CPC *A61B 17/7055* (2013.01); *A61F 2/30988* (2013.01); *A61F 2/4611* (2013.01); *A61B 17/025* (2013.01); *A61B 17/7035* (2013.01); *A61B 17/7043* (2013.01); *A61B 17/863* (2013.01); *A61B 17/8645* (2013.01); *A61B 2017/0046* (2013.01); *A61F 2/4455* (2013.01); *A61F 2002/30179* (2013.01); *A61F 2002/30622* (2013.01); *A61F 2002/30995* (2013.01); *A61F 2002/4687* (2013.01); *A61F 2310/00017* (2013.01); *A61F 2310/00023* (2013.01); *A61F 2310/00179* (2013.01); *A61F 2310/00359* (2013.01)

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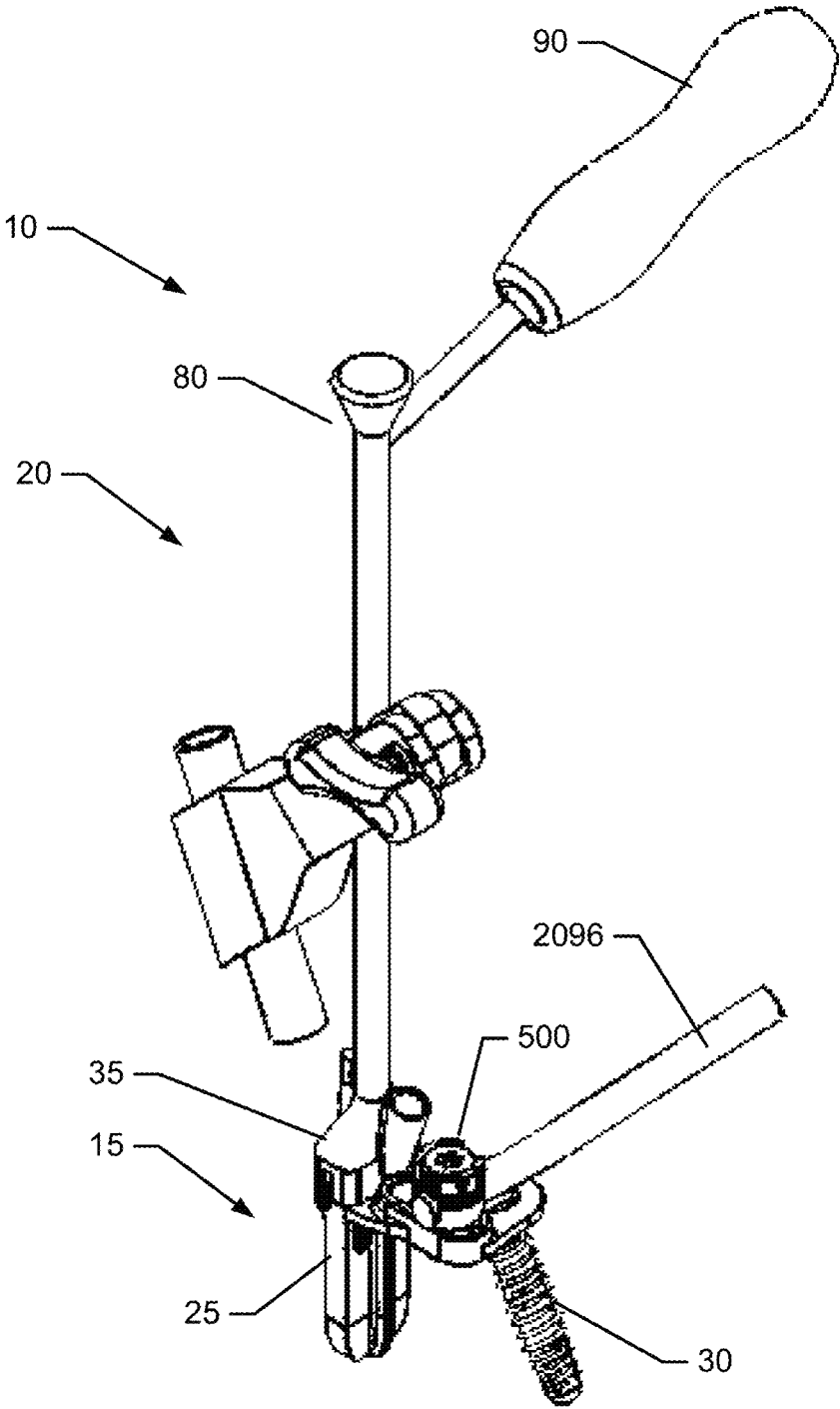


FIG. 1

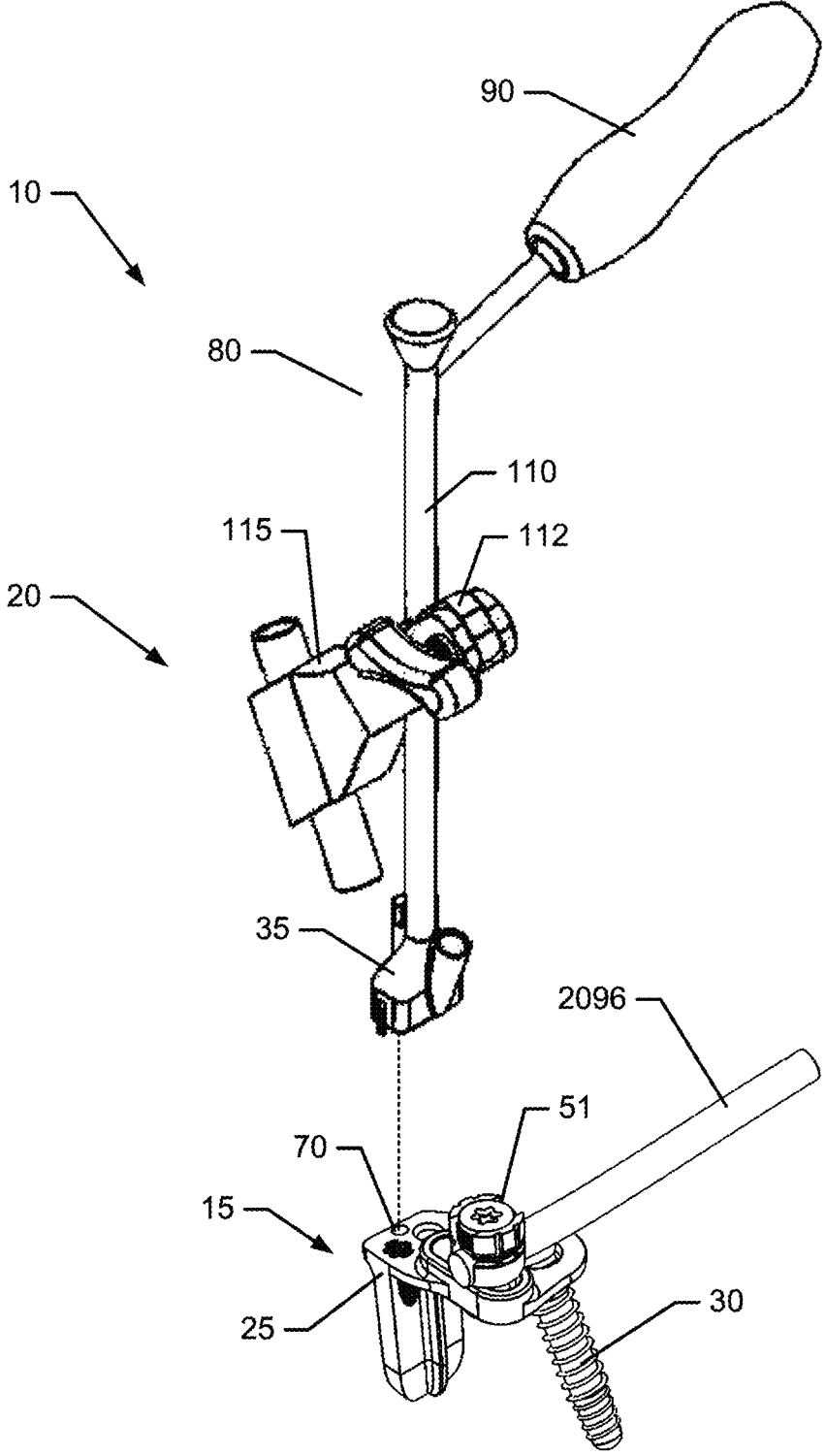


FIG. 2

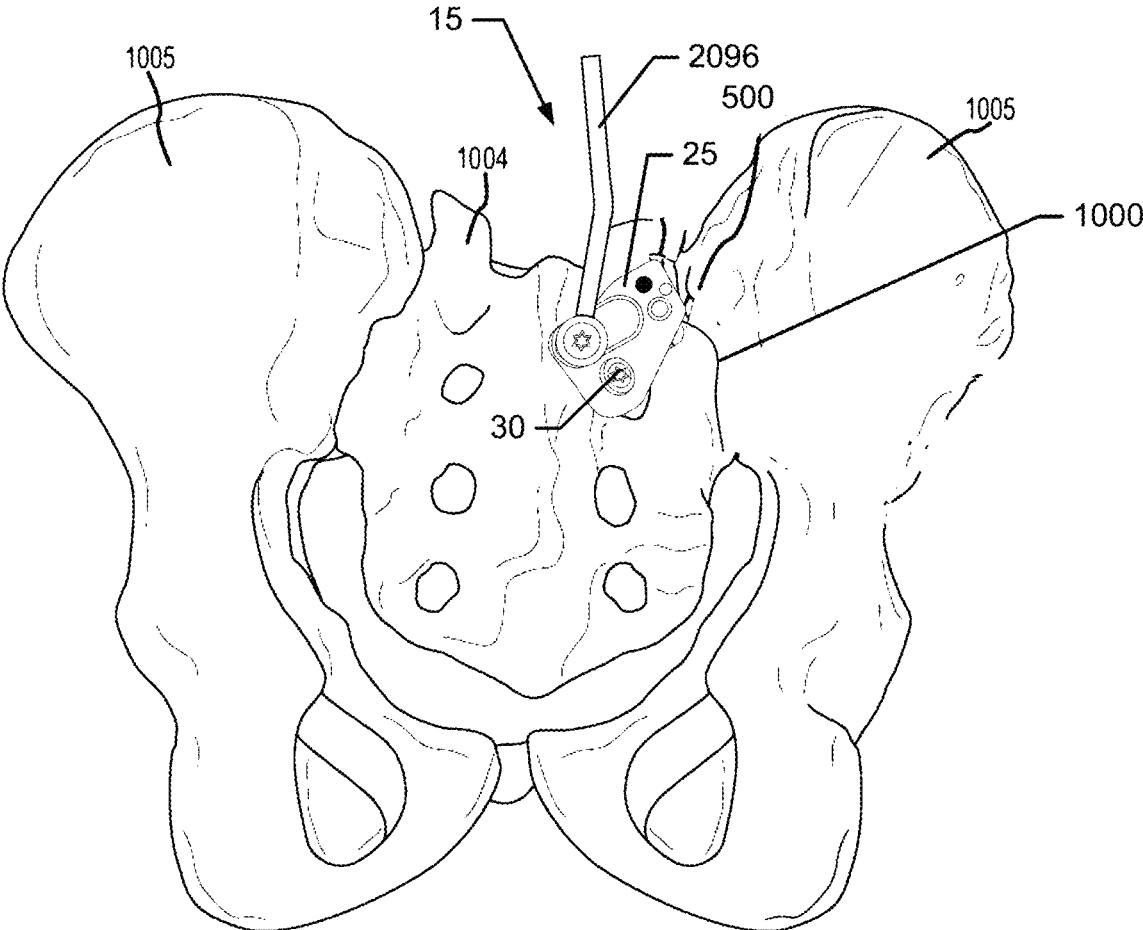


FIG. 3

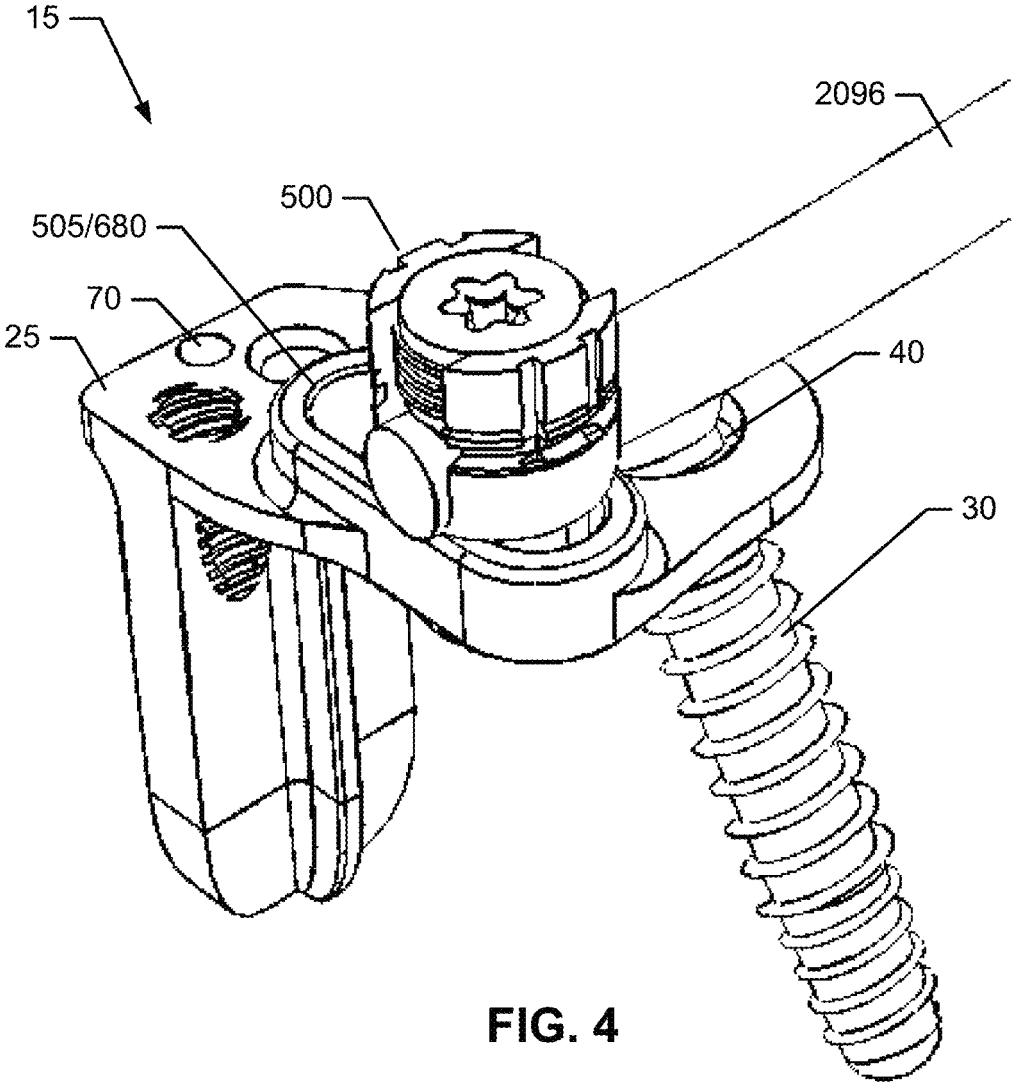


FIG. 4

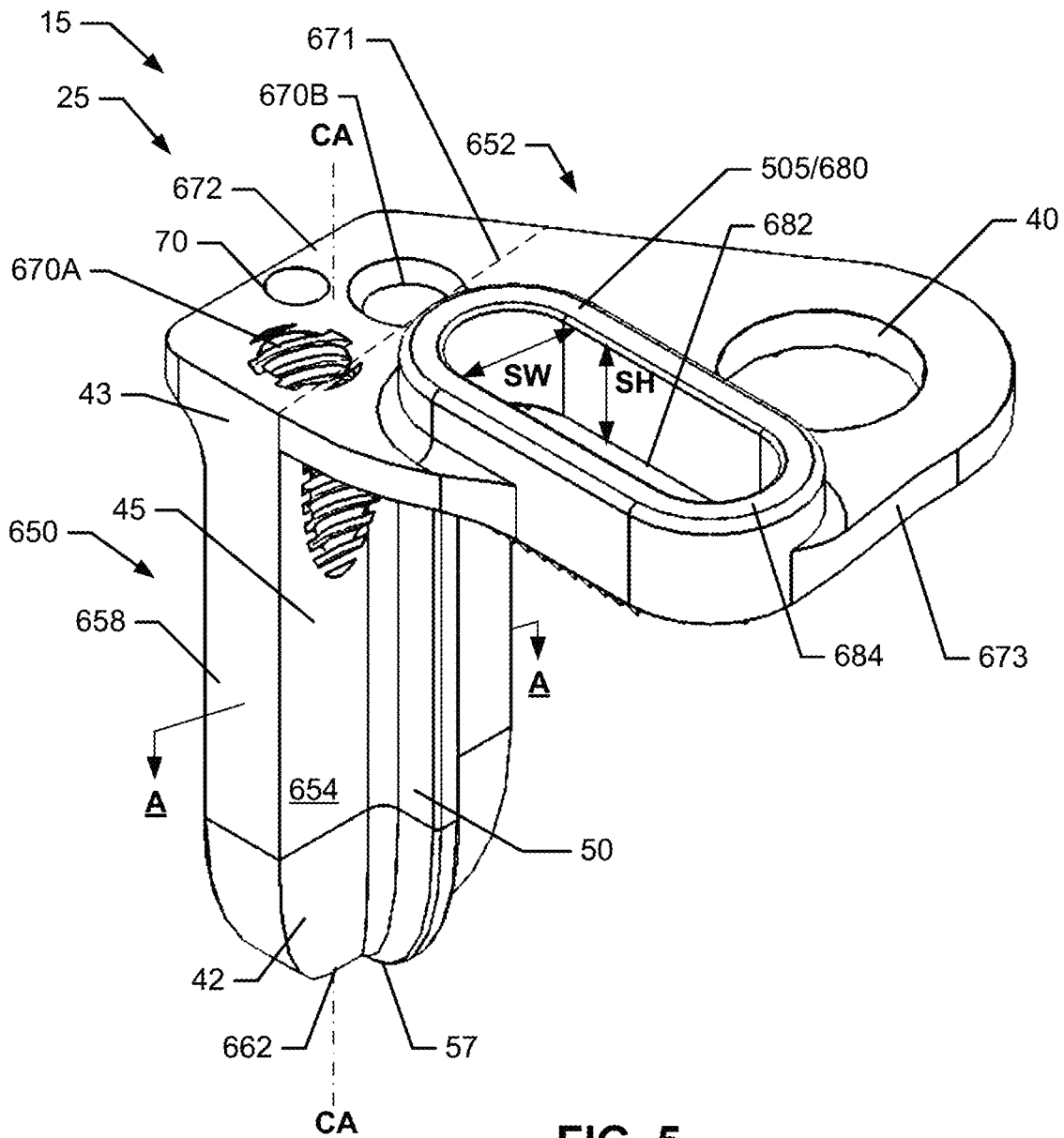


FIG. 5

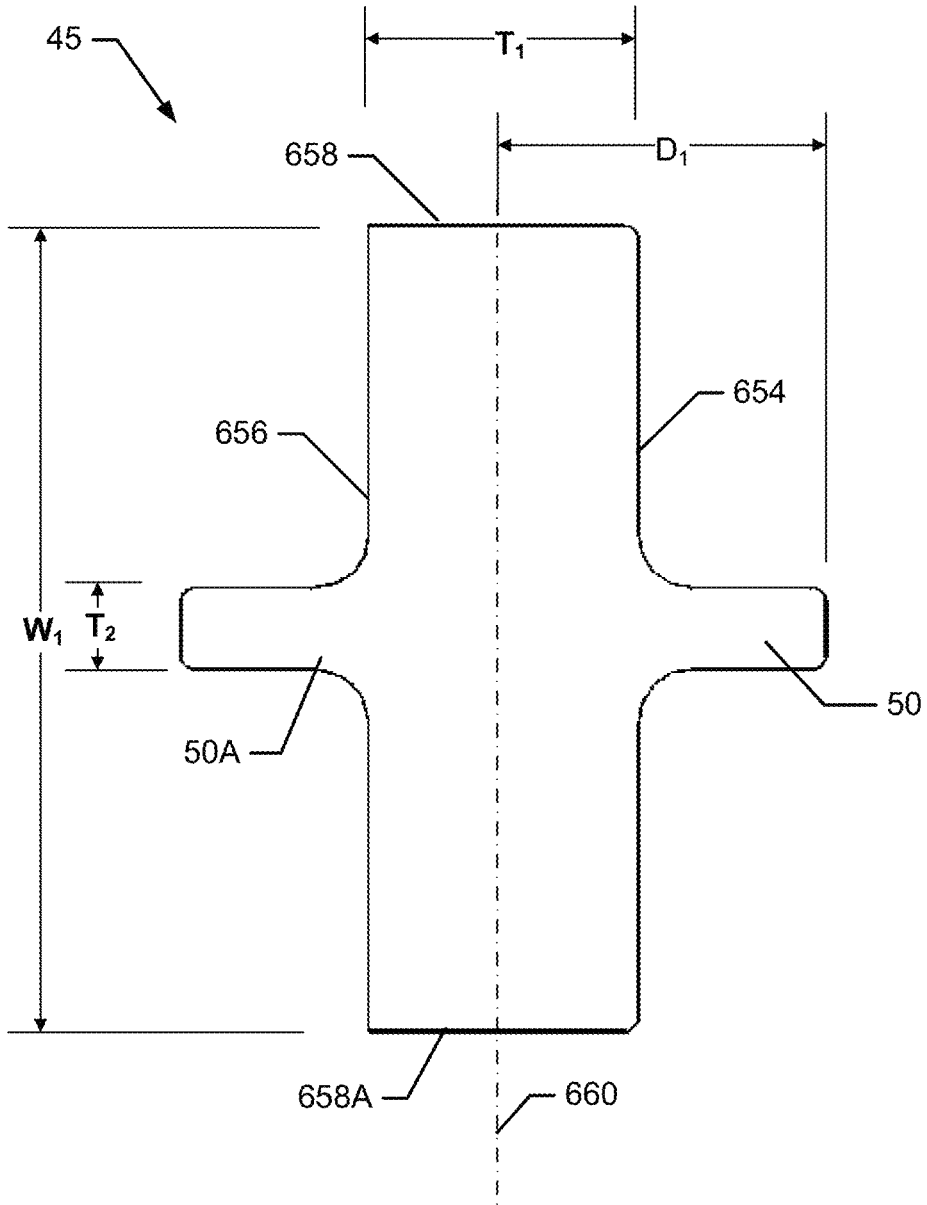


FIG. 6A

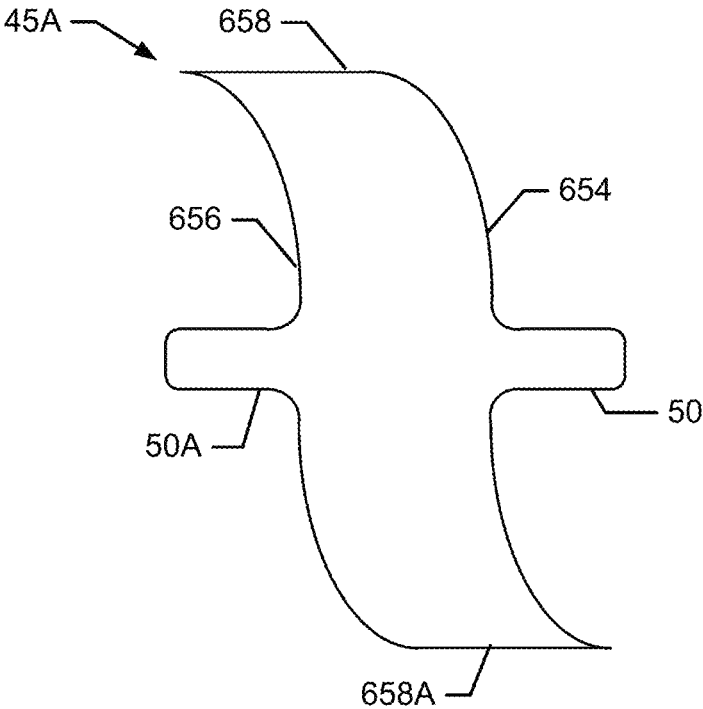


FIG. 6B

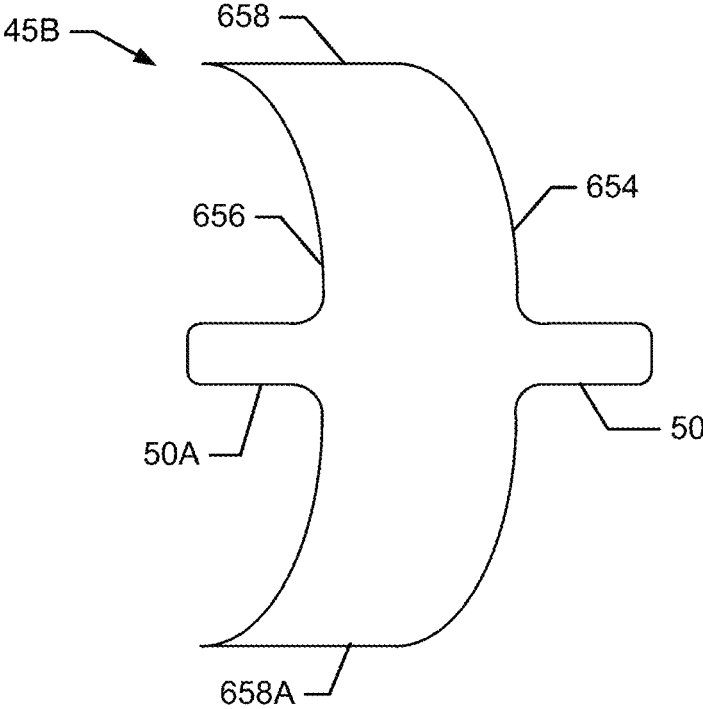


FIG. 6C

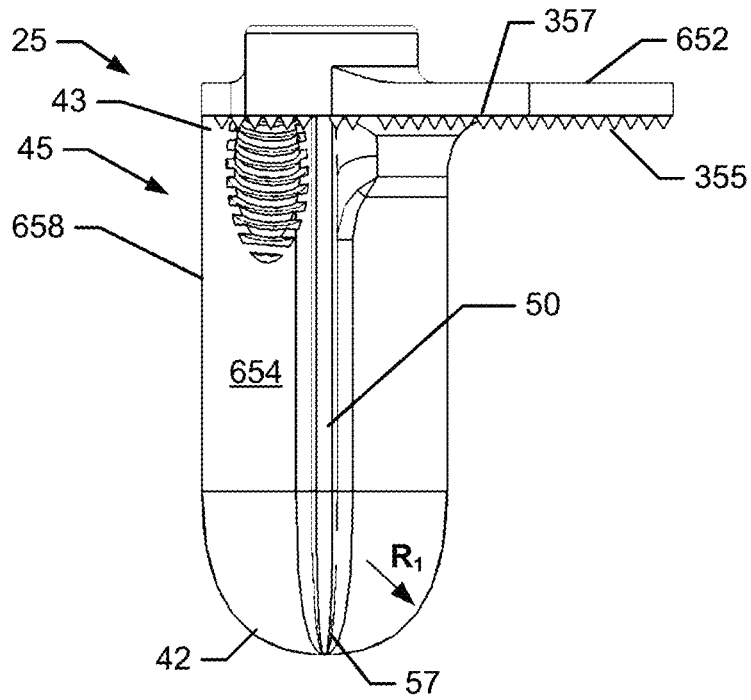


FIG. 7A

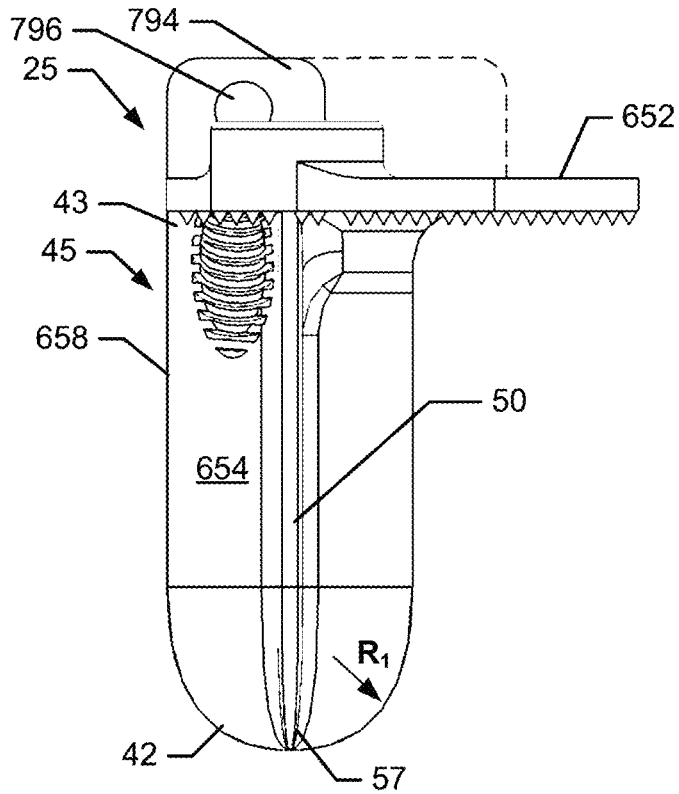


FIG. 7B

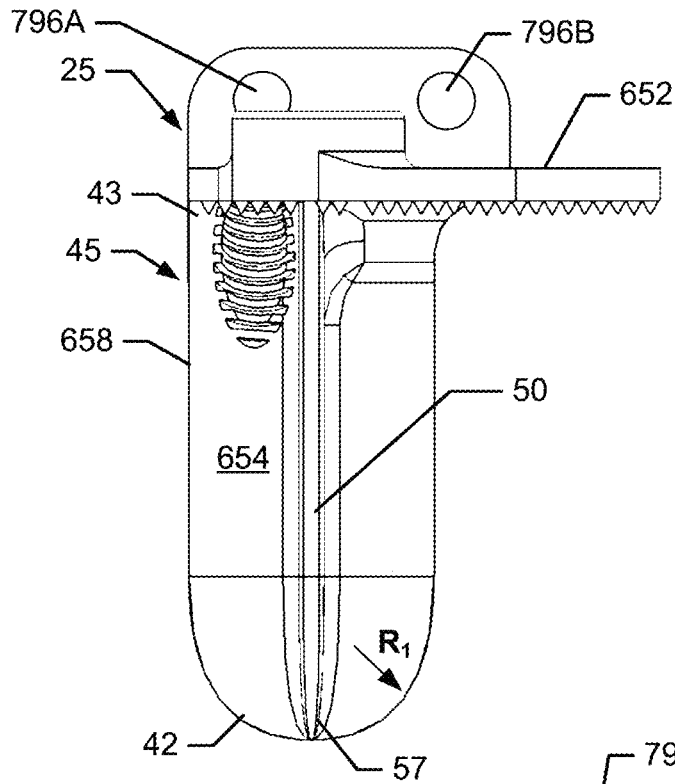


FIG. 7C

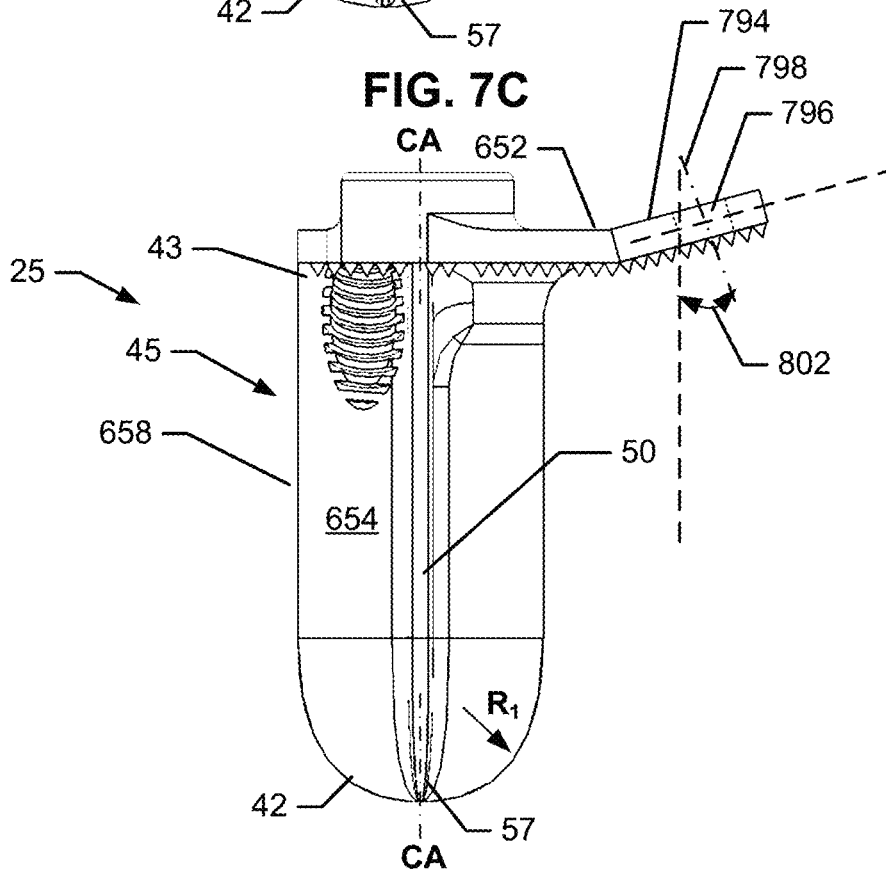


FIG. 7D

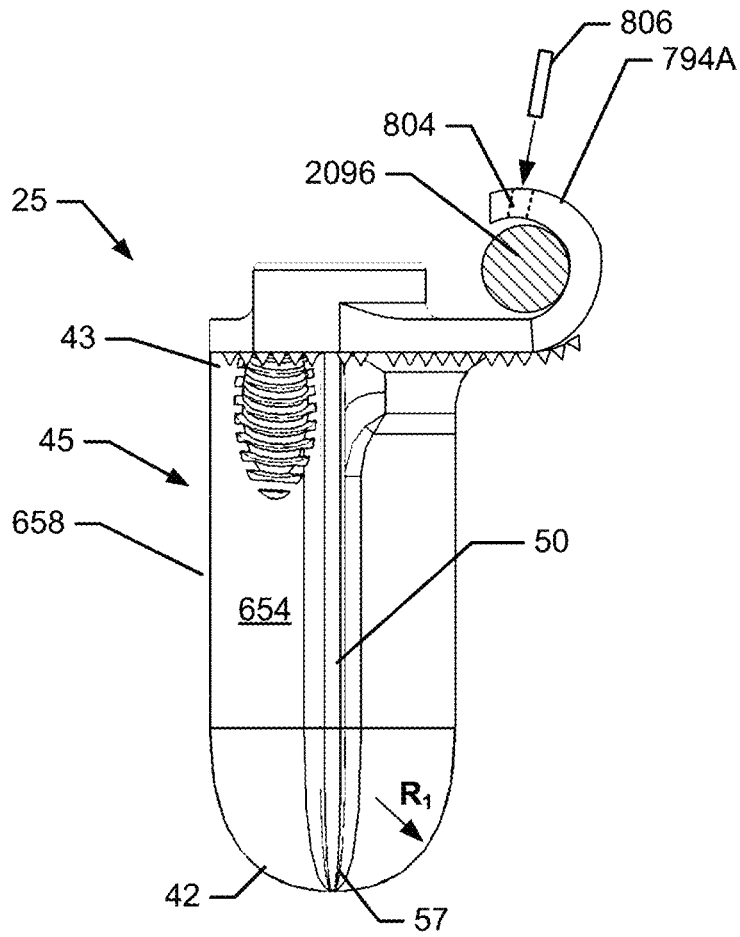


FIG. 7E

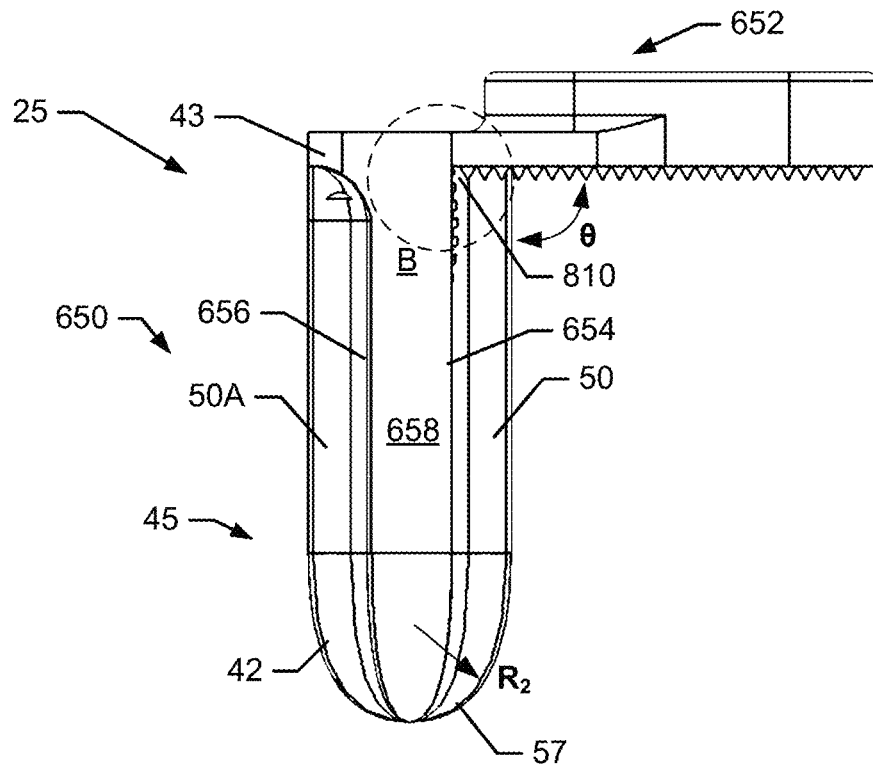


FIG. 8A

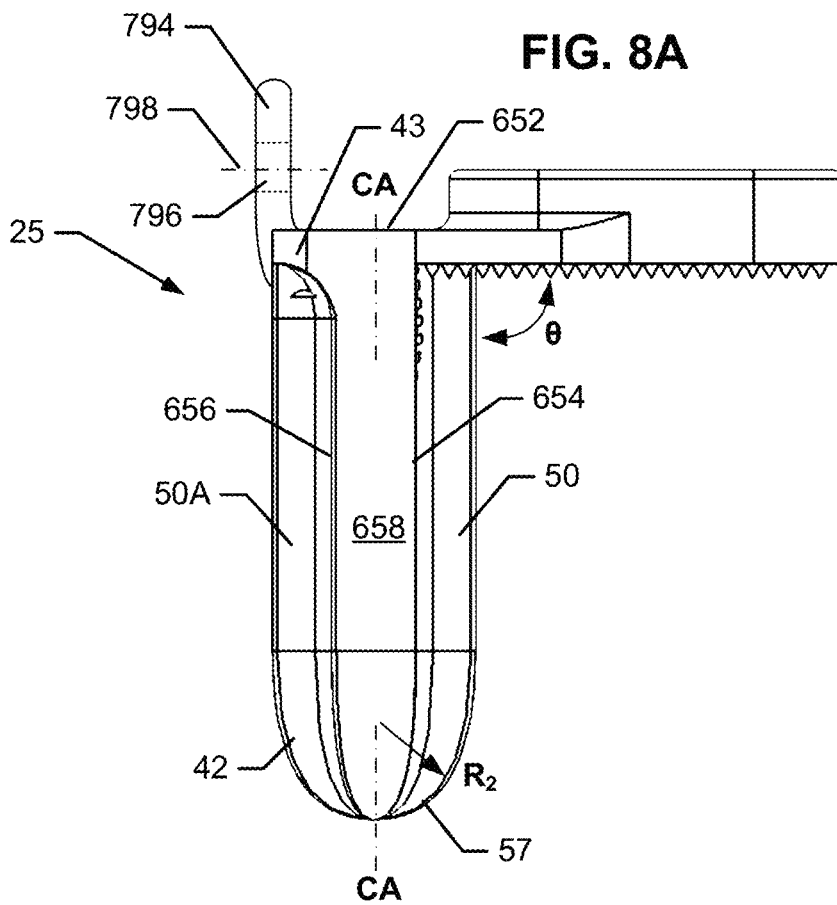


FIG. 8B

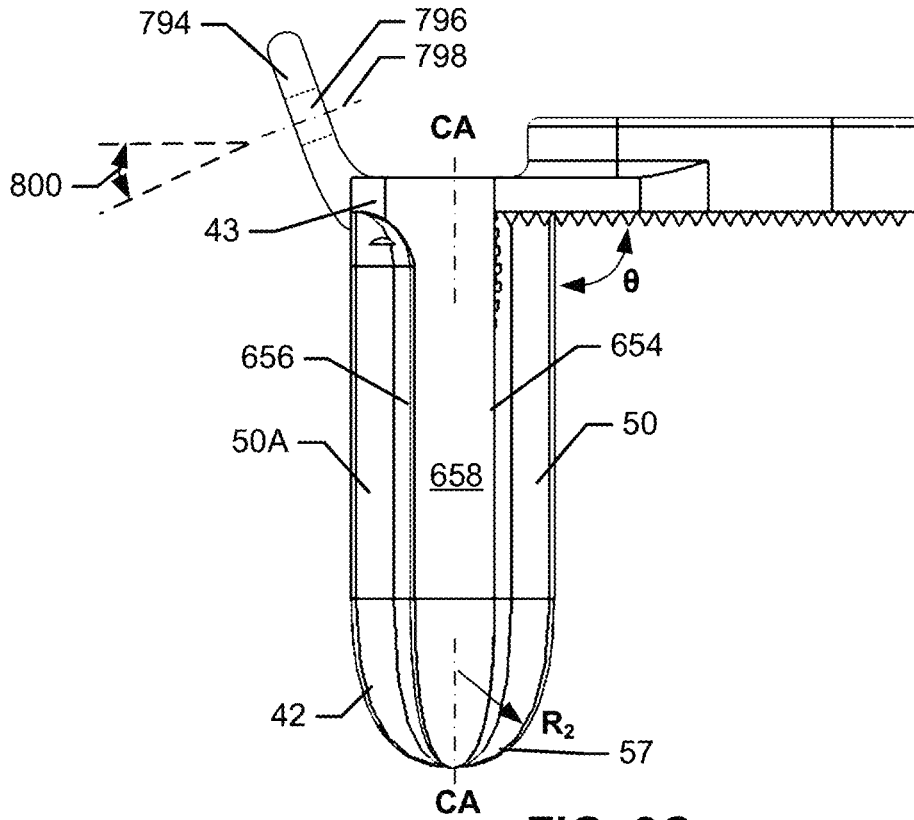


FIG. 8C

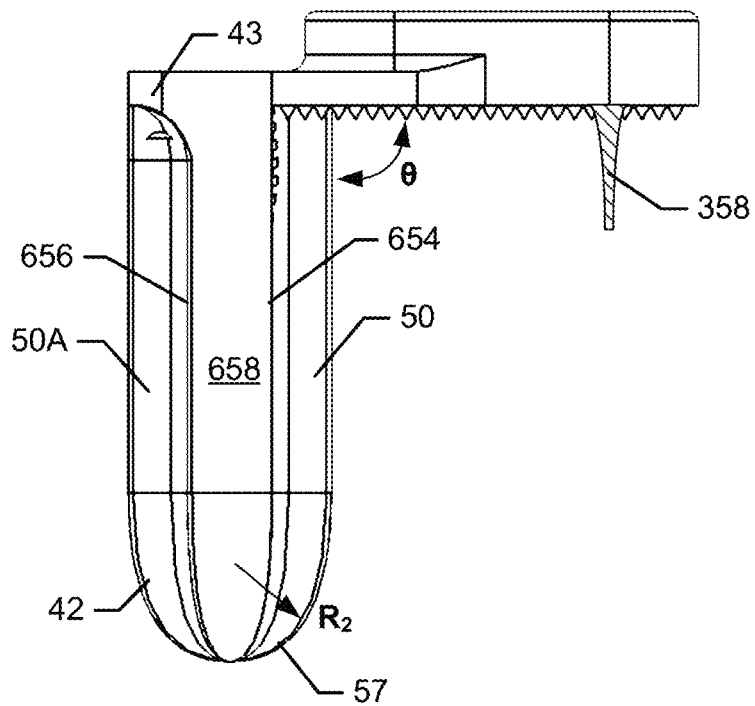


FIG. 8D

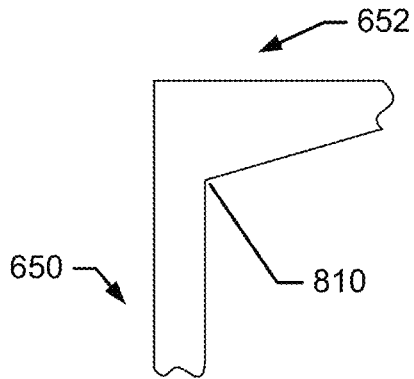


FIG. 8E

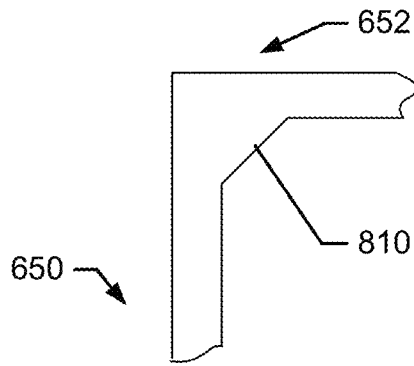


FIG. 8F

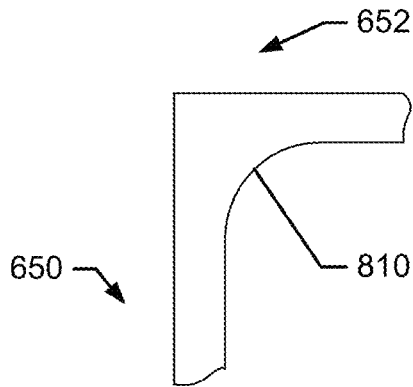


FIG. 8G

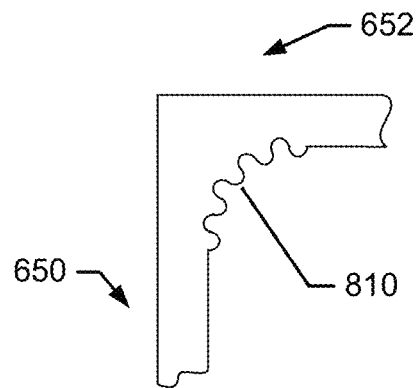


FIG. 8H

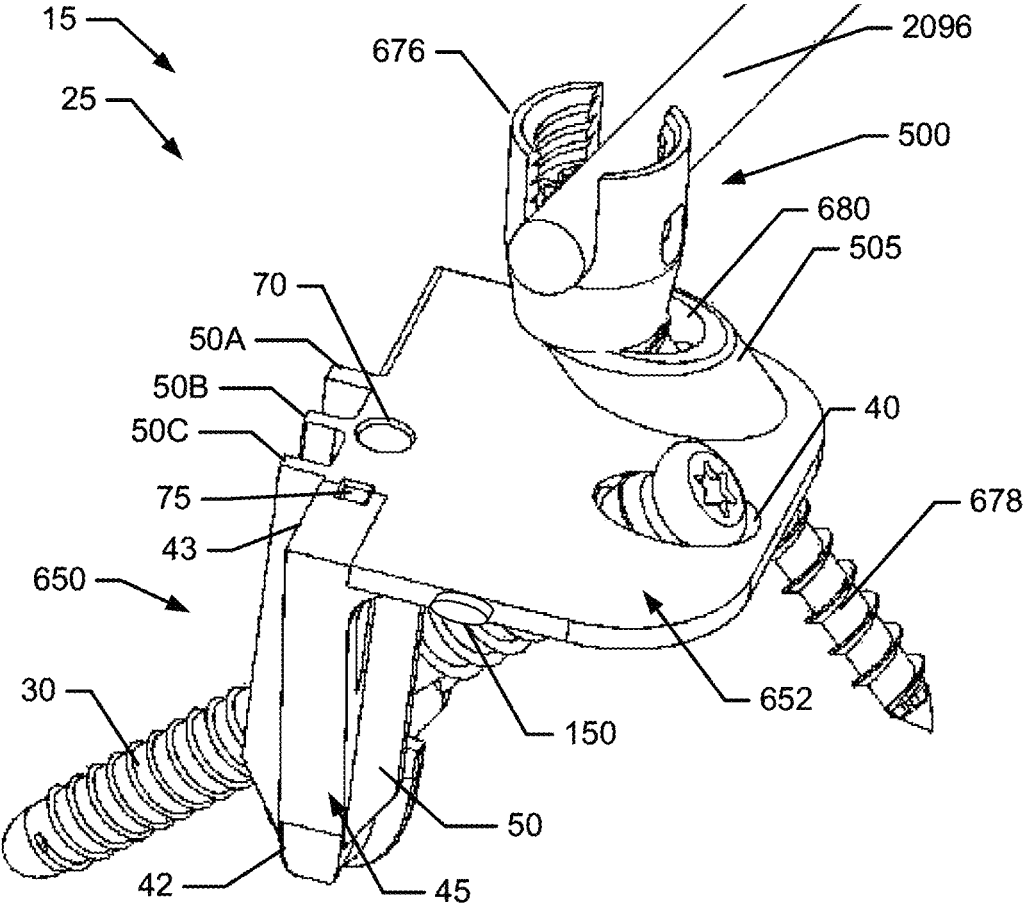


FIG. 9

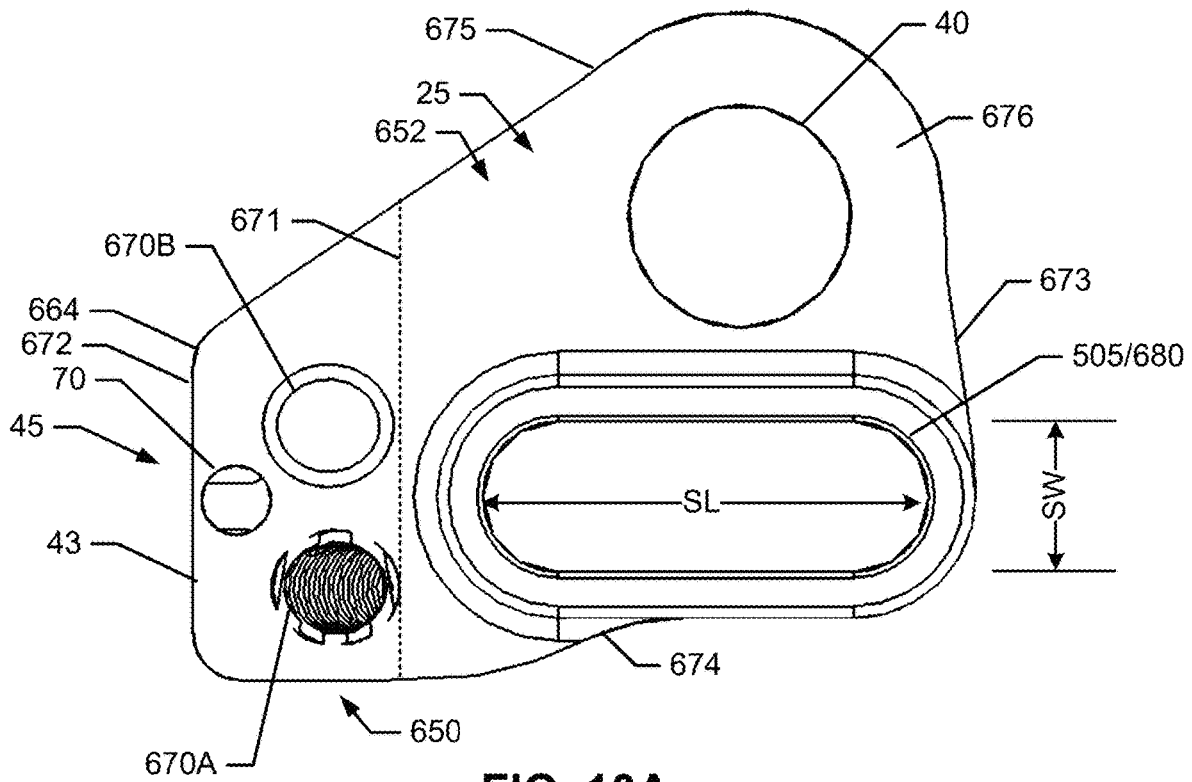


FIG. 10A

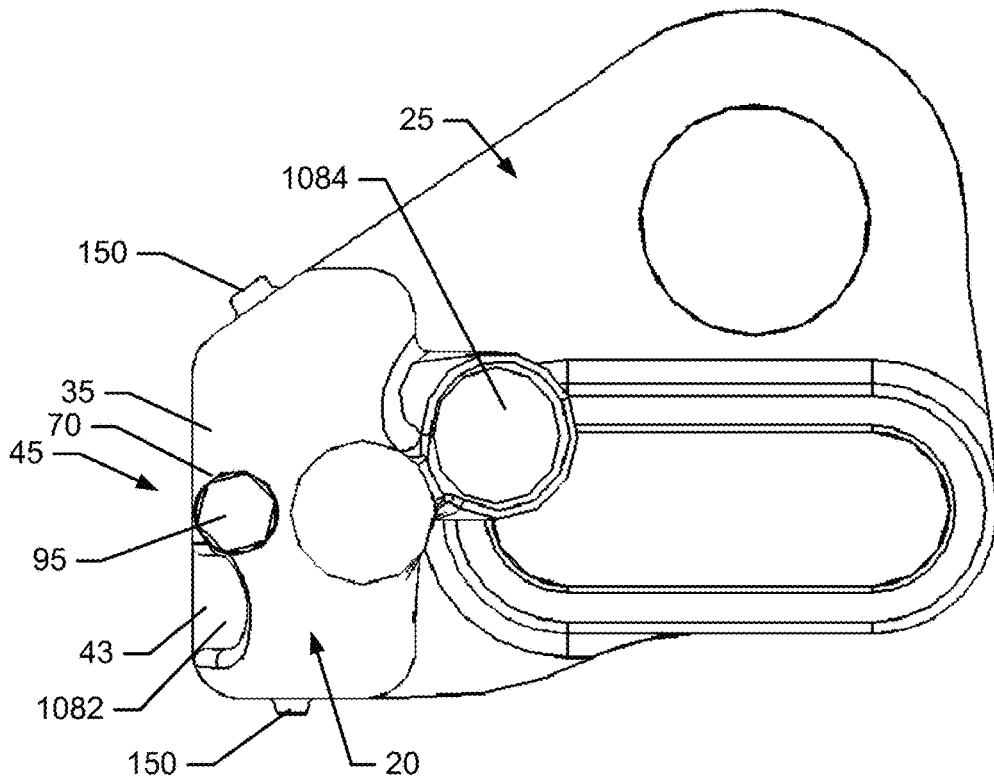


FIG. 10B

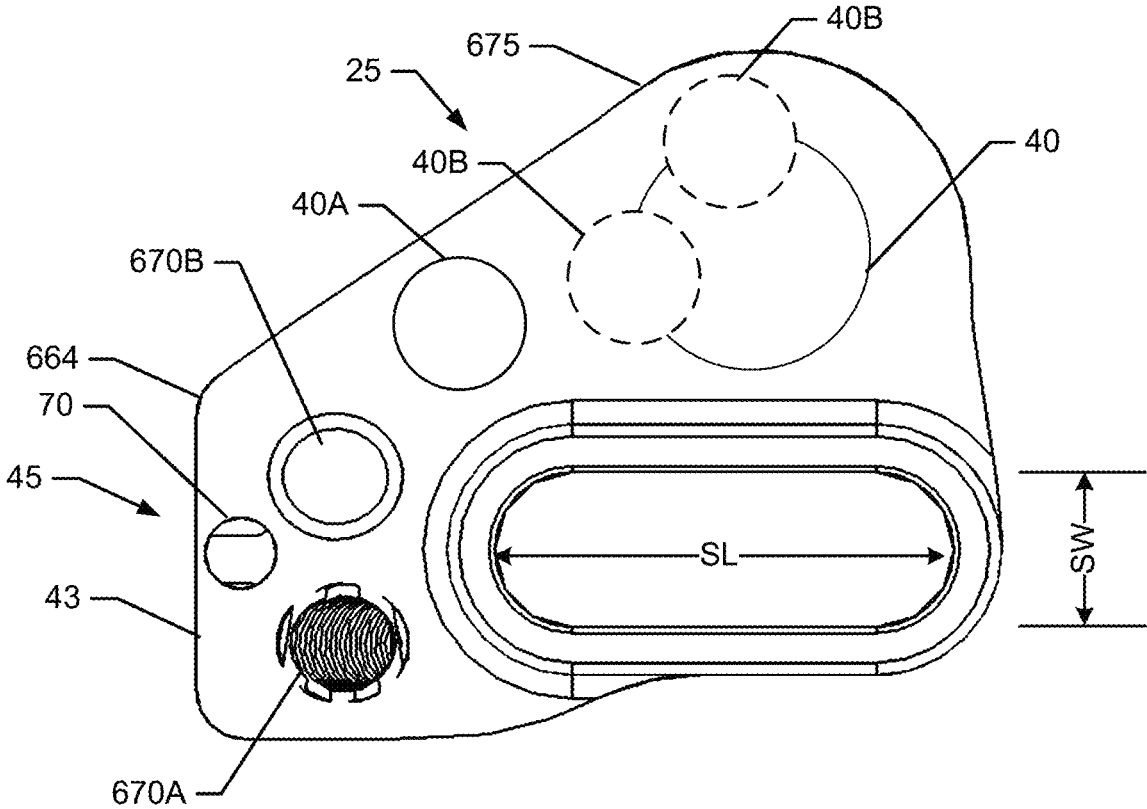


FIG. 10C

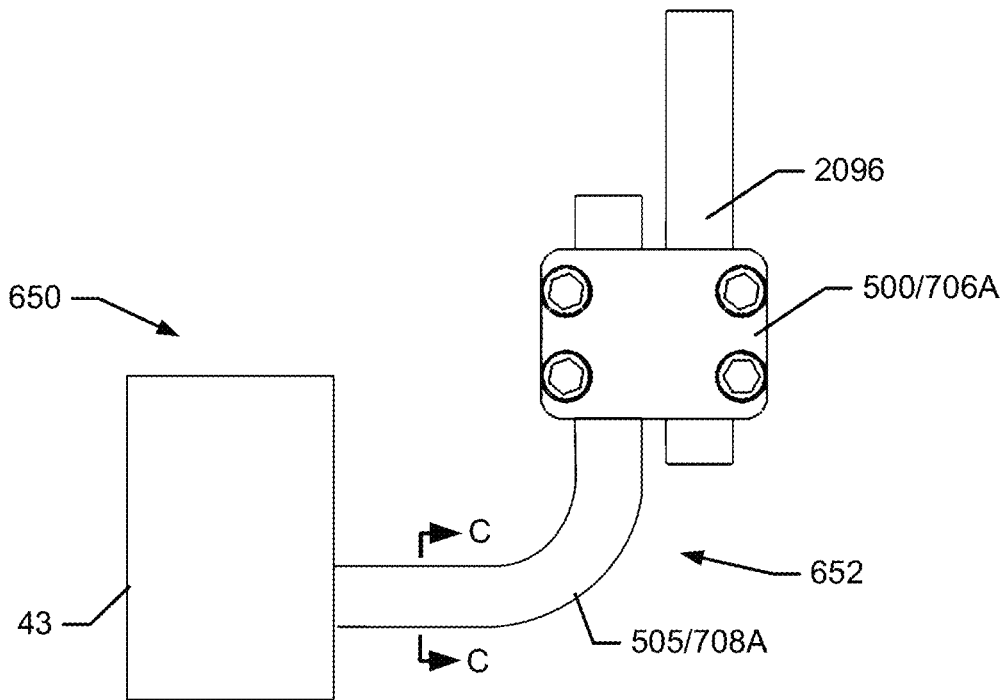


FIG. 10D

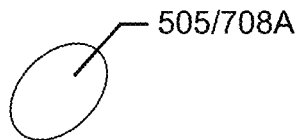


FIG. 10E

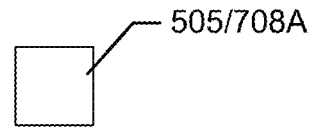


FIG. 10F

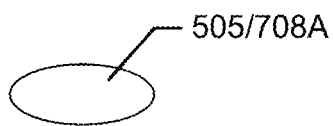


FIG. 10G

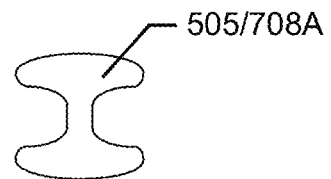


FIG. 10H

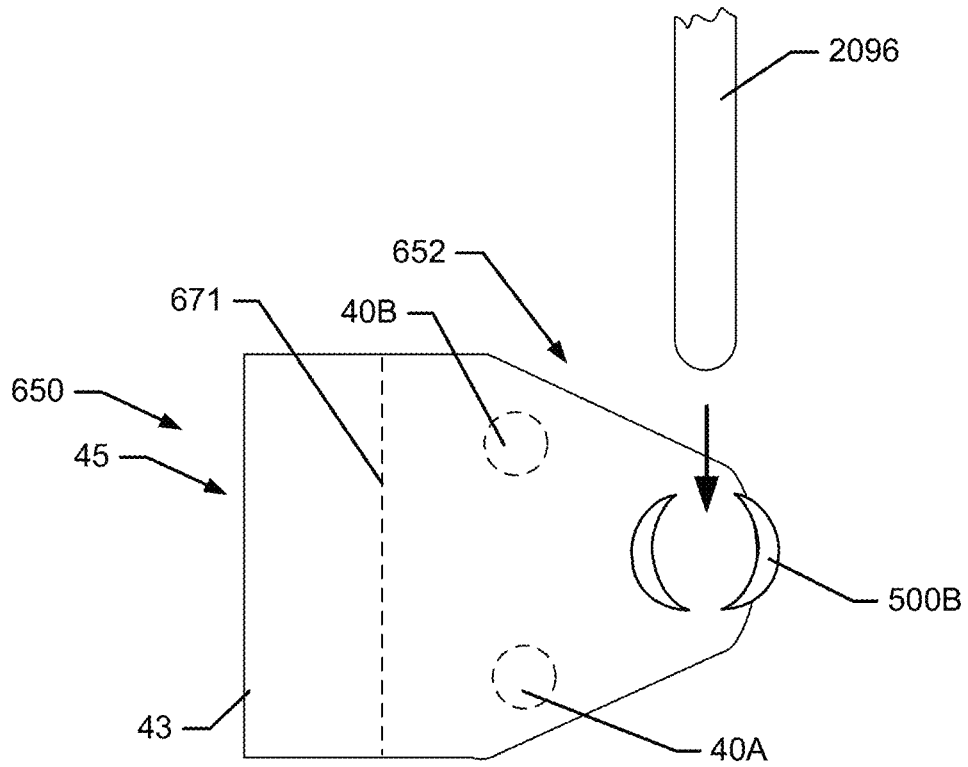


FIG. 10I

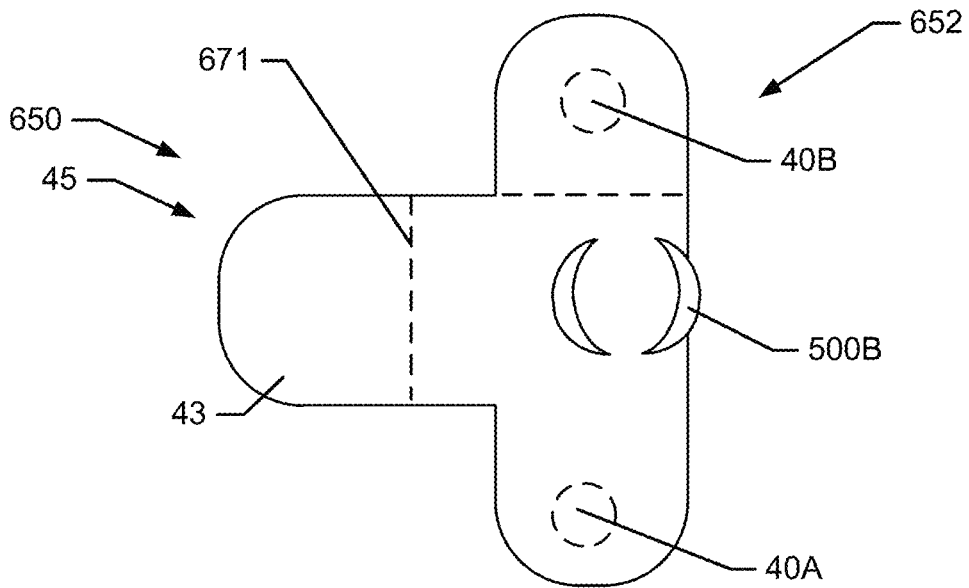


FIG. 10J

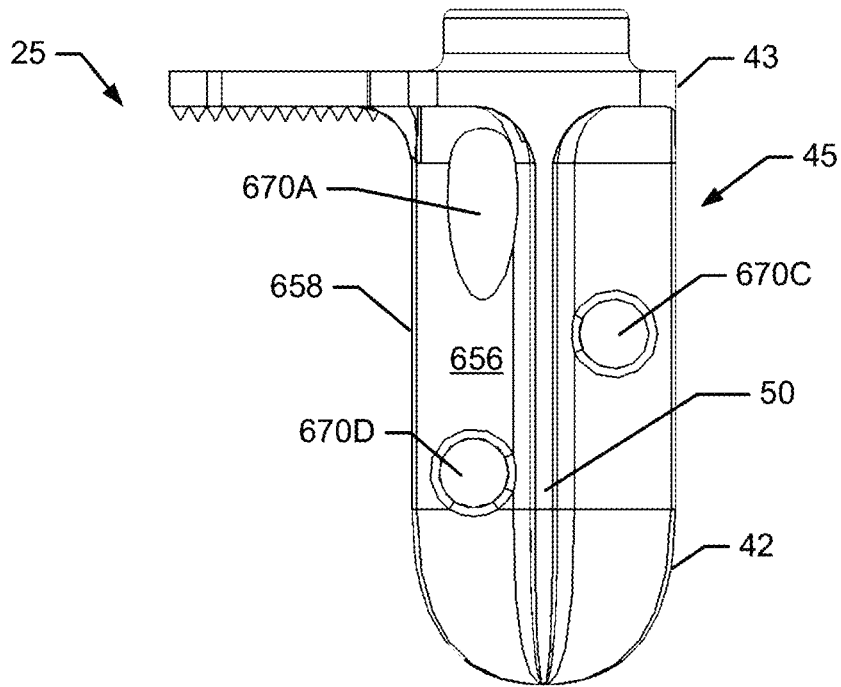


FIG. 11A

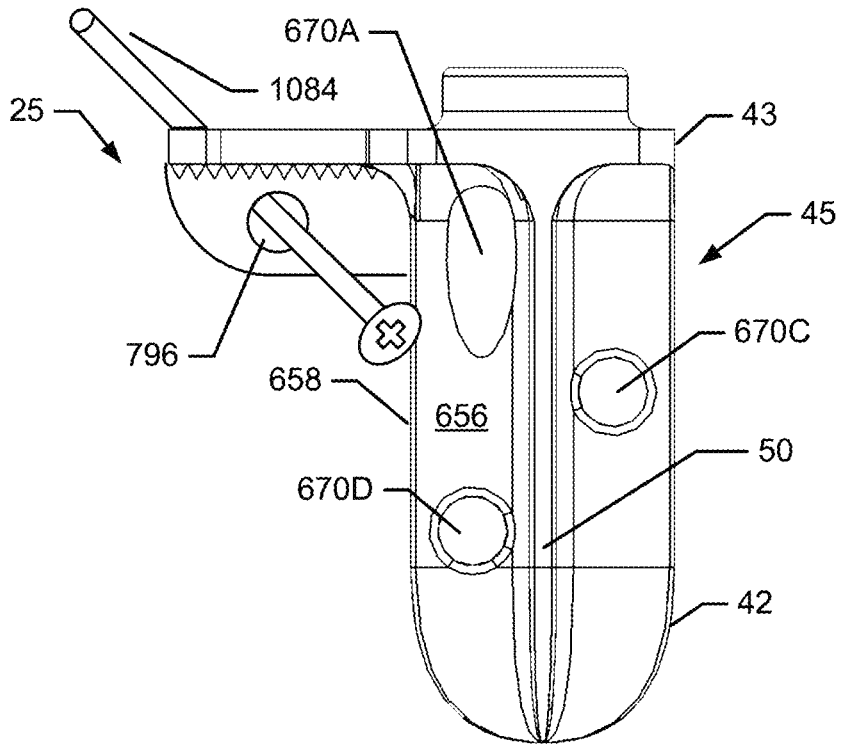


FIG. 11B

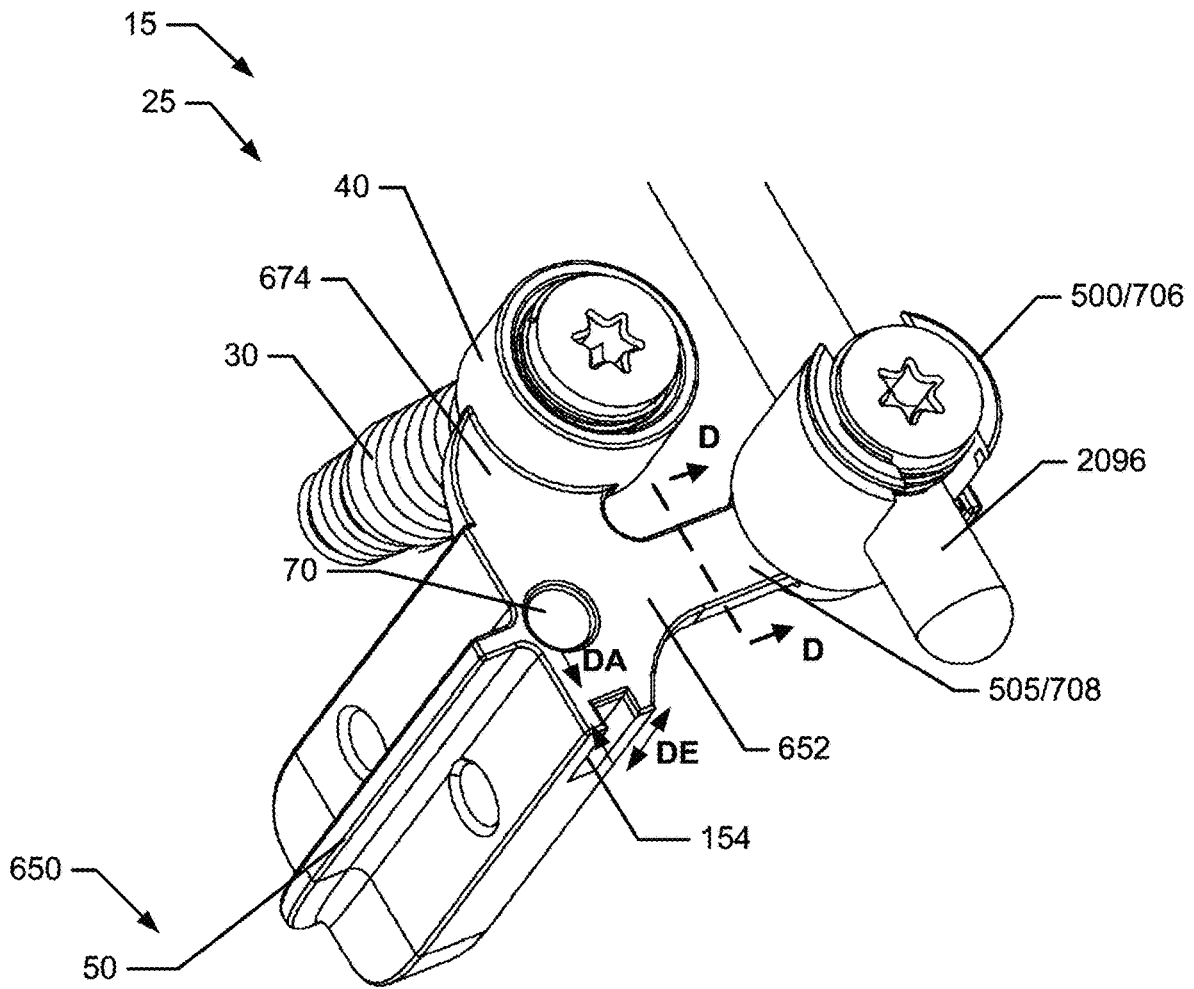


FIG. 12A



FIG. 12B

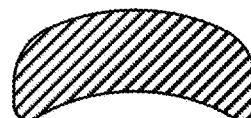


FIG. 12C

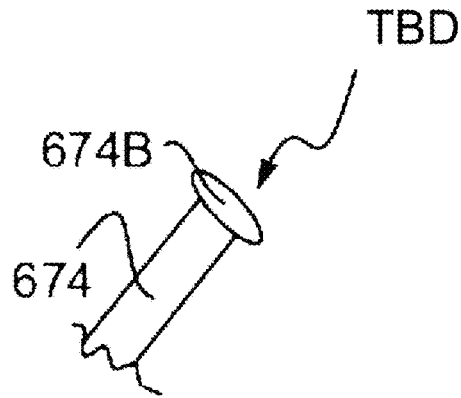


FIG. 12D

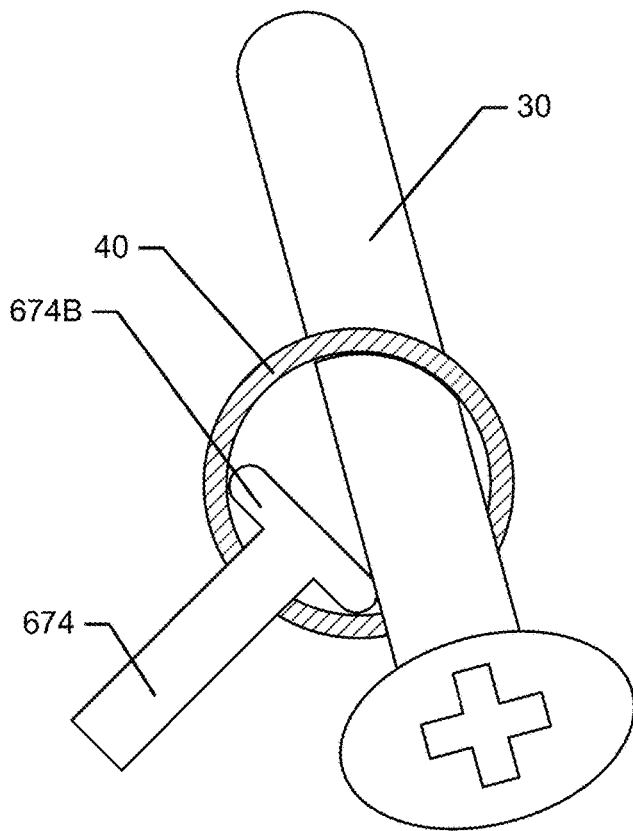


FIG. 12E

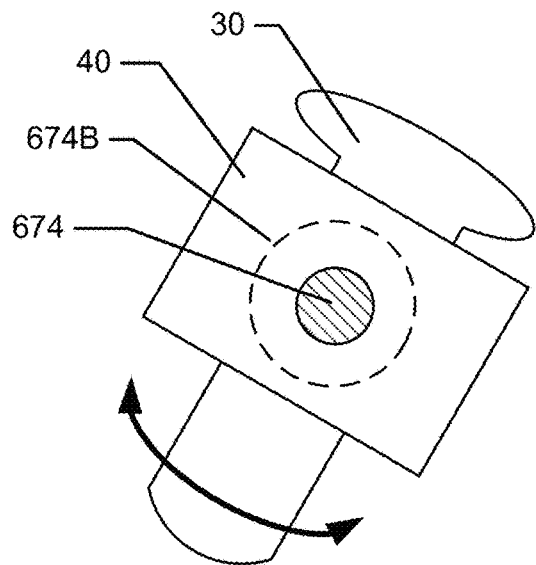


FIG. 12F

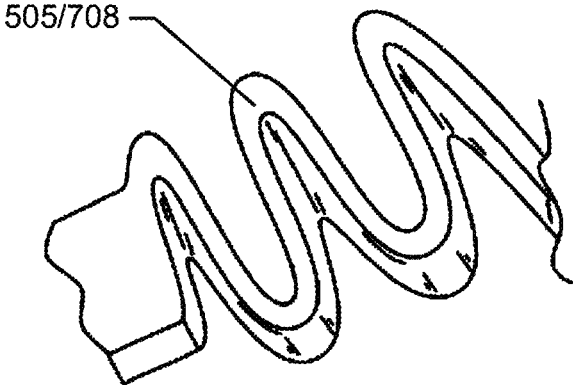


FIG. 12G

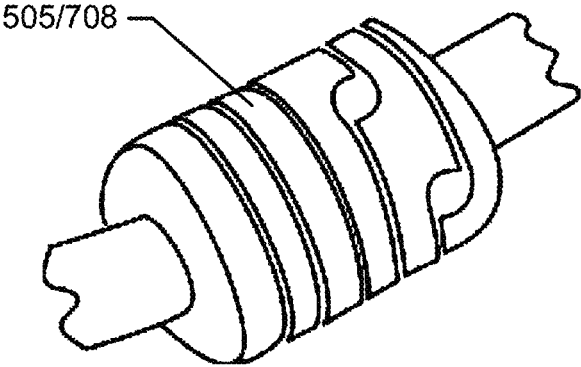


FIG. 12H

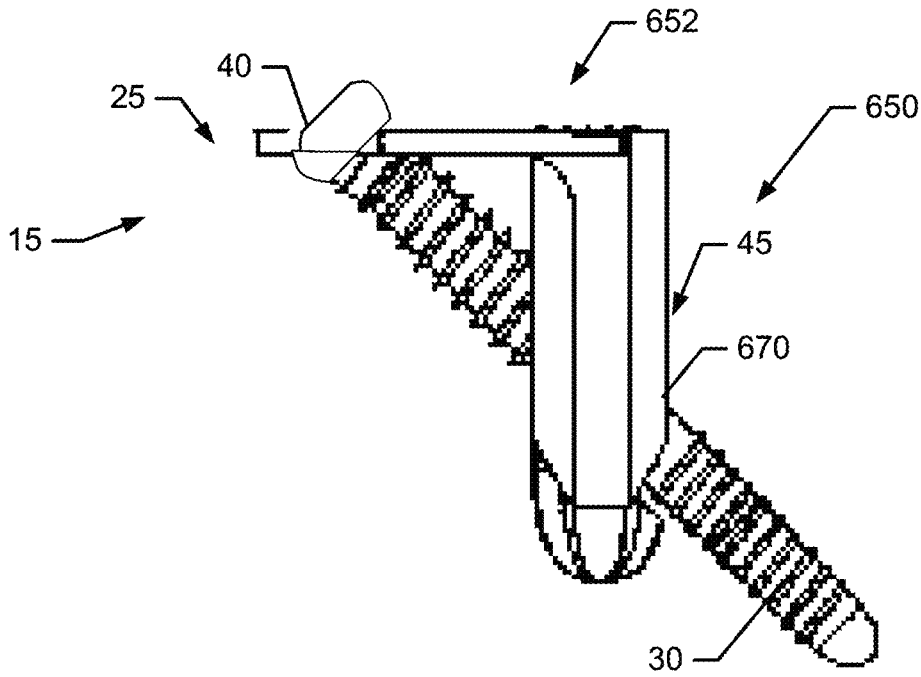


FIG. 13A

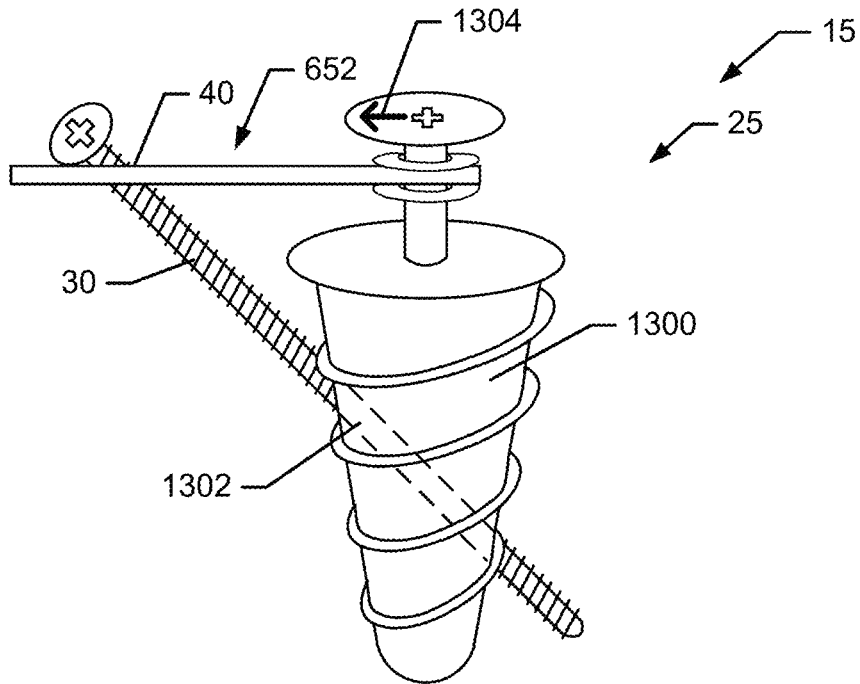


FIG. 13B

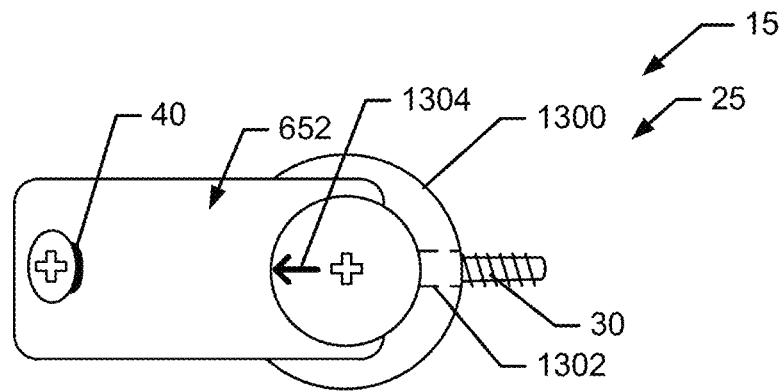


FIG. 13C

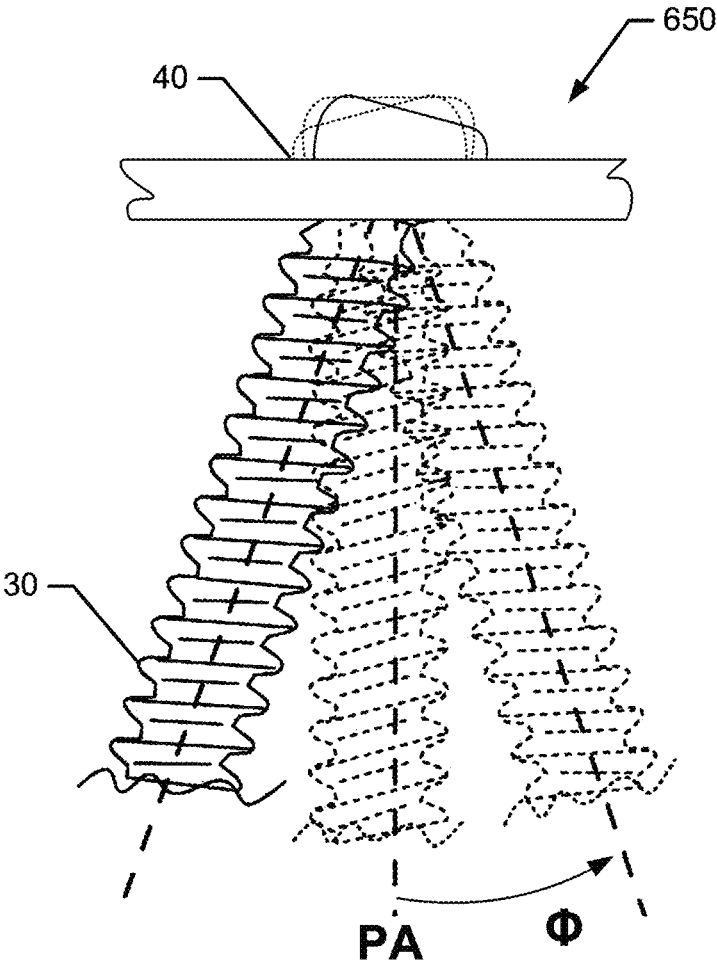


FIG. 14

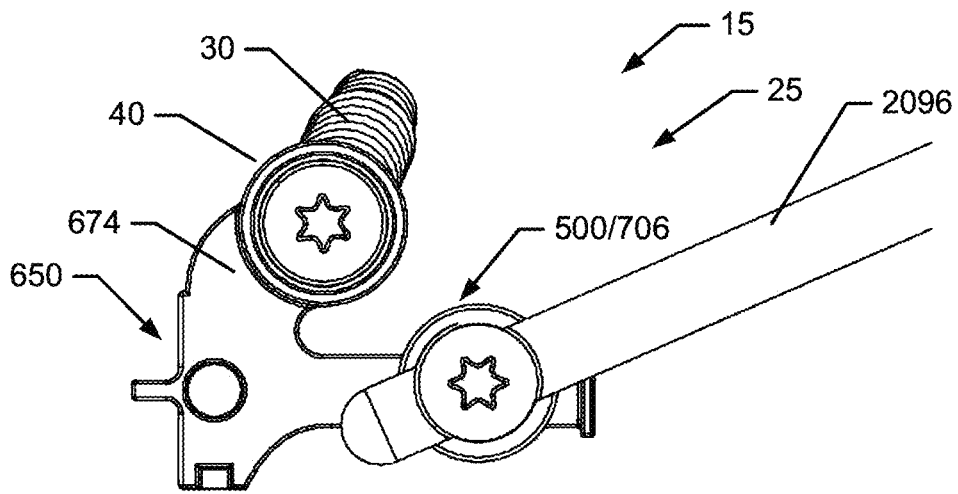


FIG. 15A

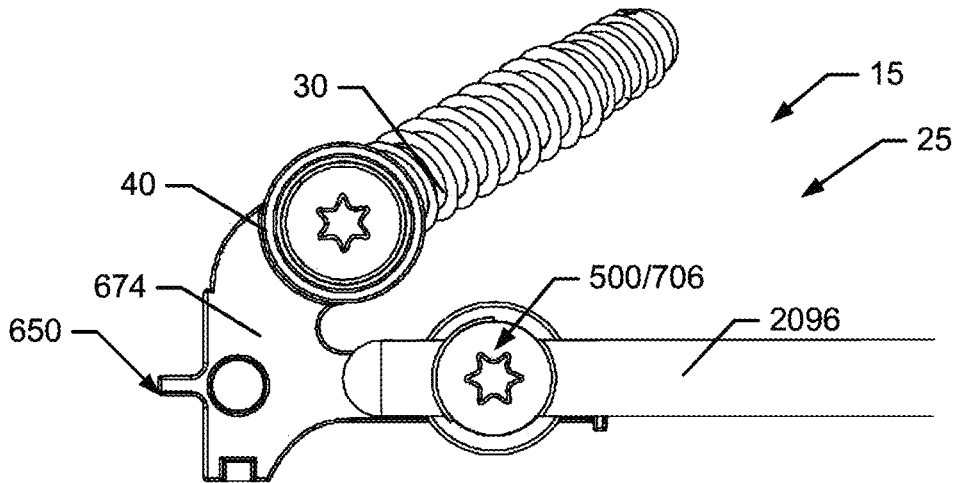


FIG. 15B

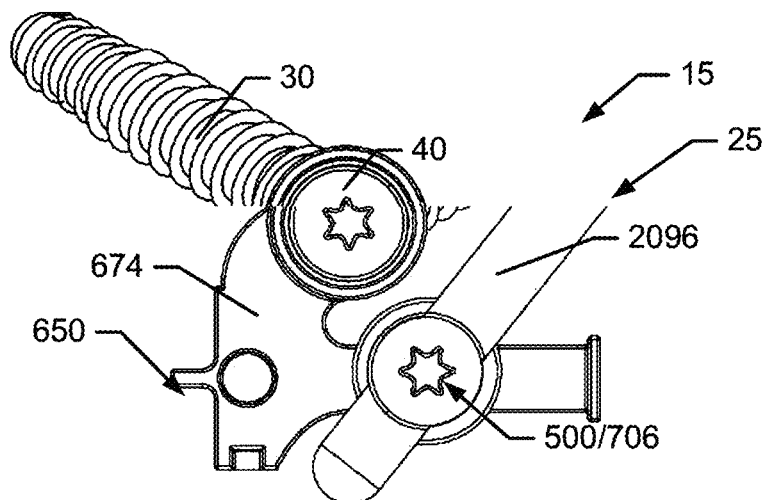


FIG. 15C

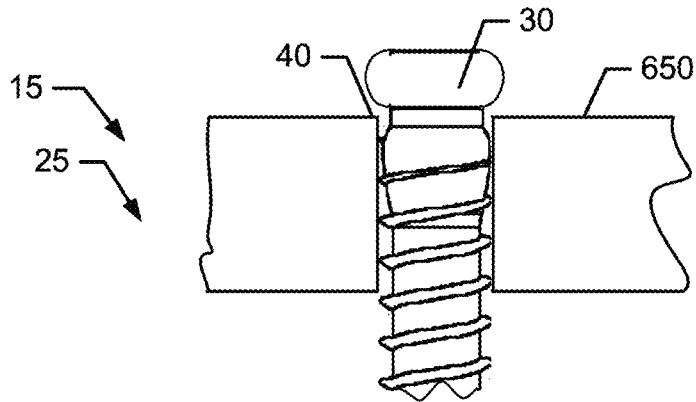


FIG. 16A

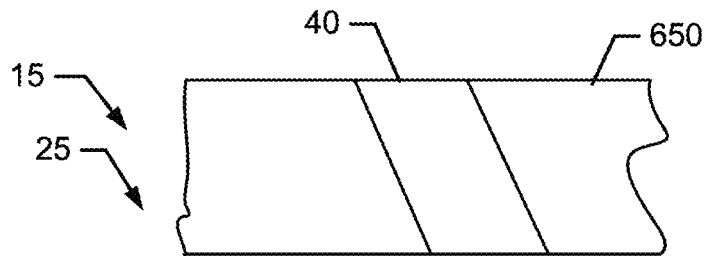


FIG. 16B

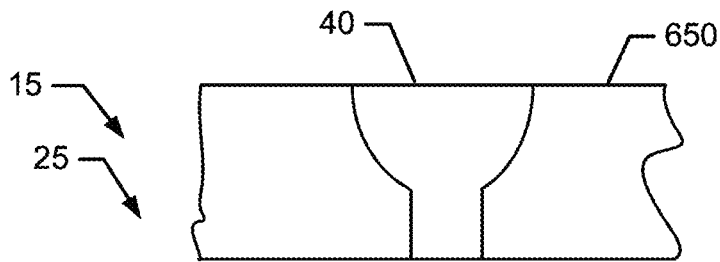


FIG. 16C

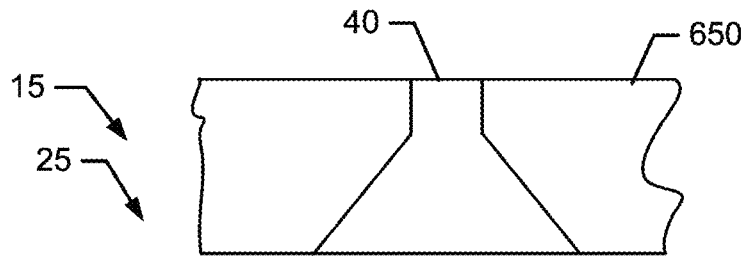


FIG. 16D

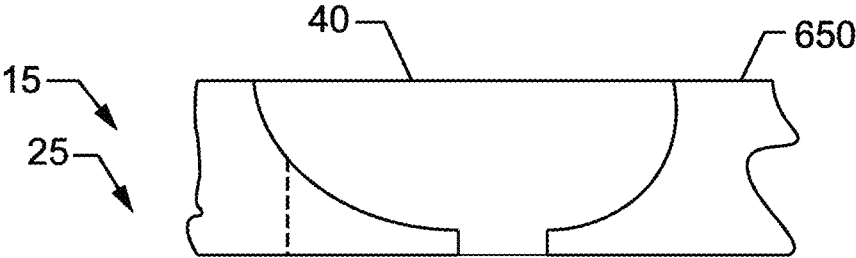


FIG. 16E

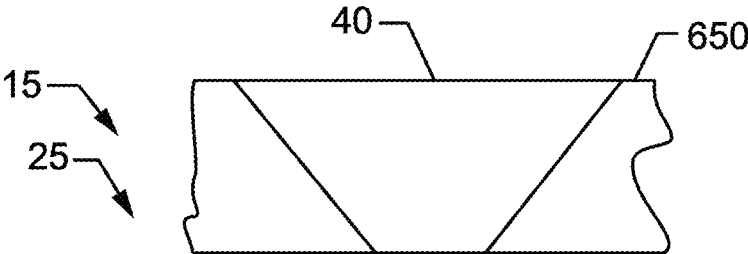


FIG. 16F

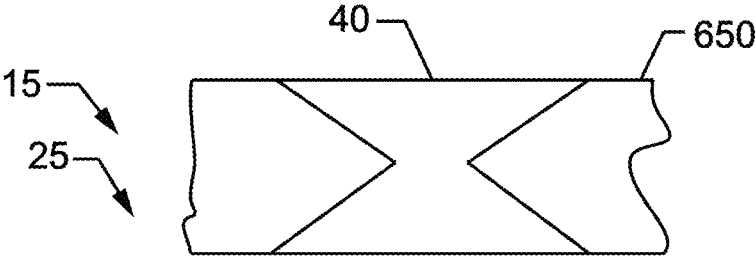


FIG. 16G

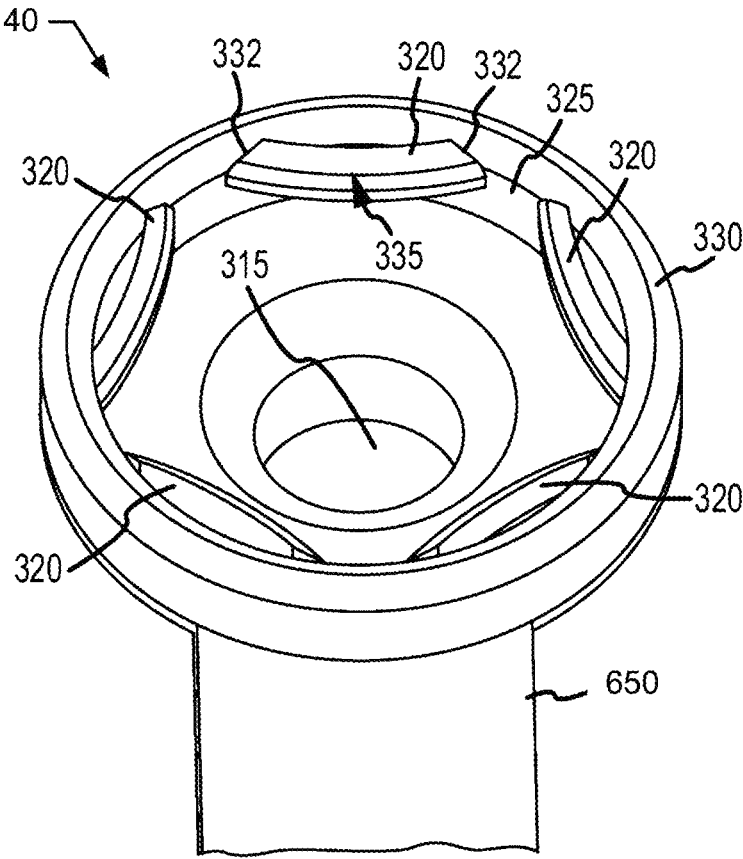


FIG. 17

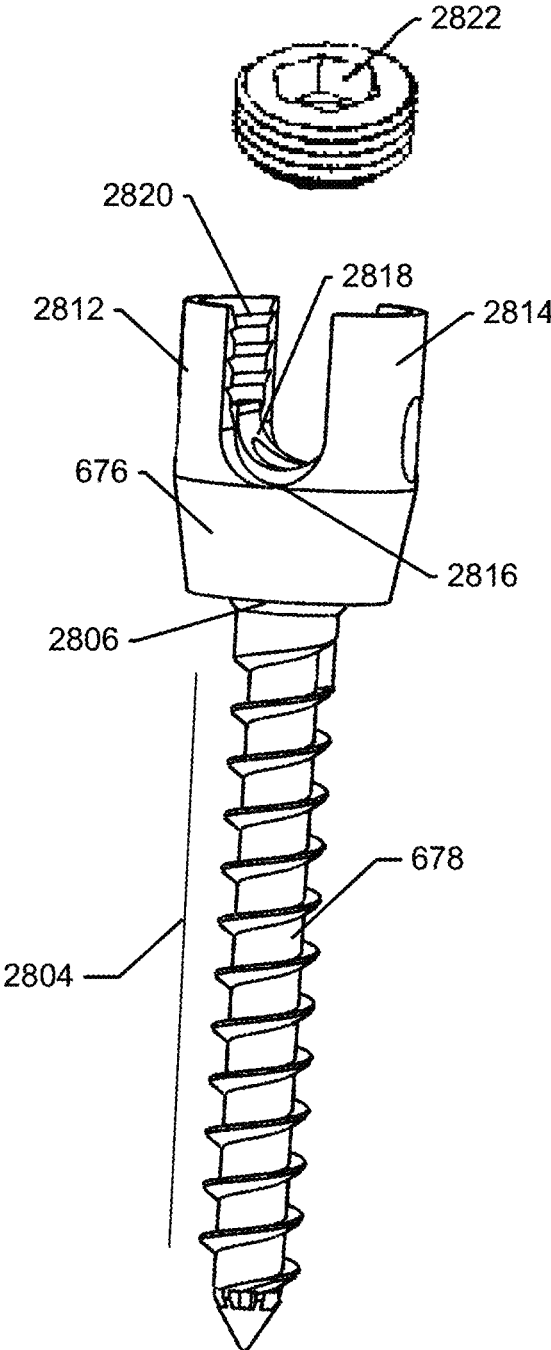


FIG. 18

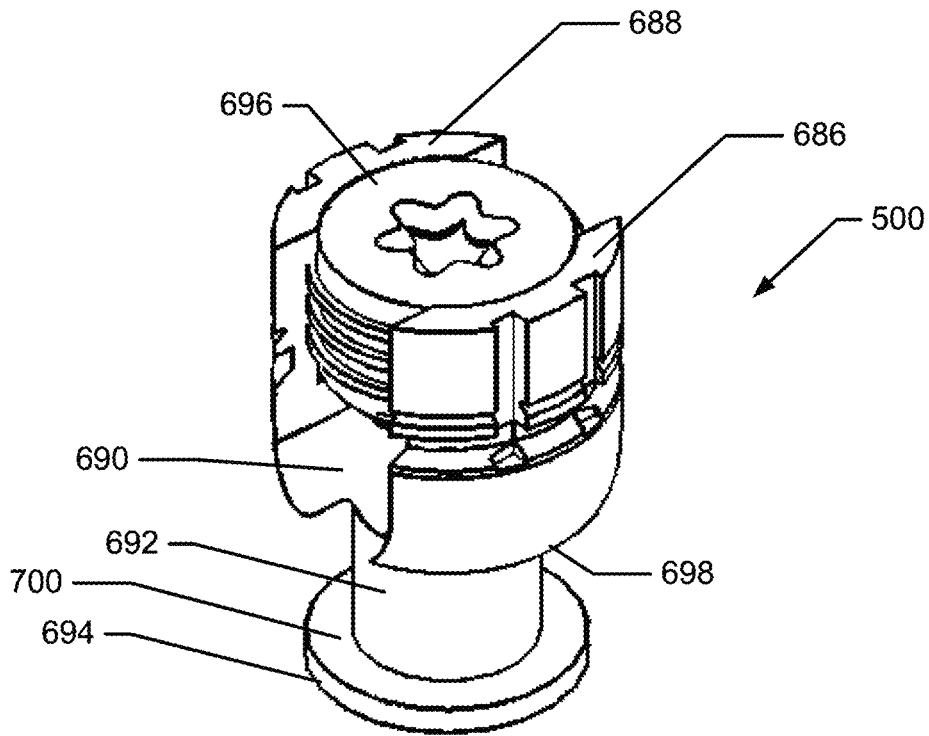


FIG. 19

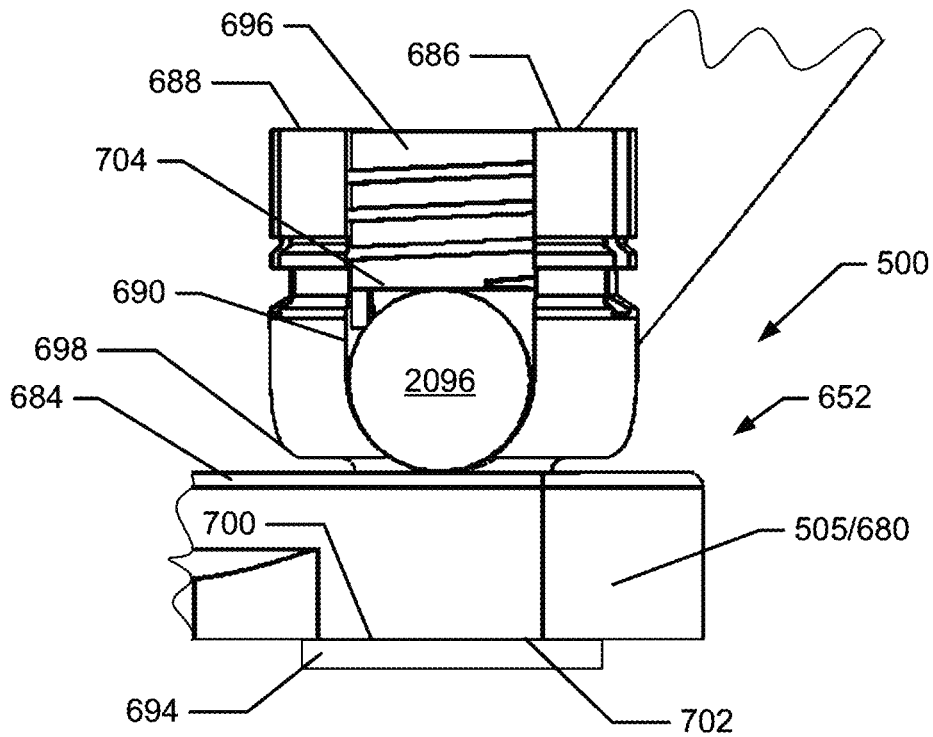


FIG. 20

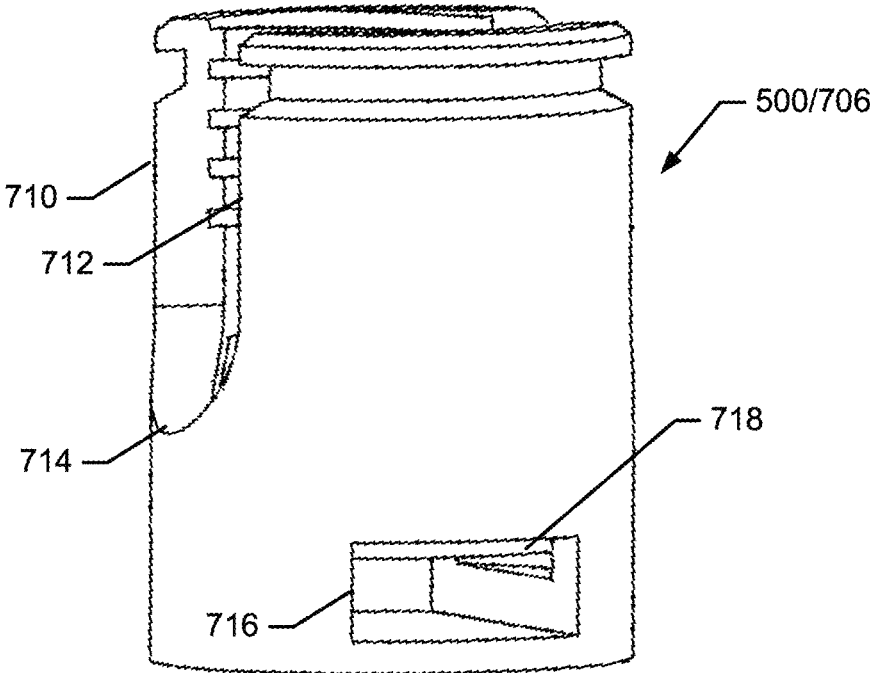


FIG. 21

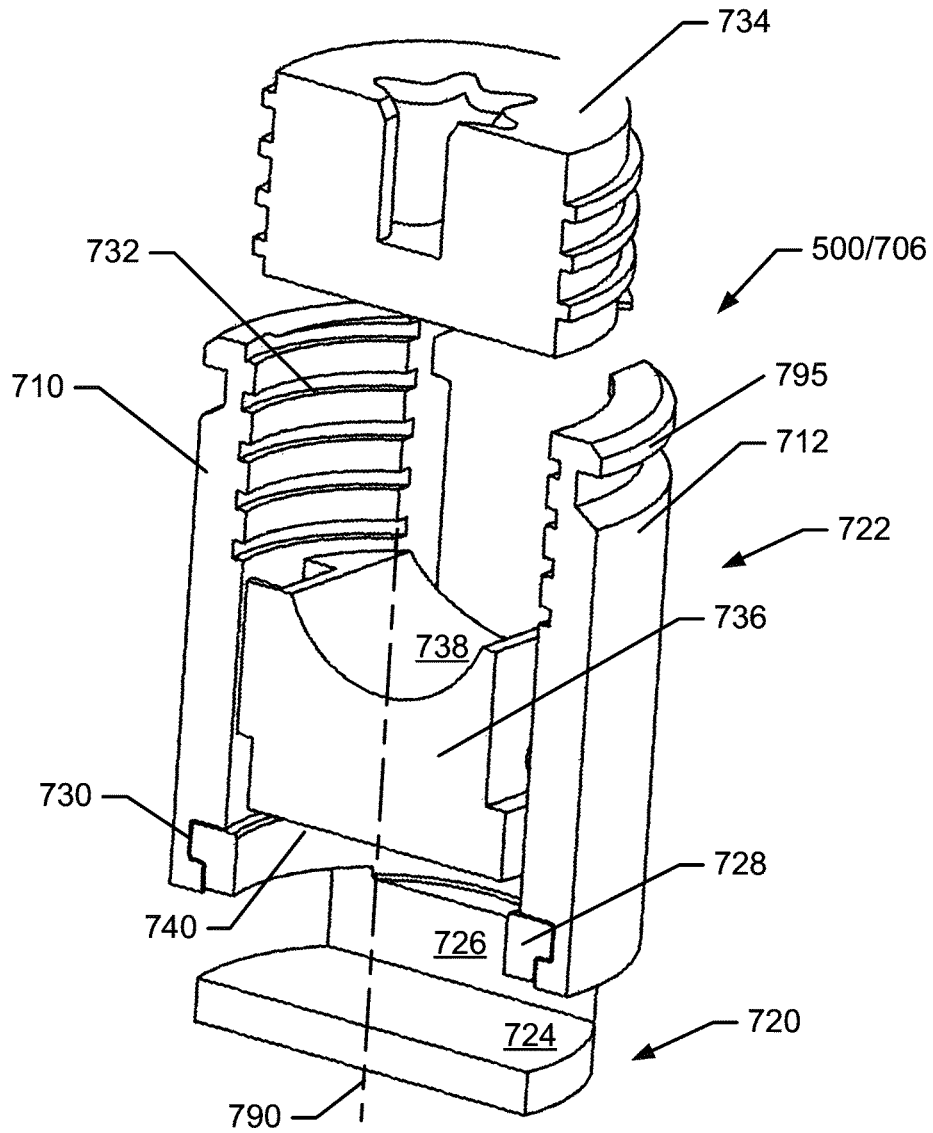


FIG. 22

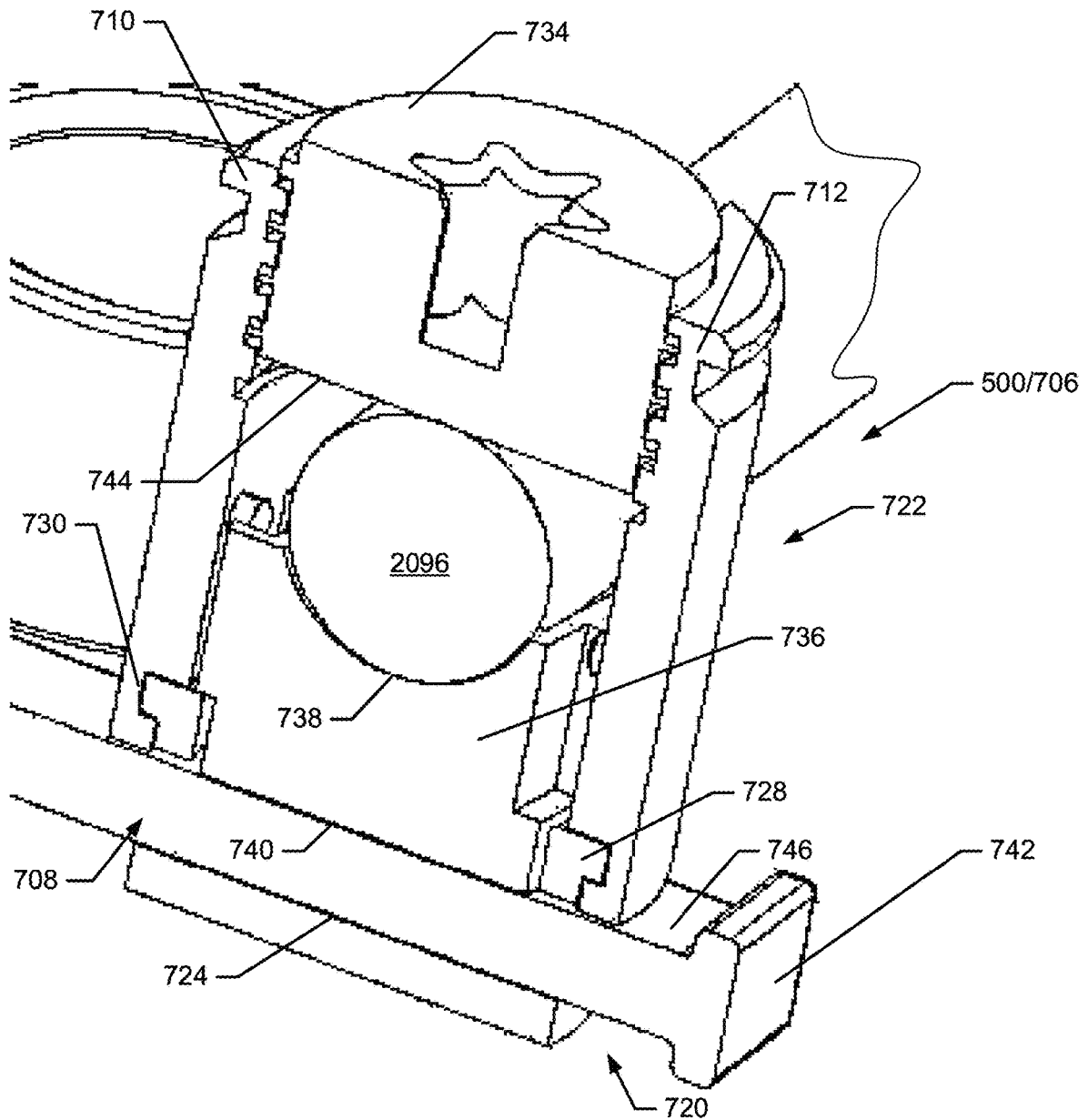


FIG. 23

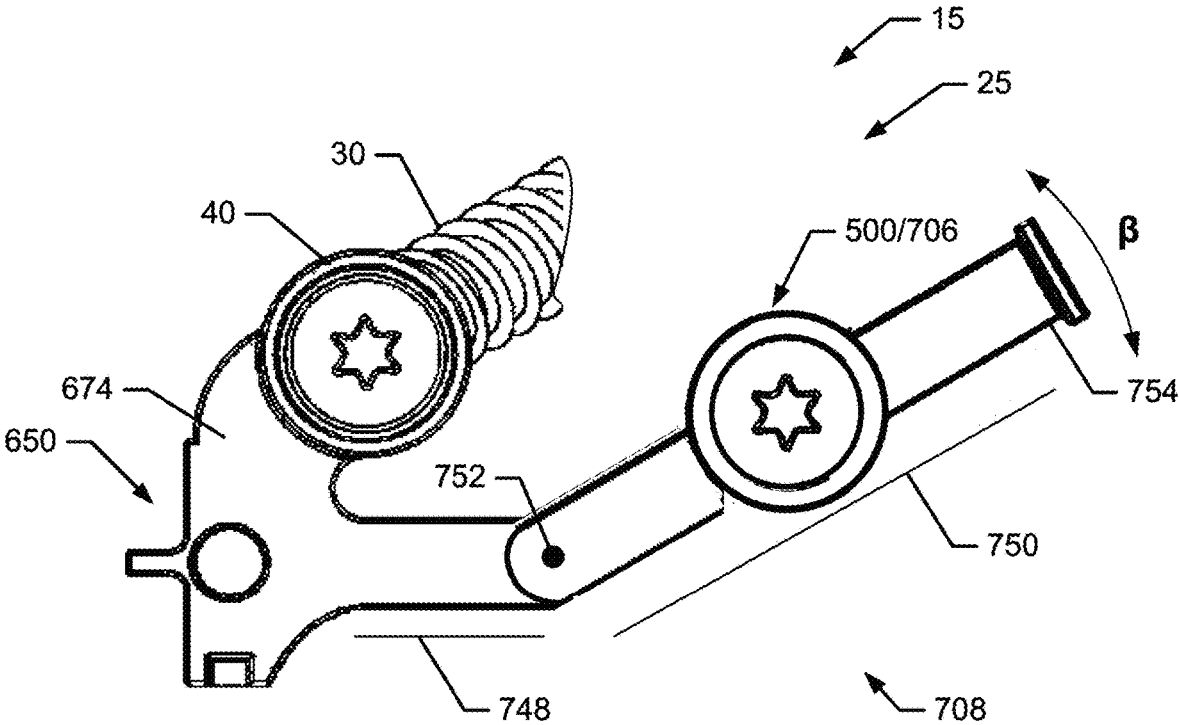


FIG. 24

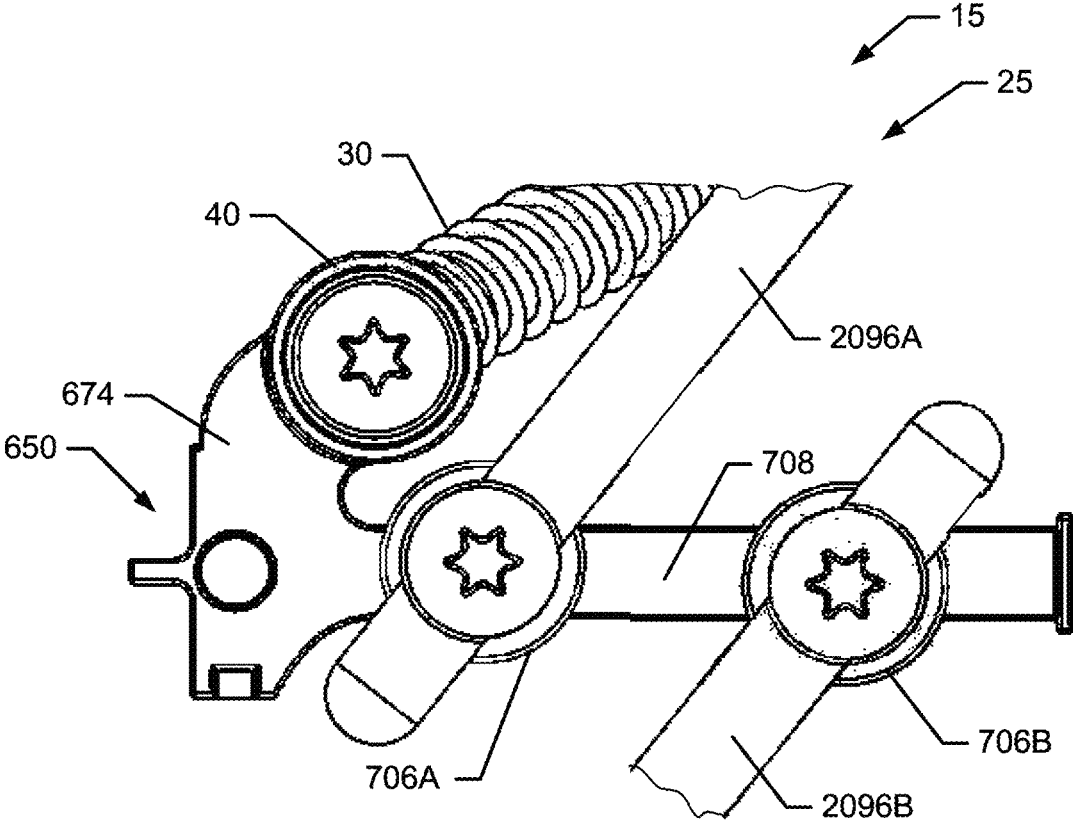


FIG. 25

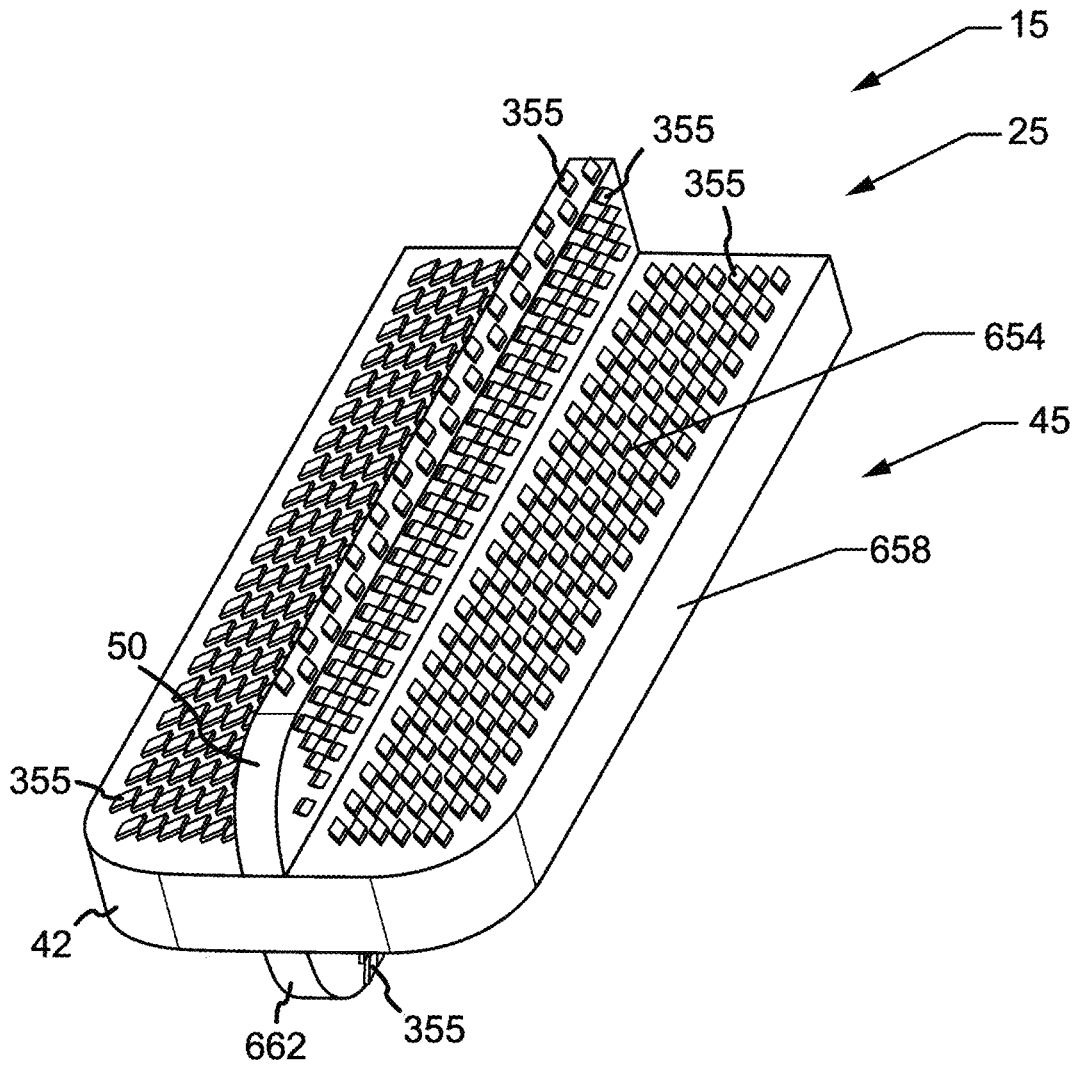


FIG. 26

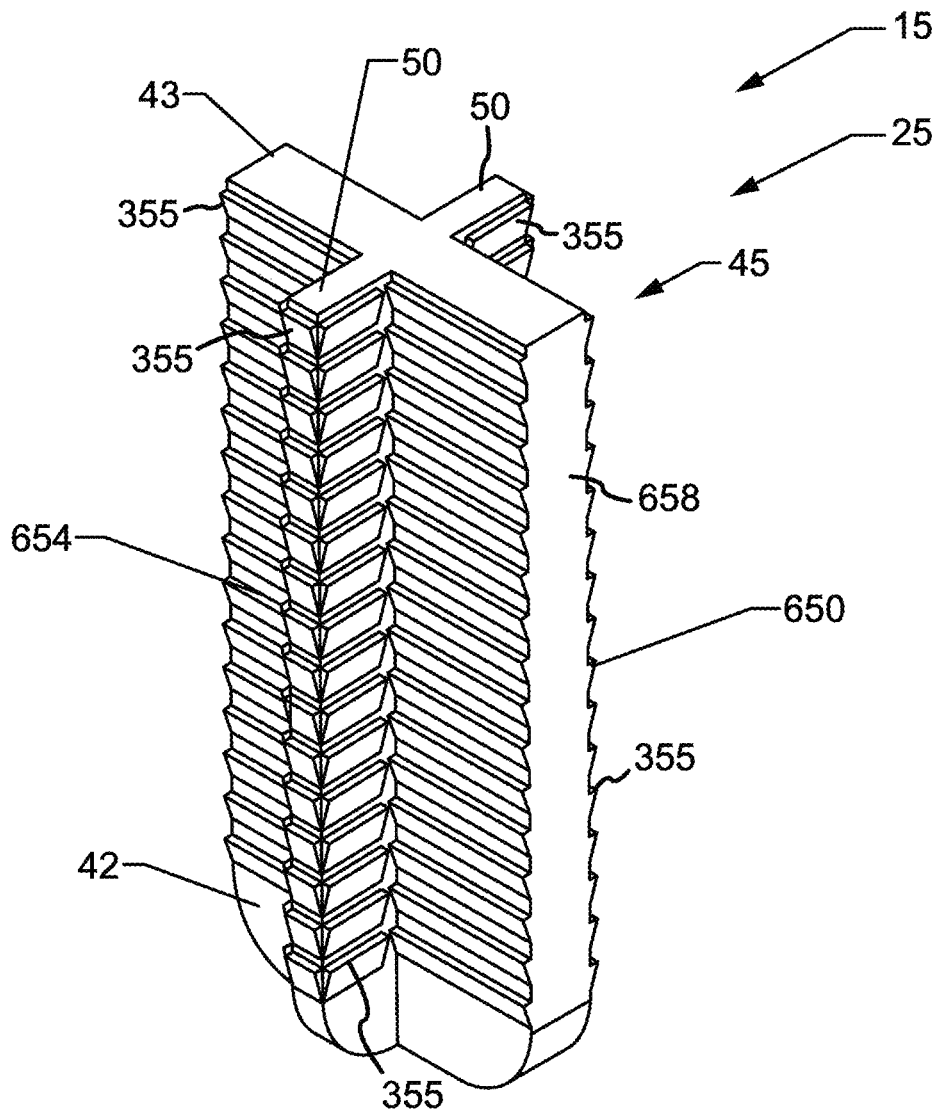


FIG. 27

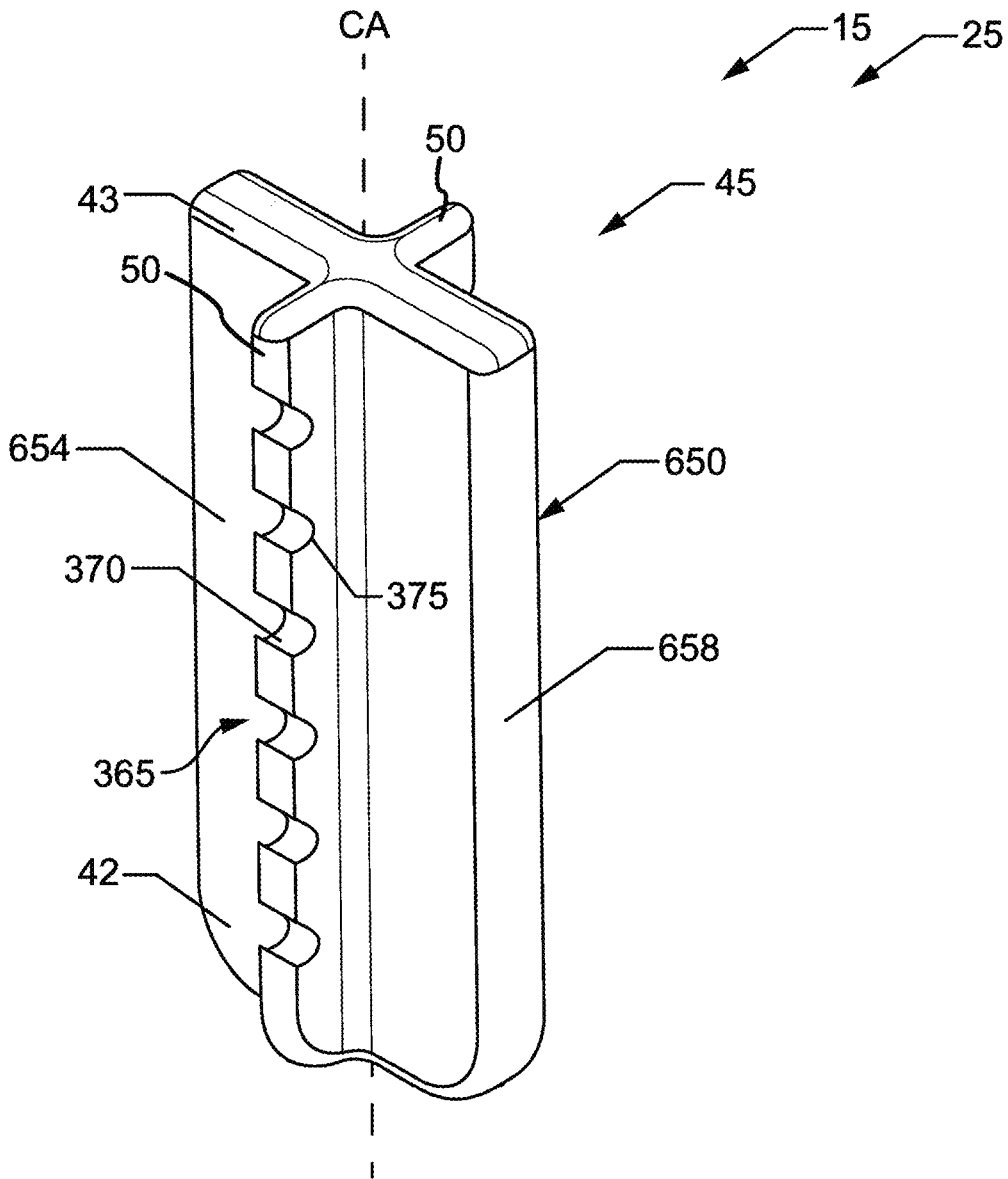


FIG. 28A

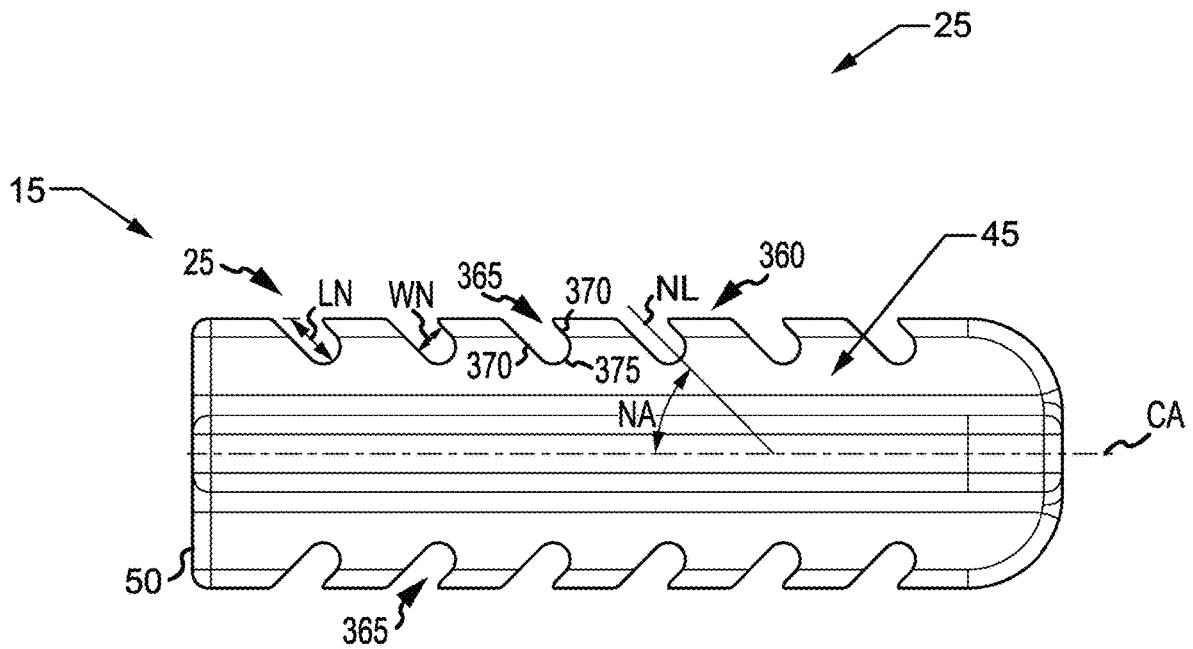


FIG. 28B

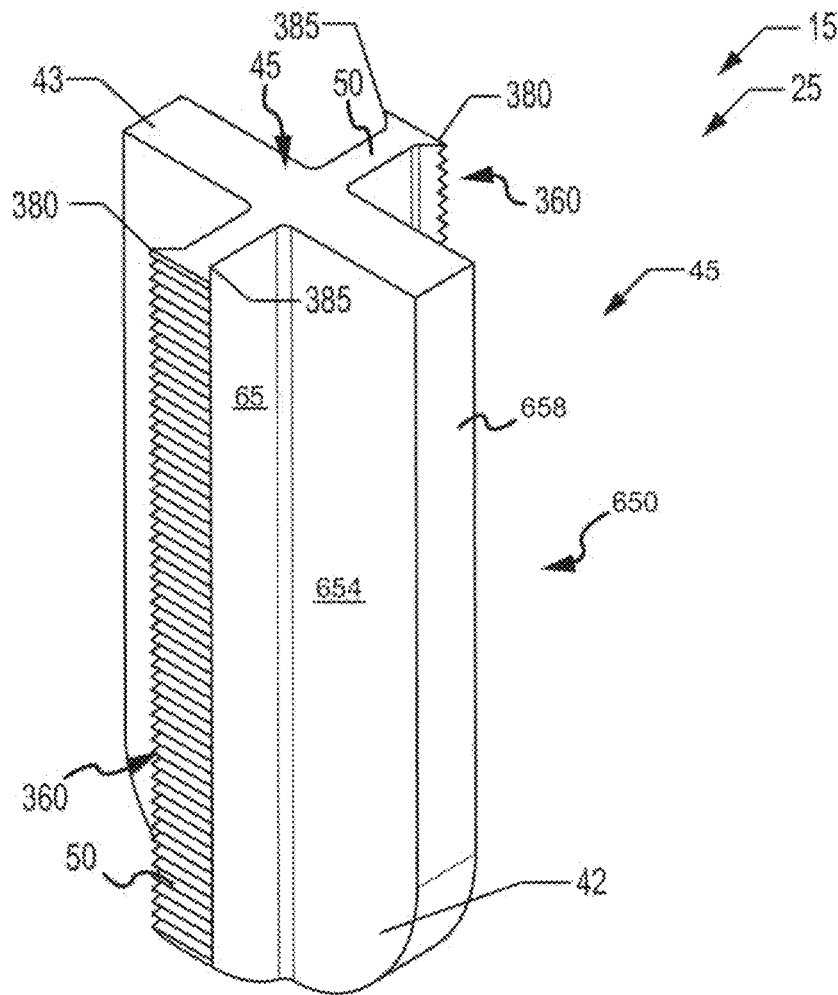


FIG. 29A

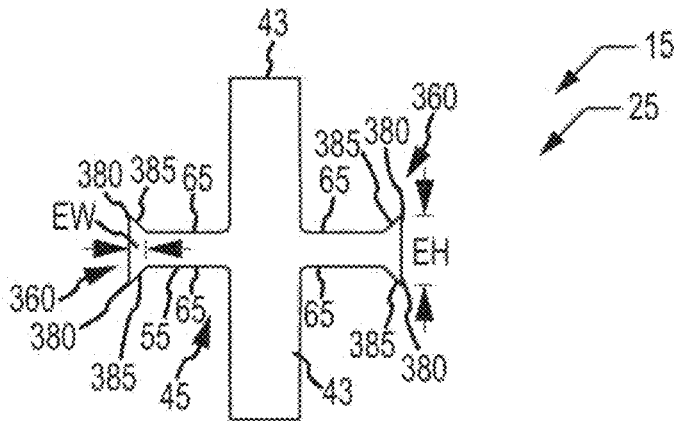


FIG. 29B

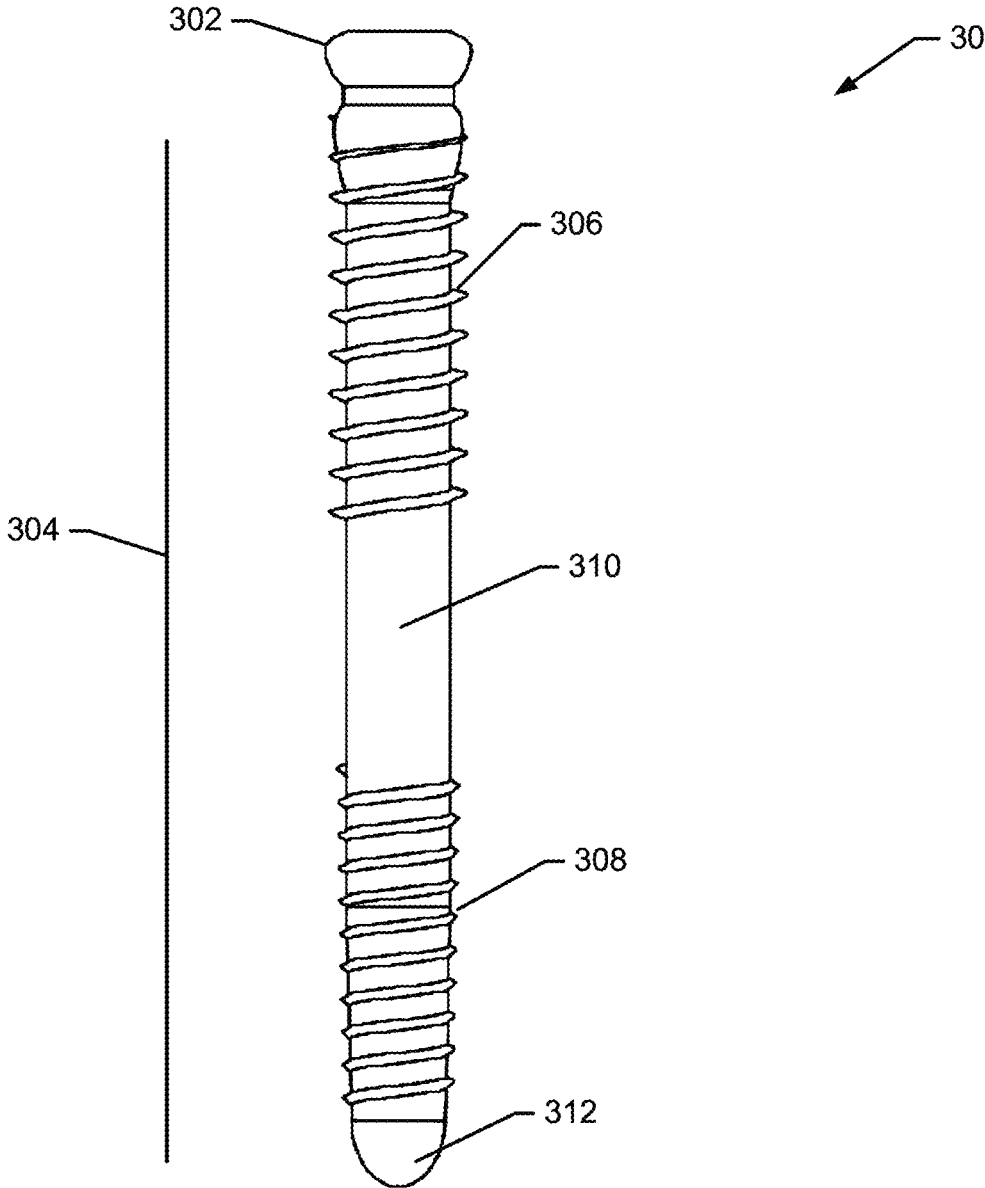


FIG. 30

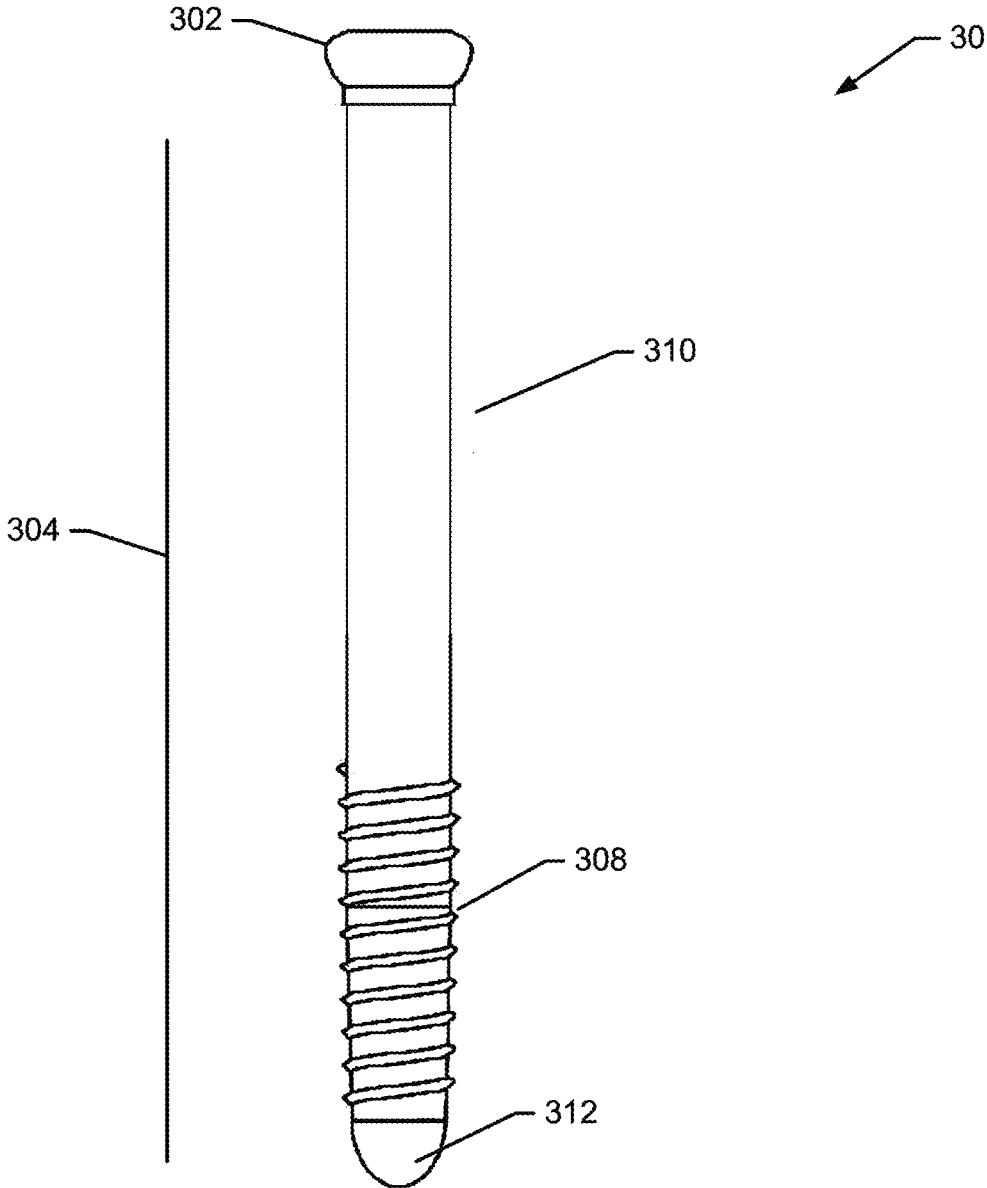


FIG. 31

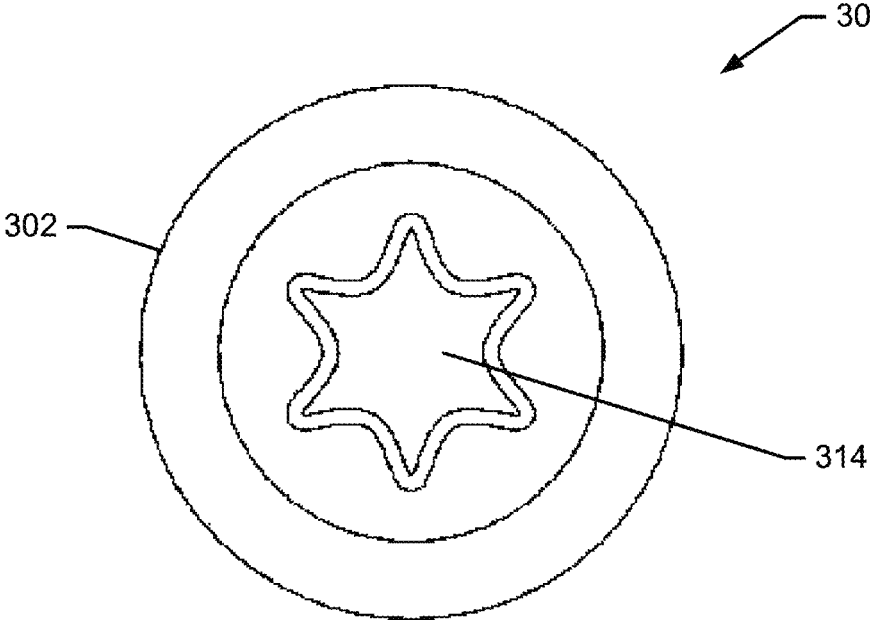


FIG. 32

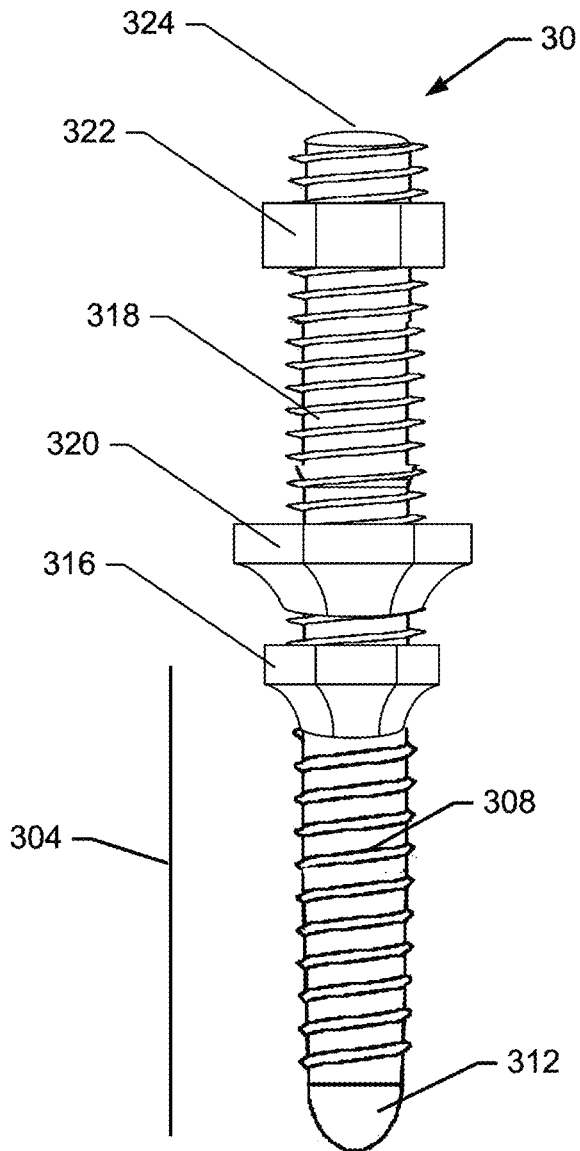


FIG. 33A

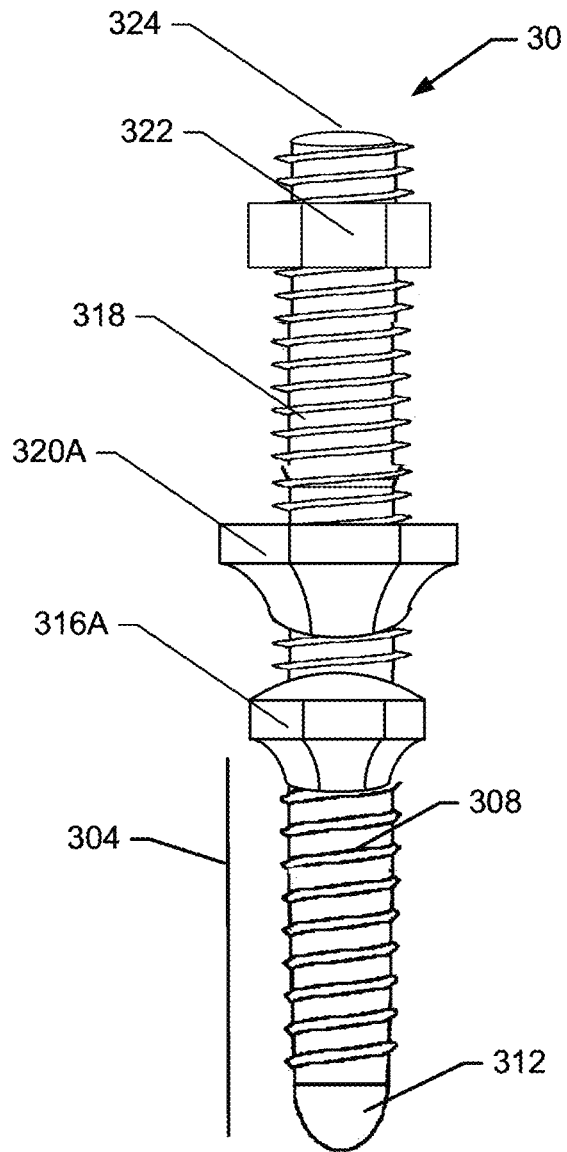


FIG. 33B

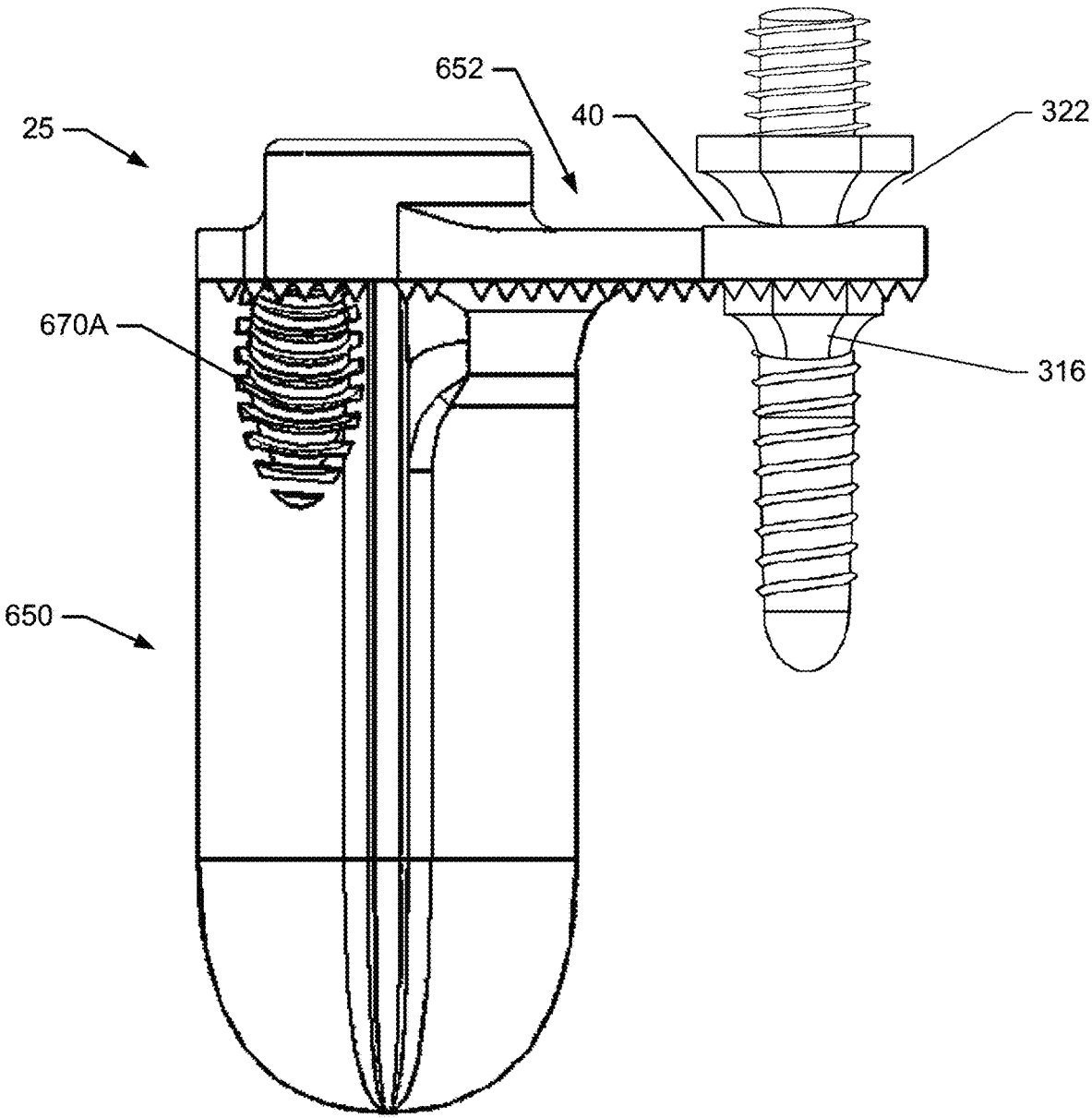


FIG. 34A

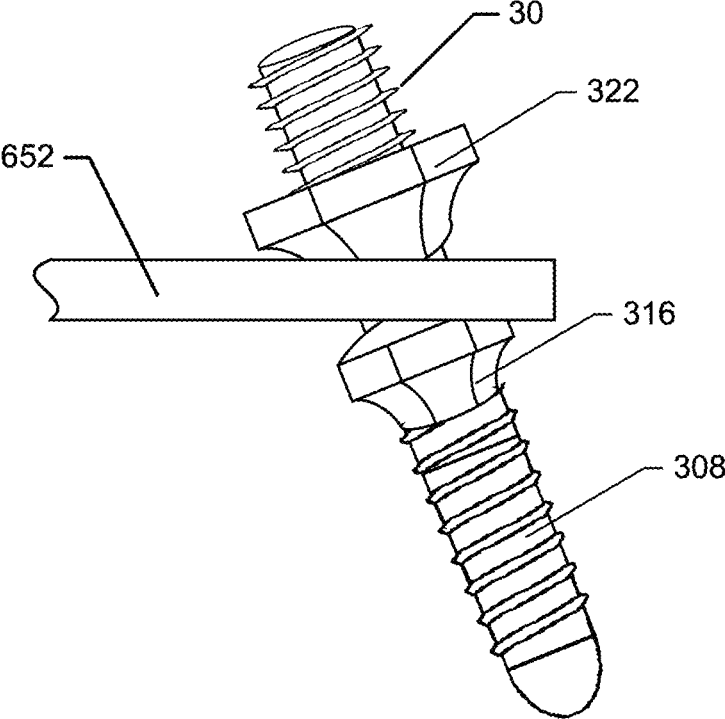


FIG. 34B

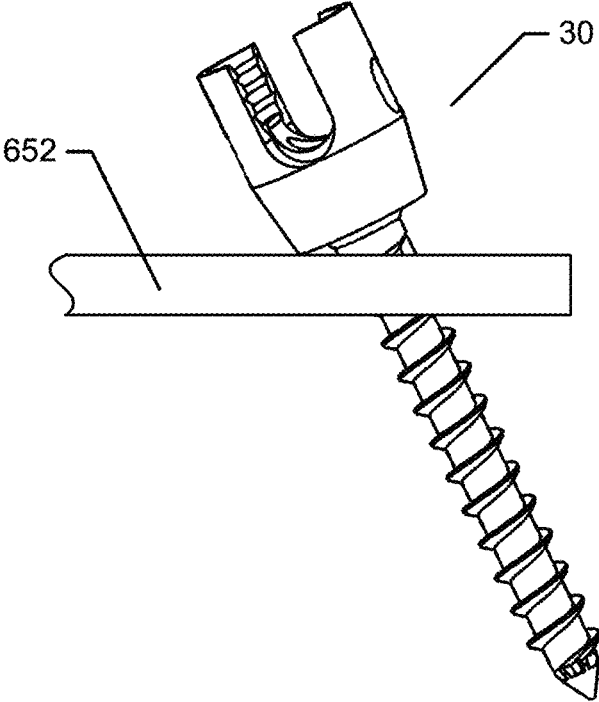


FIG. 34C

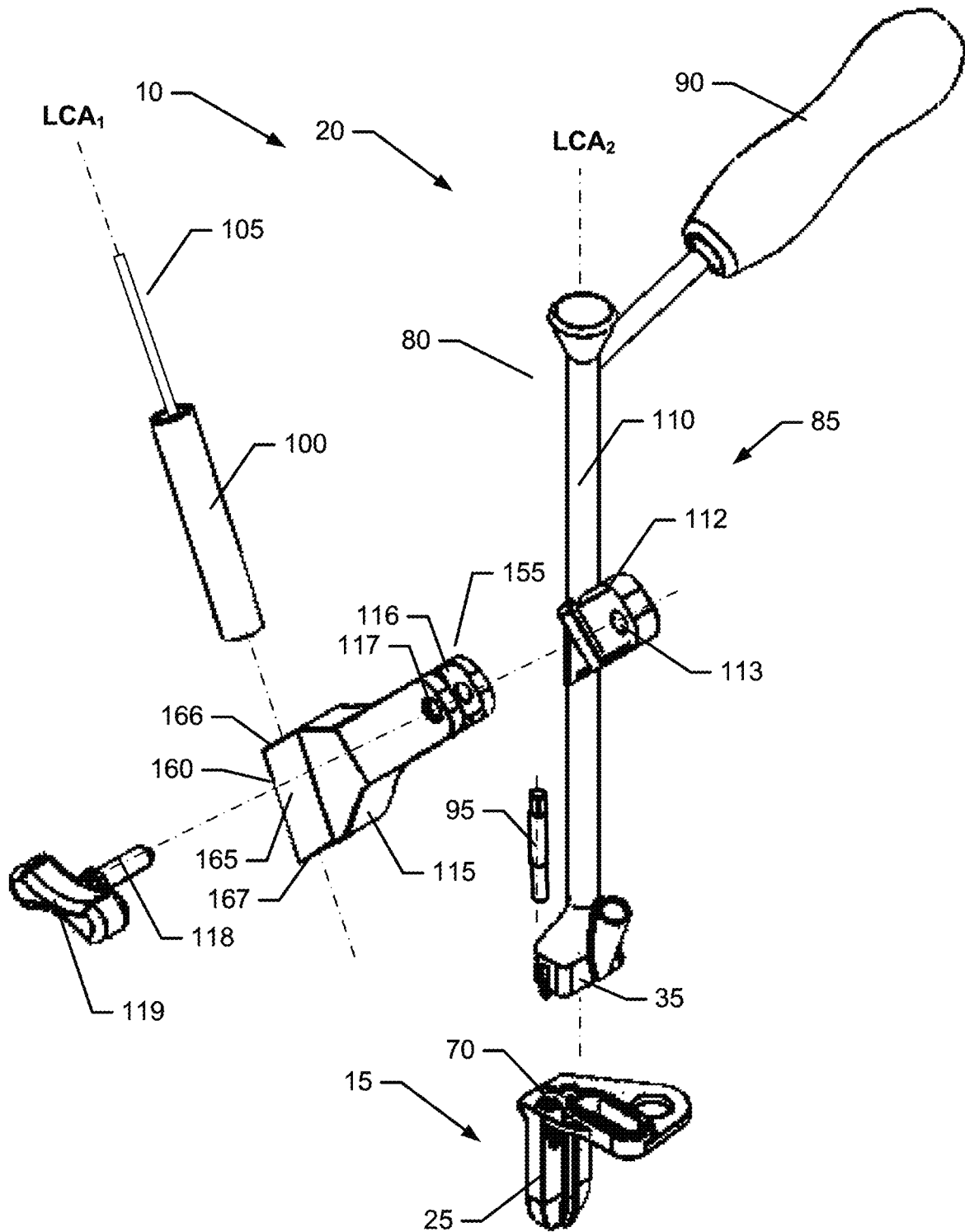


FIG. 35

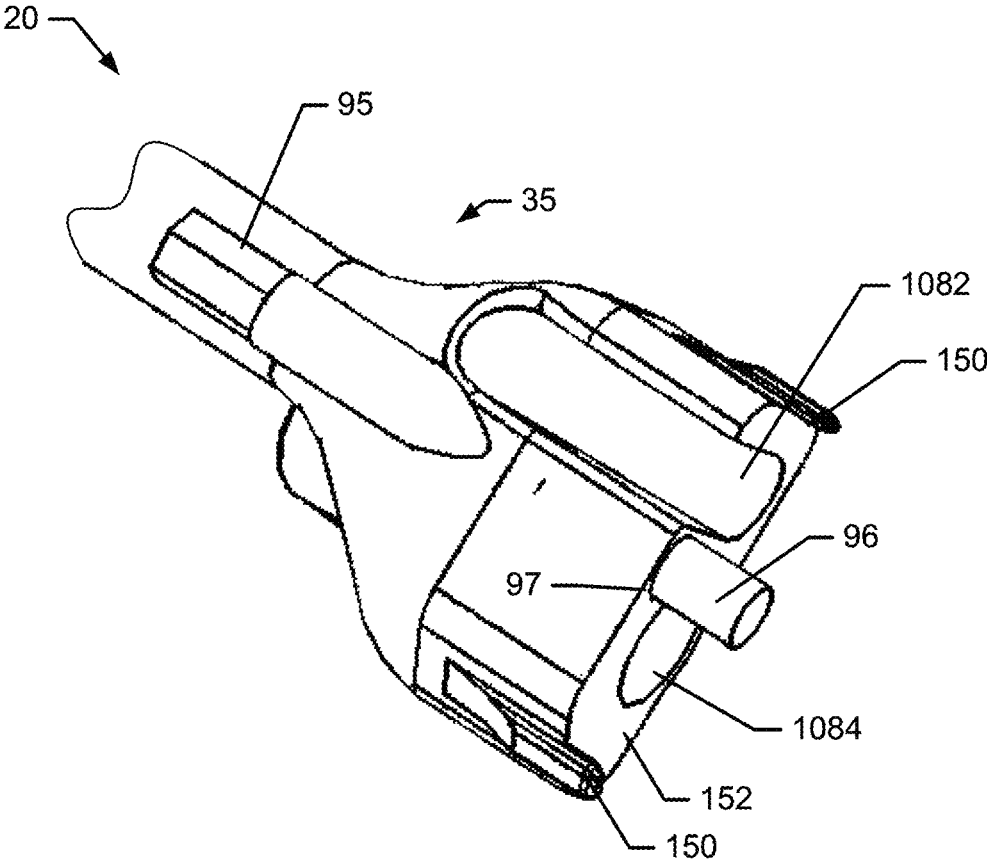


FIG. 36

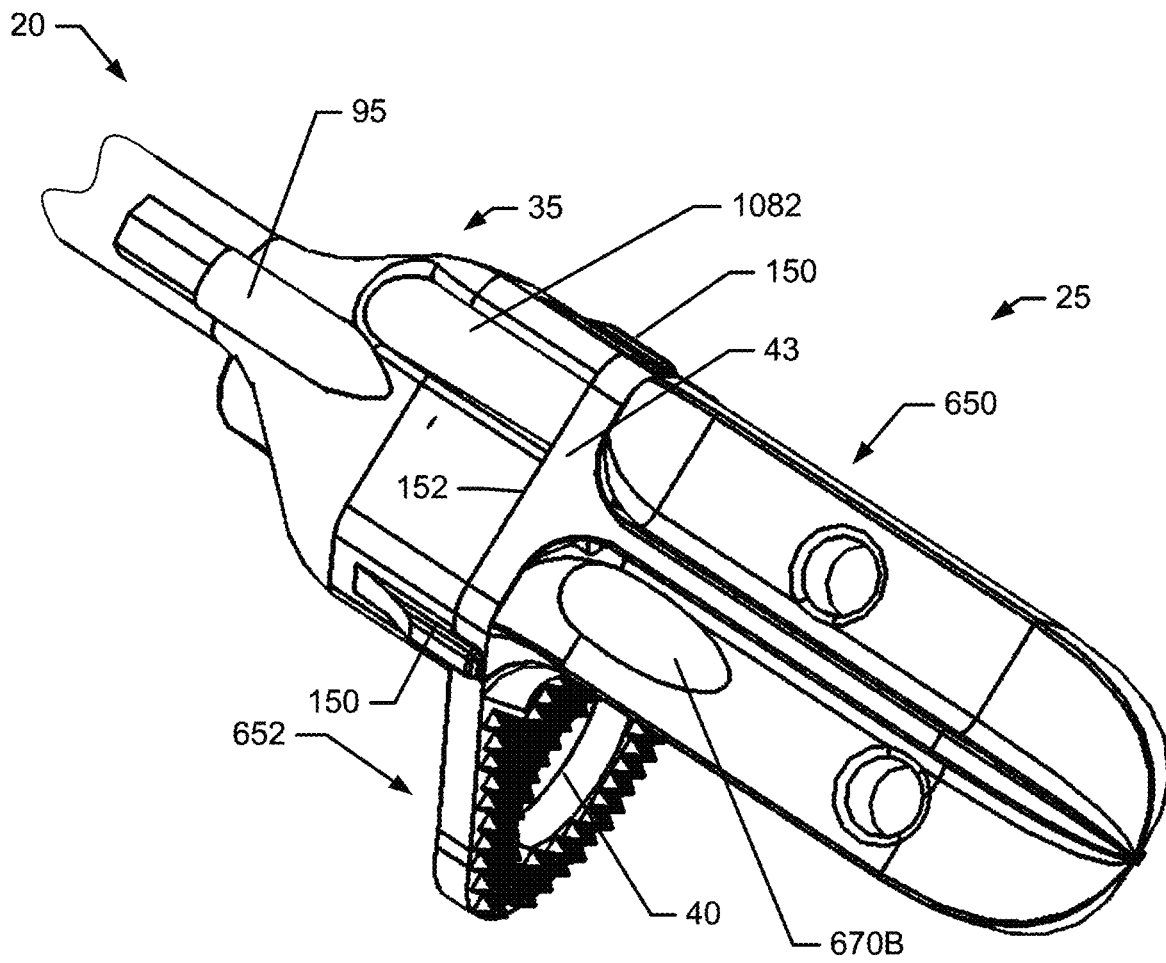


FIG. 37

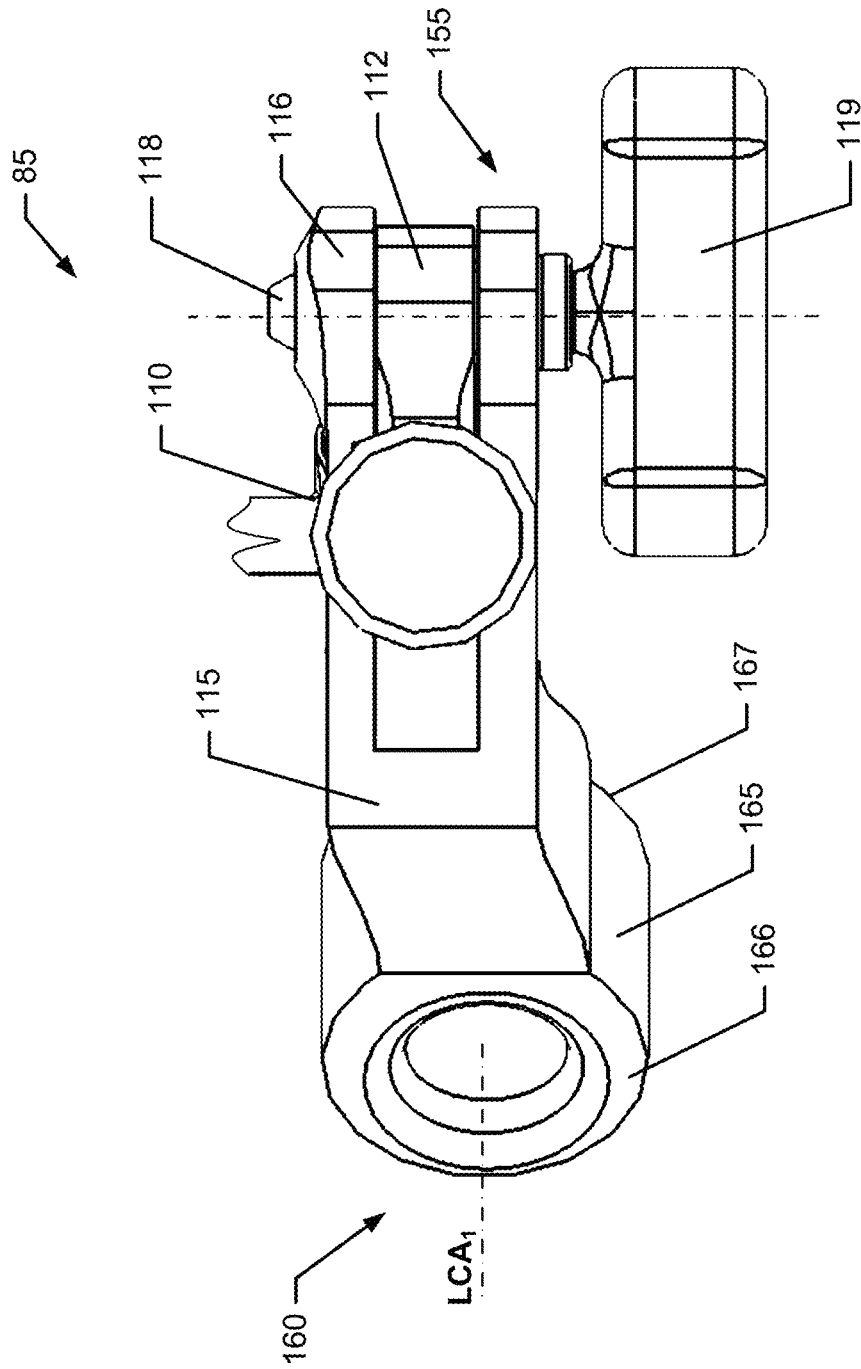


FIG. 38

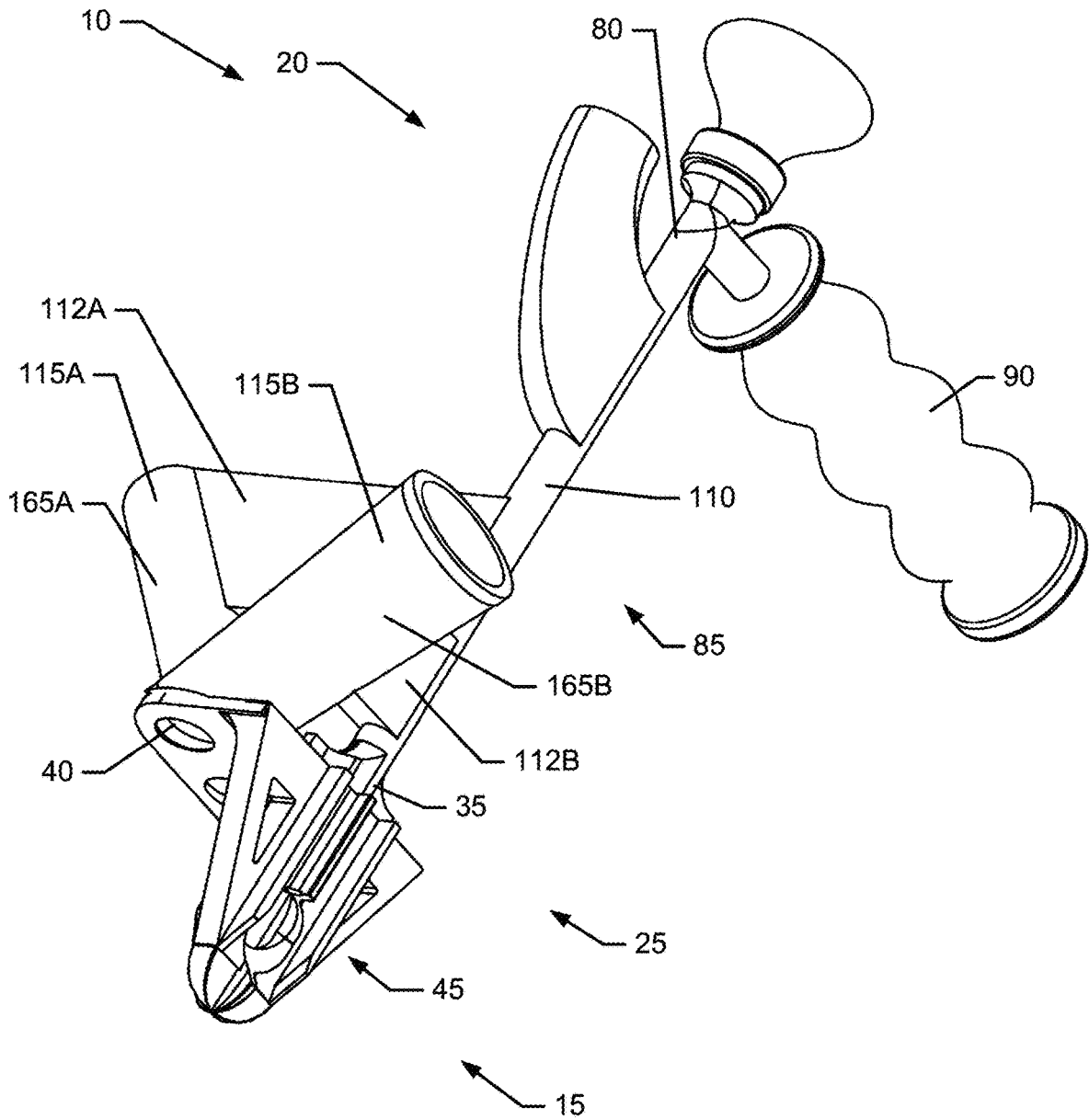
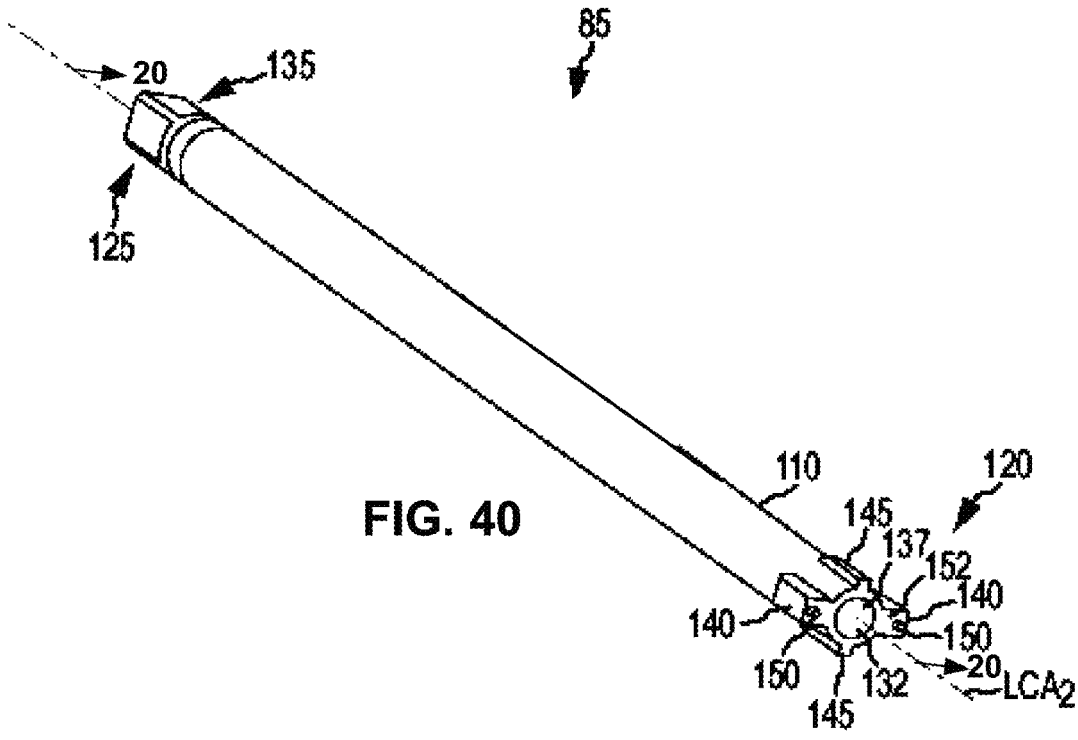
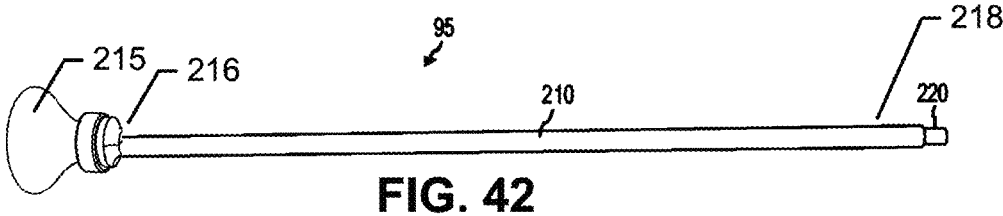
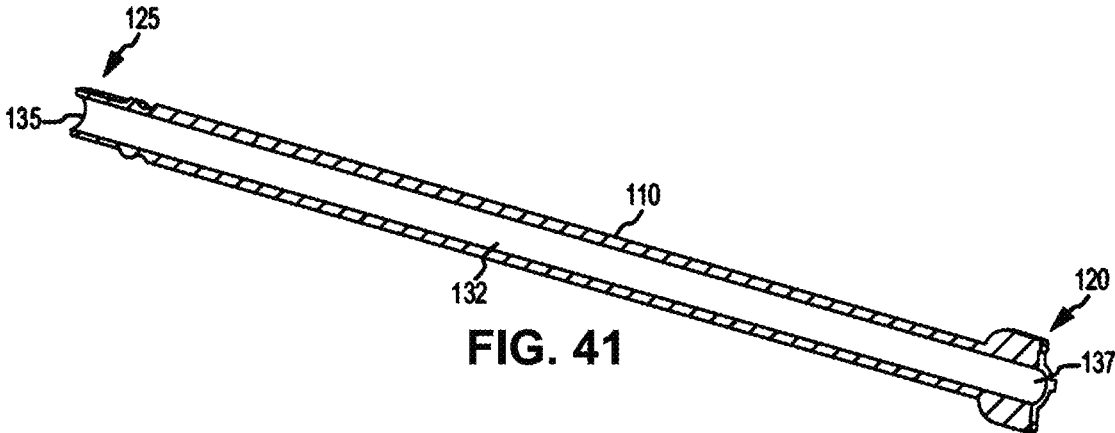


FIG. 39





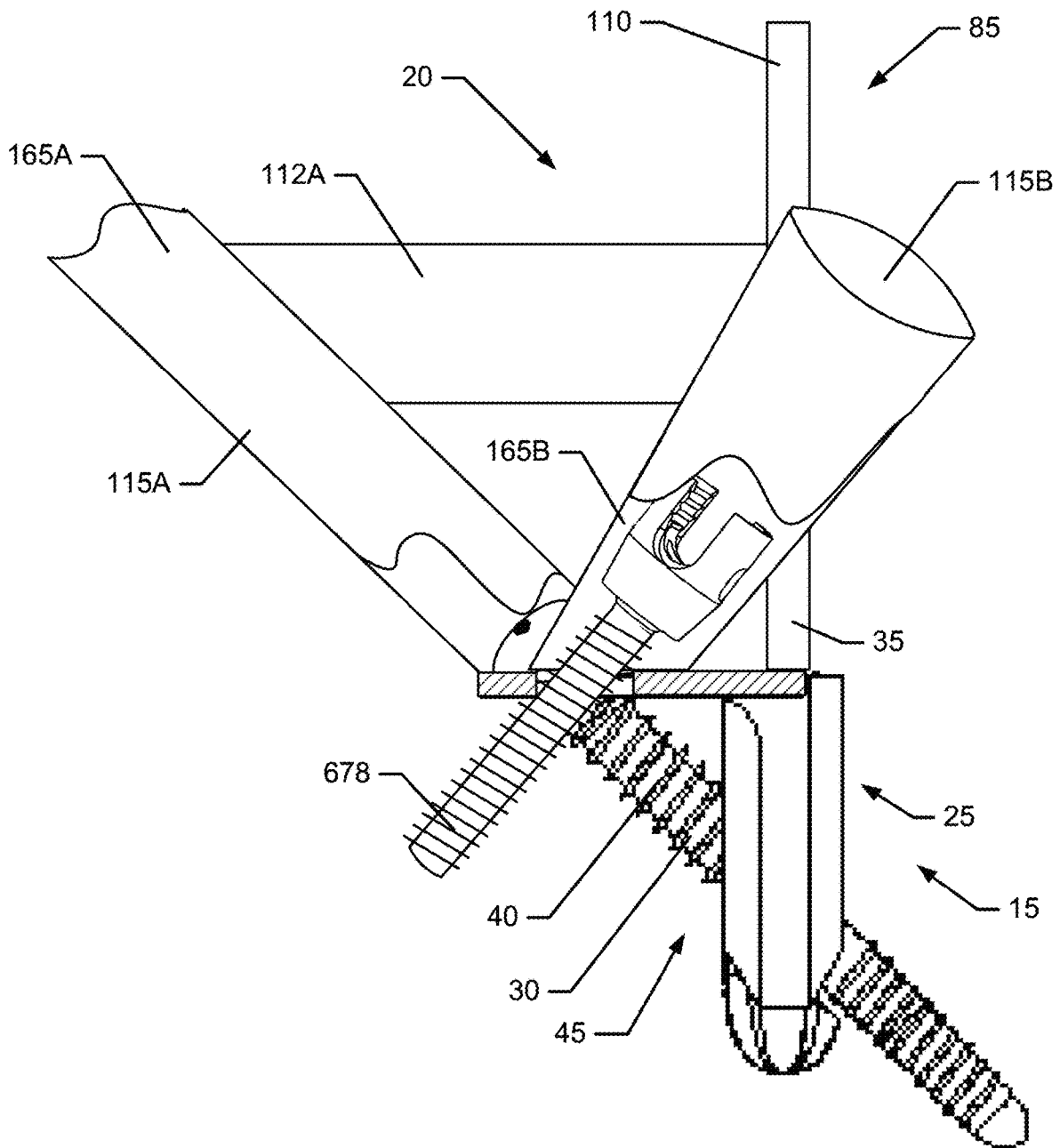


FIG. 43A

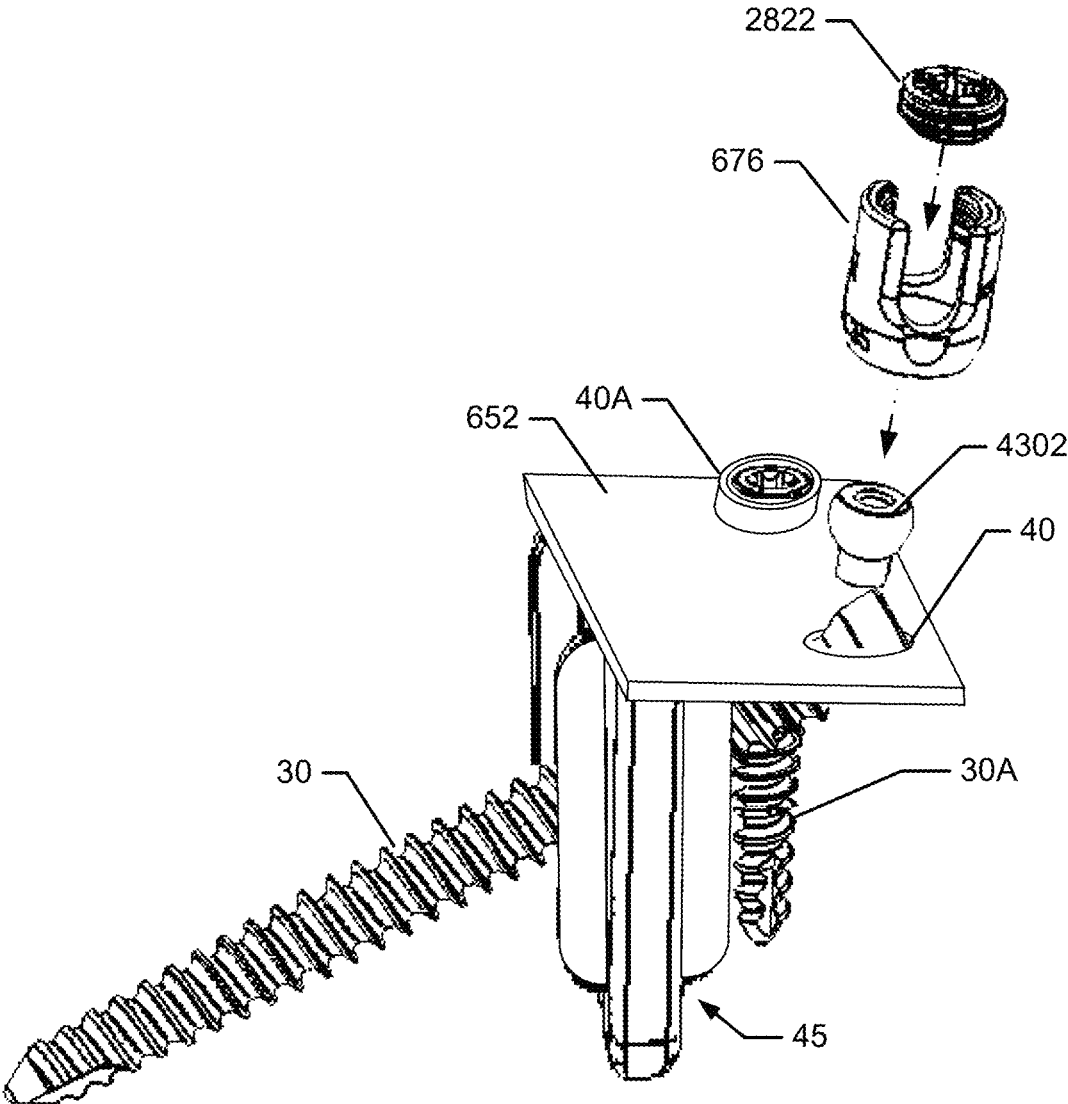


FIG. 43B

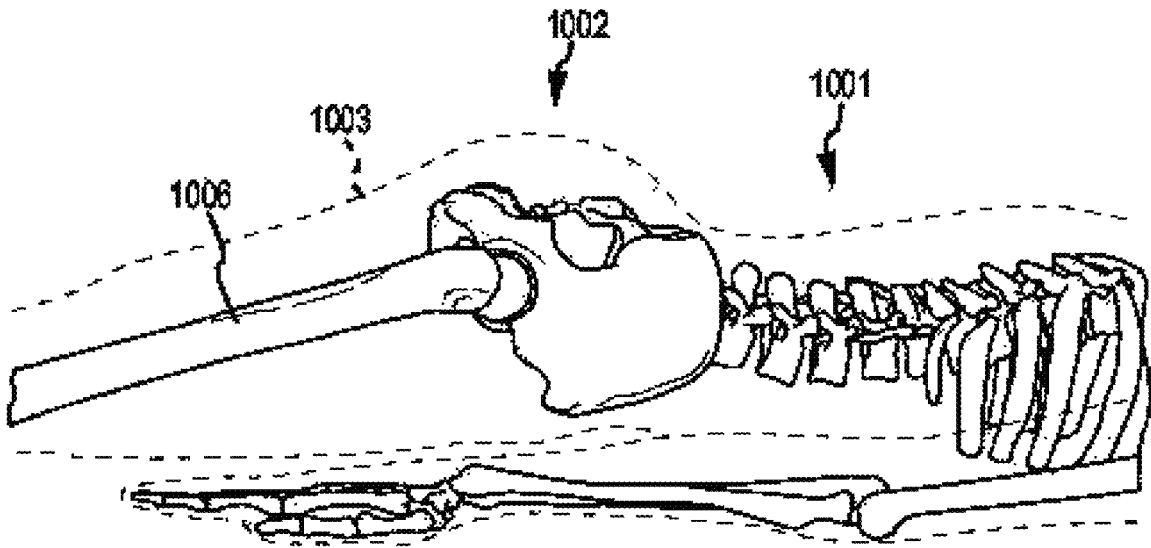


FIG. 44A

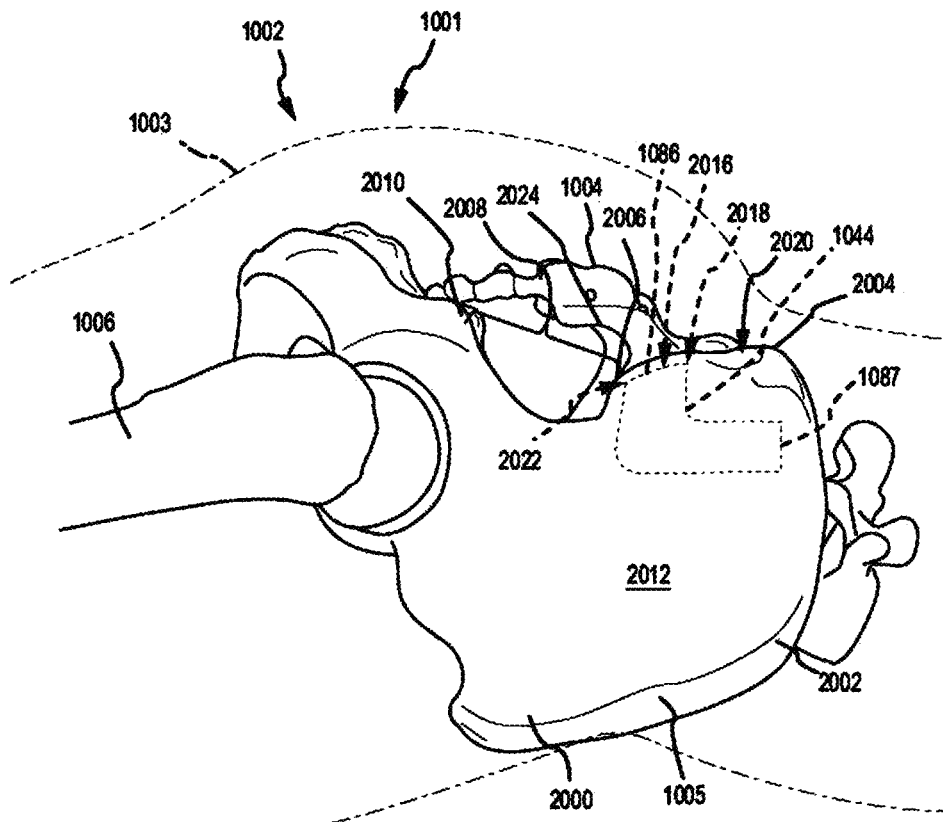


FIG. 44B

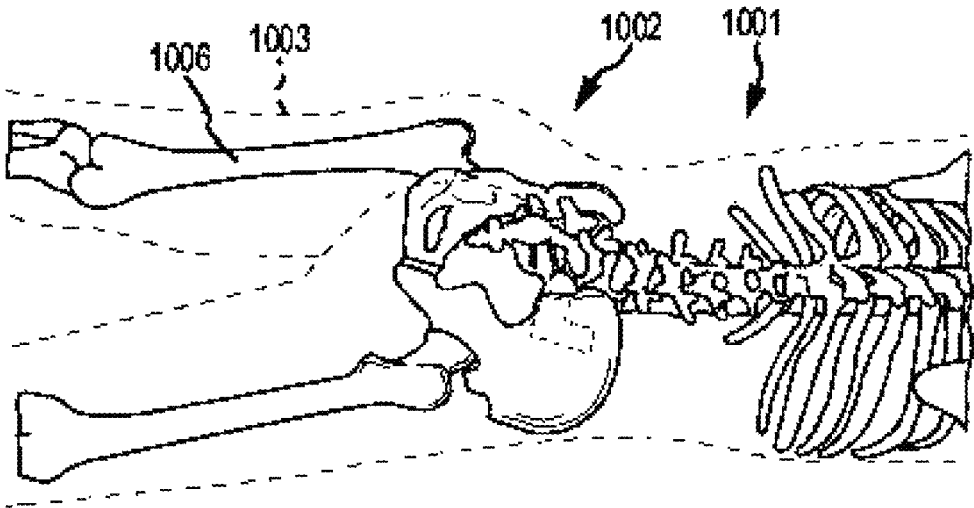


FIG. 45A

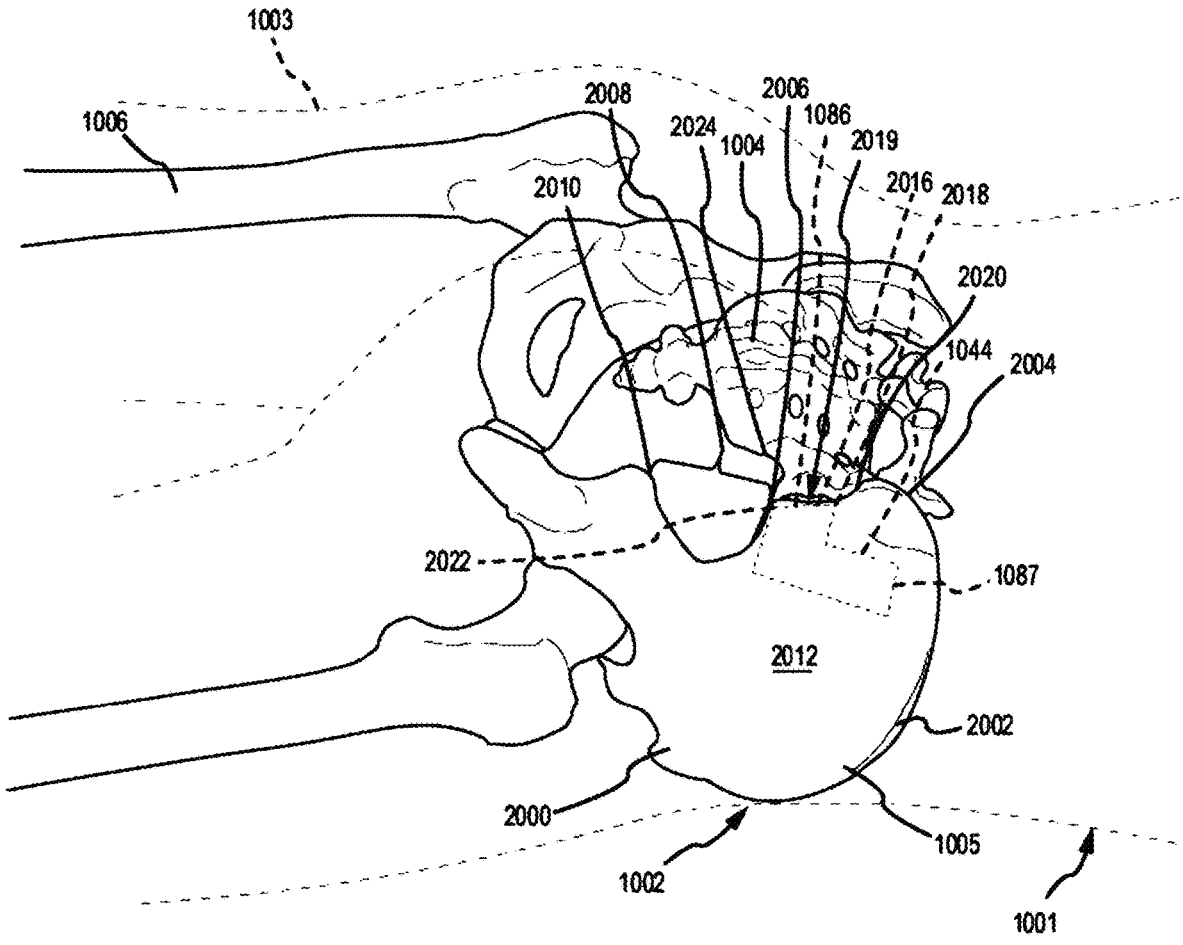


FIG. 45B

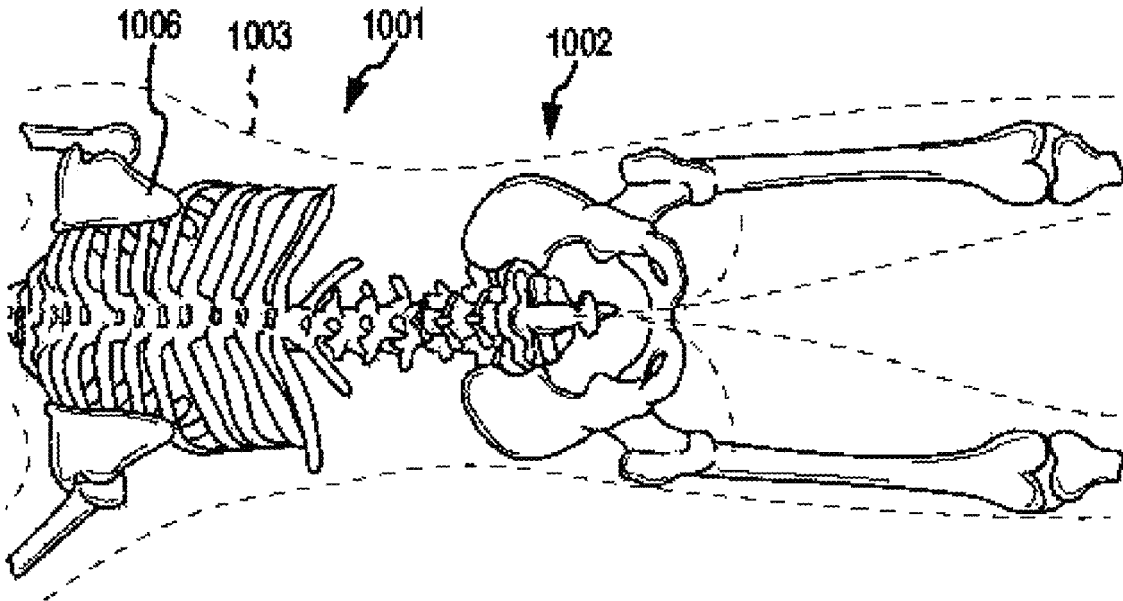


FIG. 46A

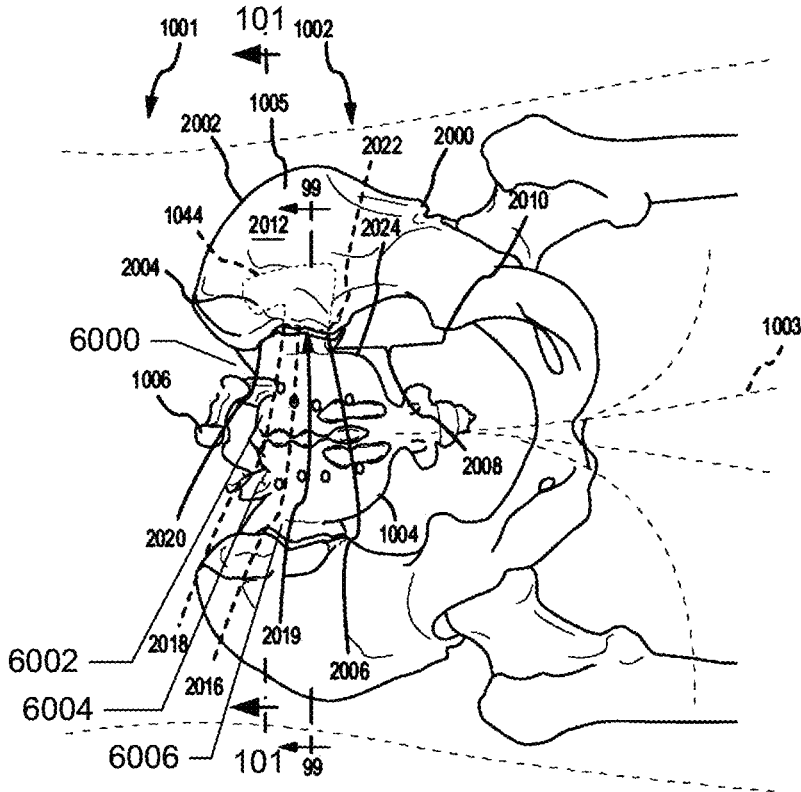


FIG. 46B

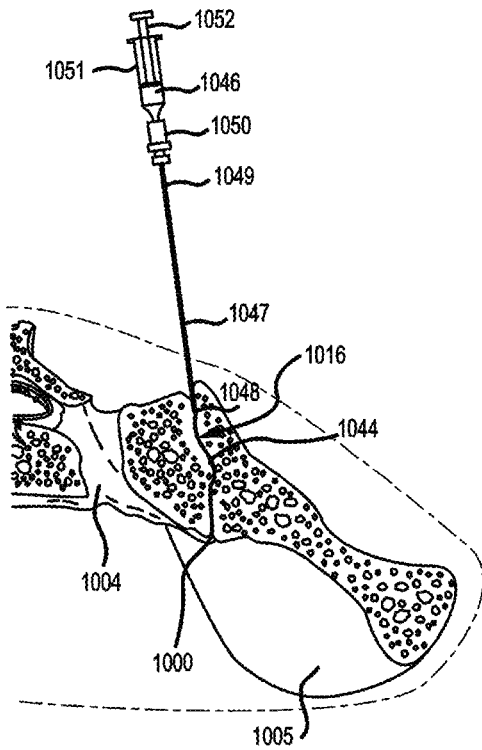


FIG. 47A

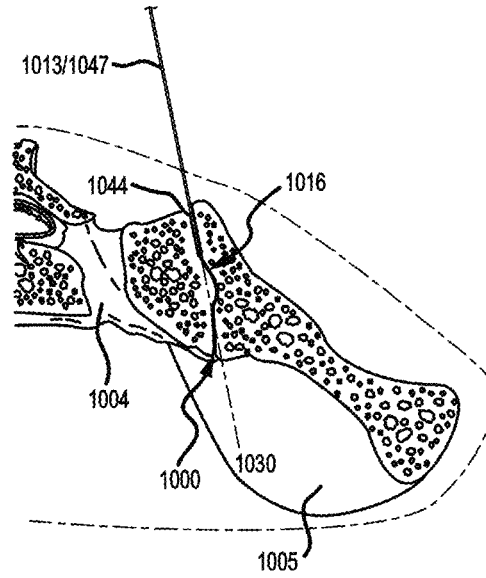


FIG. 47B

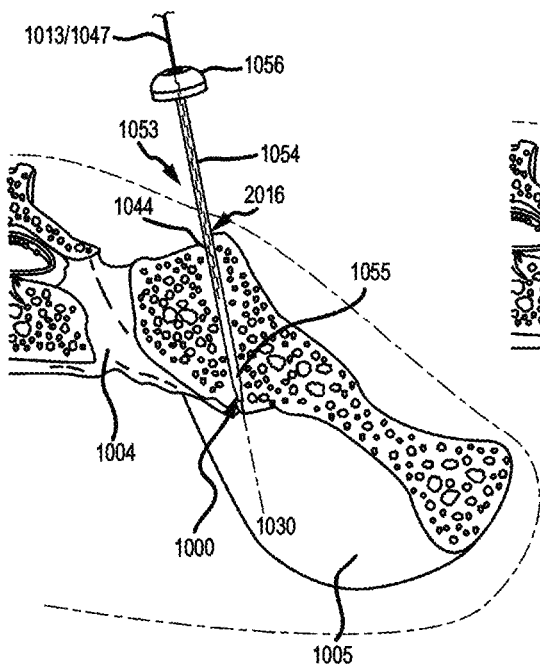


FIG. 47C

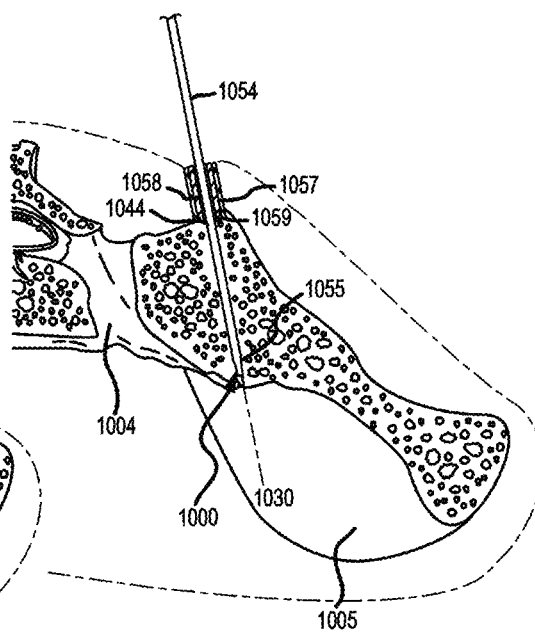


FIG. 47D

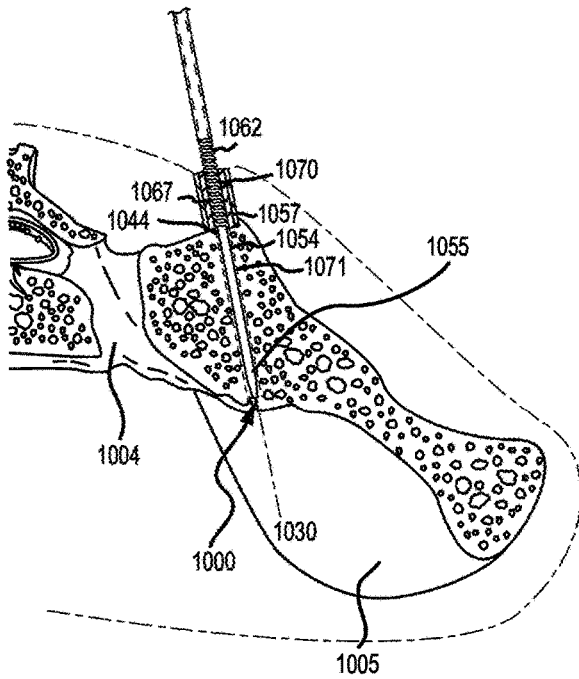


FIG. 47E

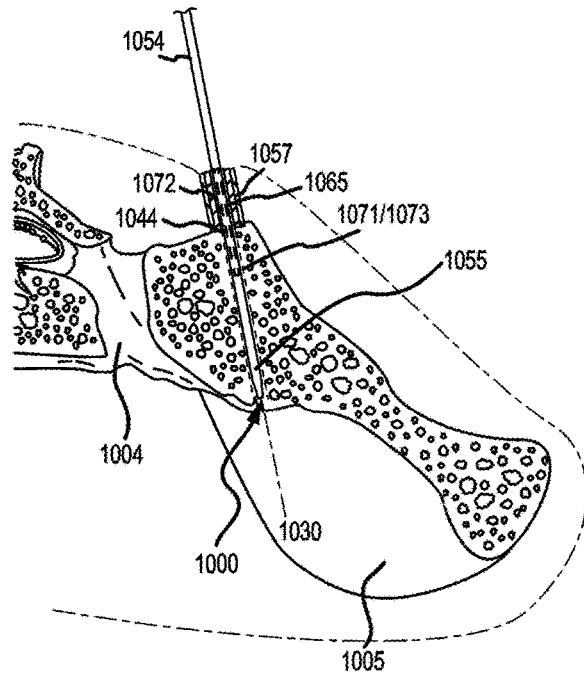


FIG. 47F

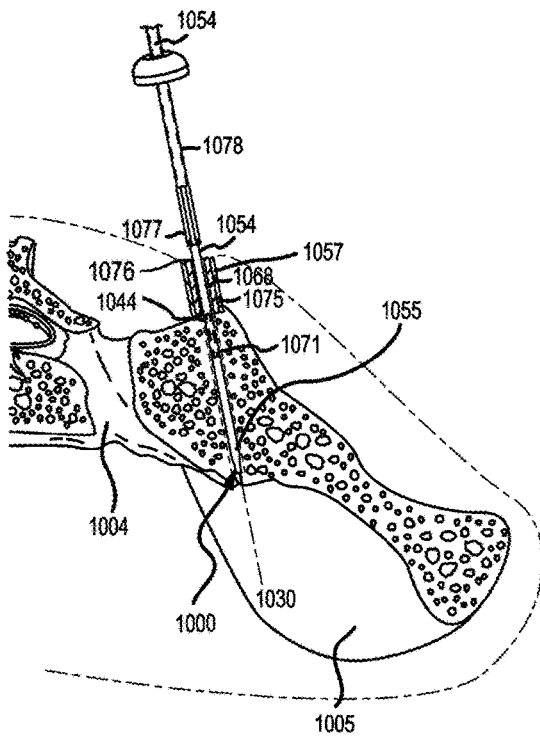


FIG. 47G

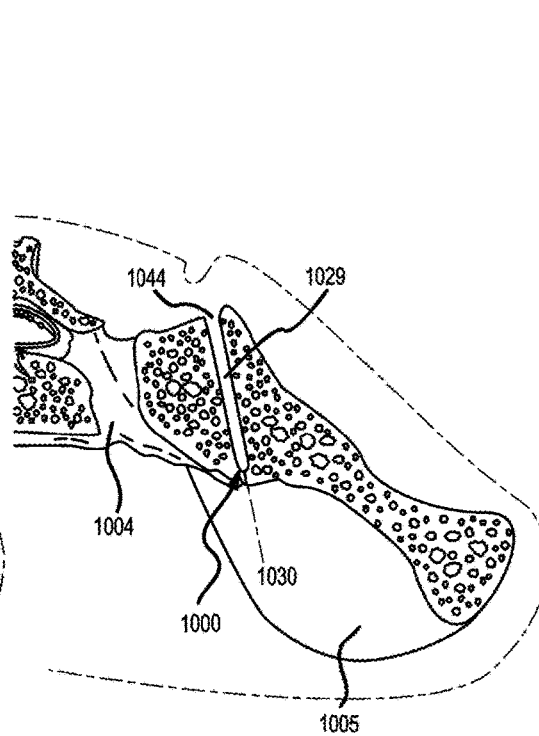


FIG. 47H

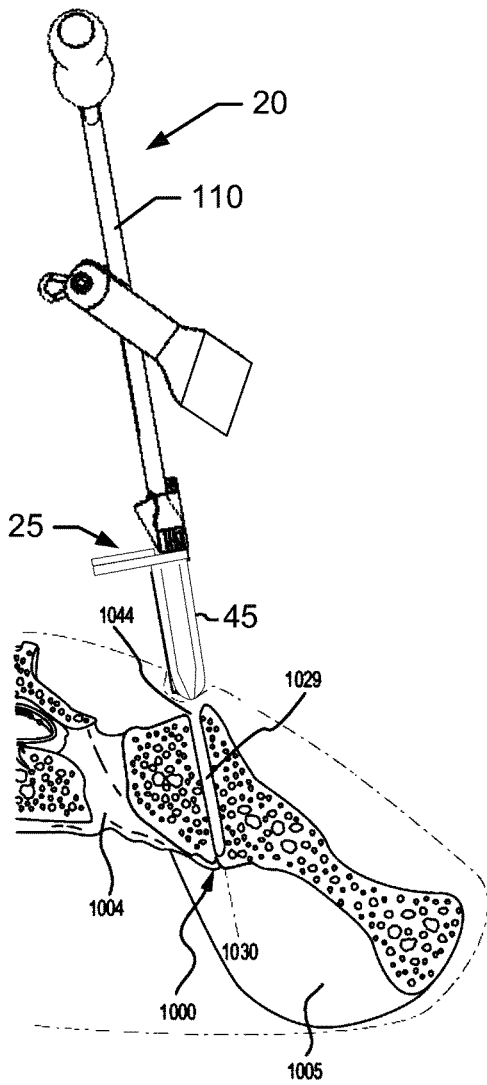


FIG. 47I

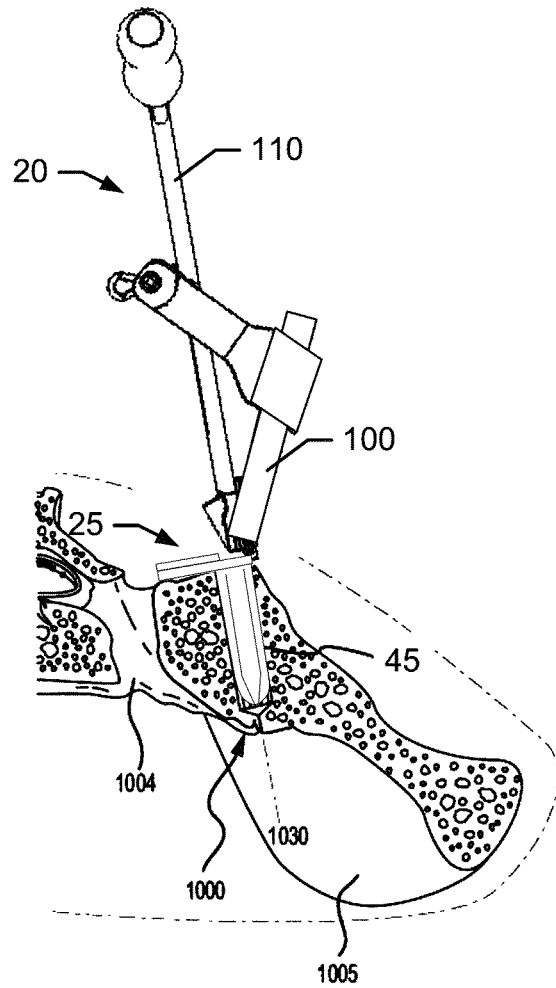


FIG. 47J

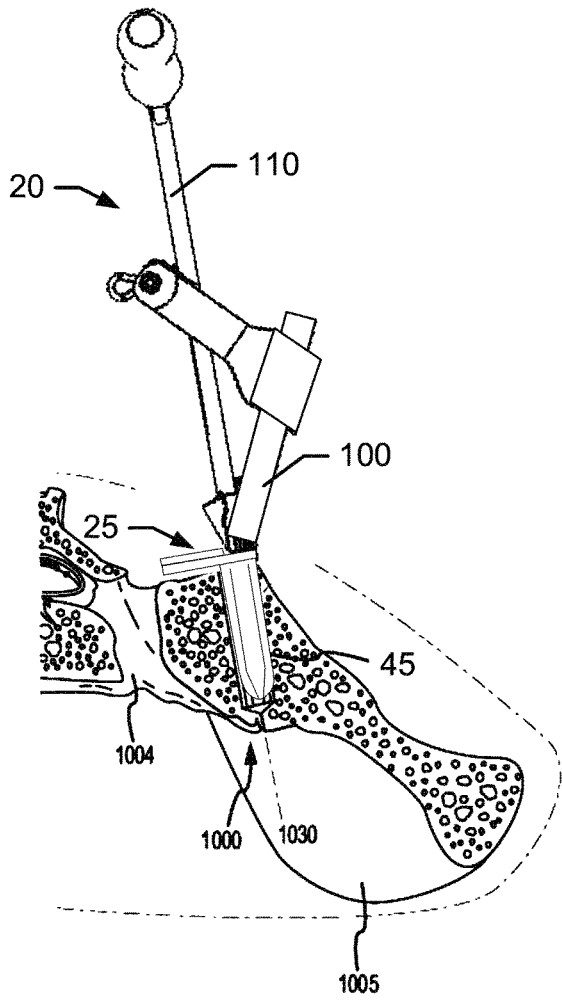


FIG. 47K

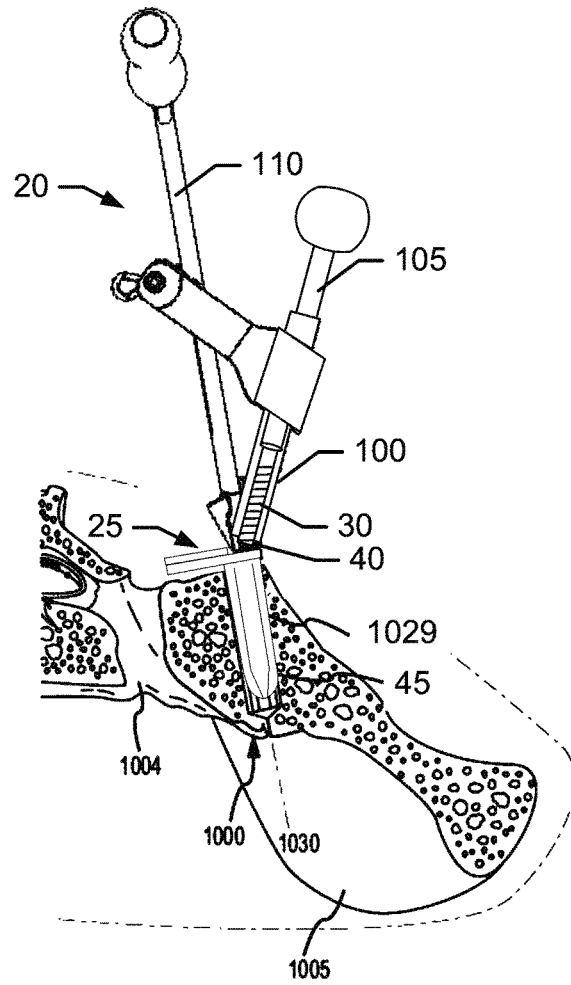


FIG. 47L

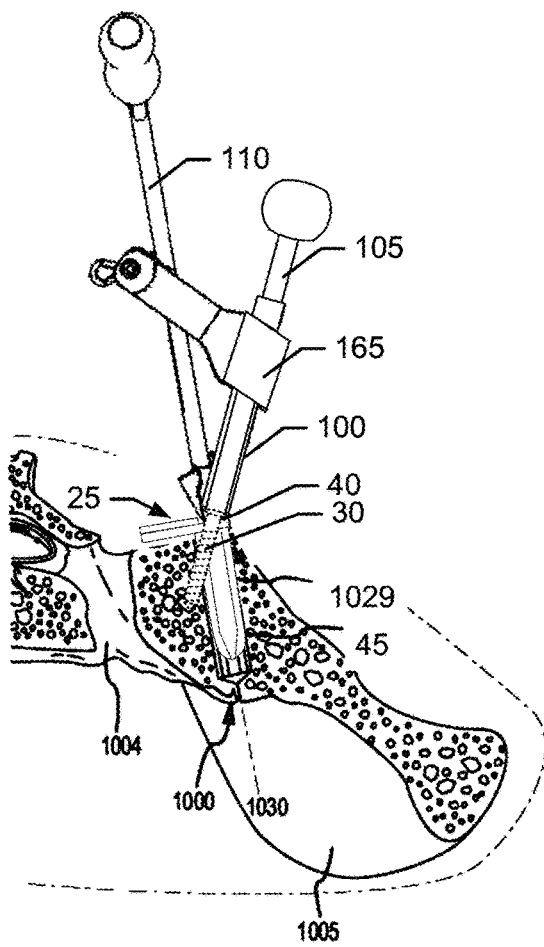


FIG. 47M

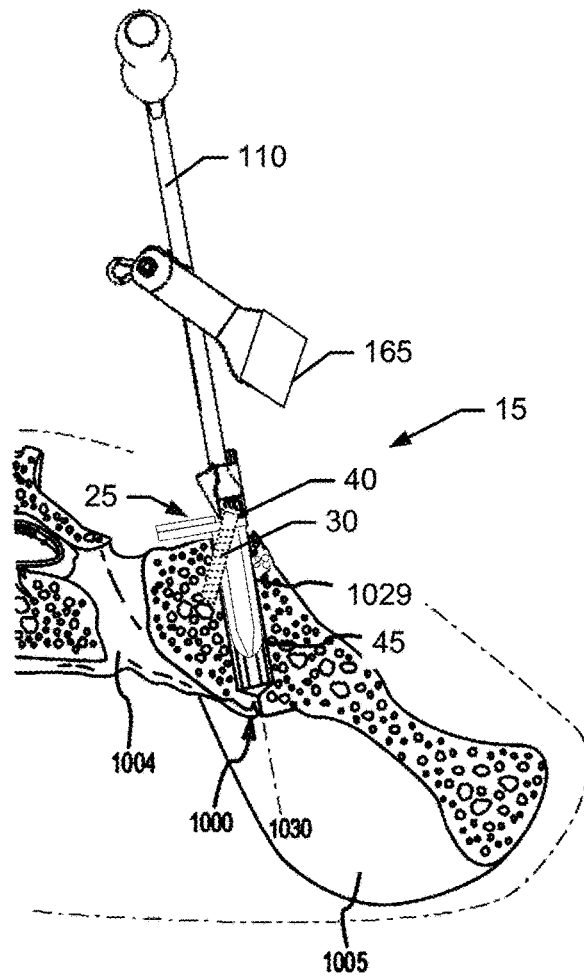


FIG. 47N

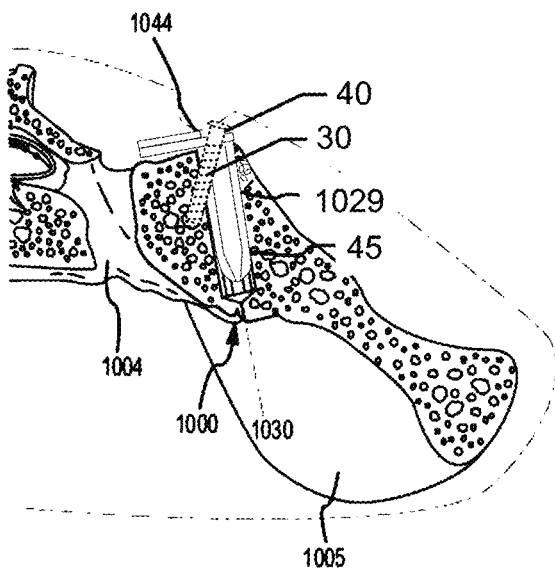


FIG. 47O

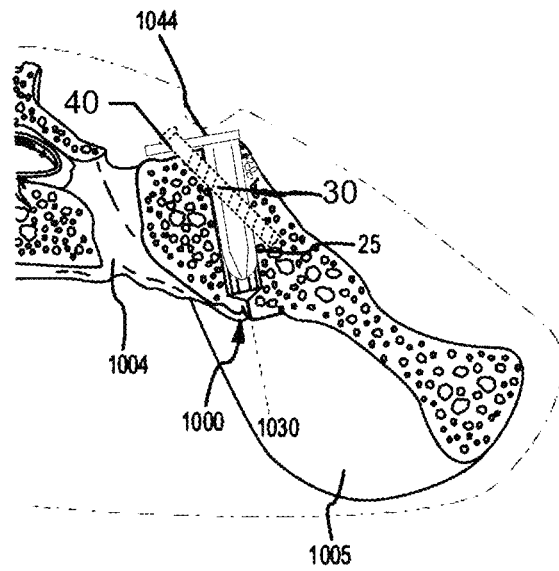


FIG. 47P

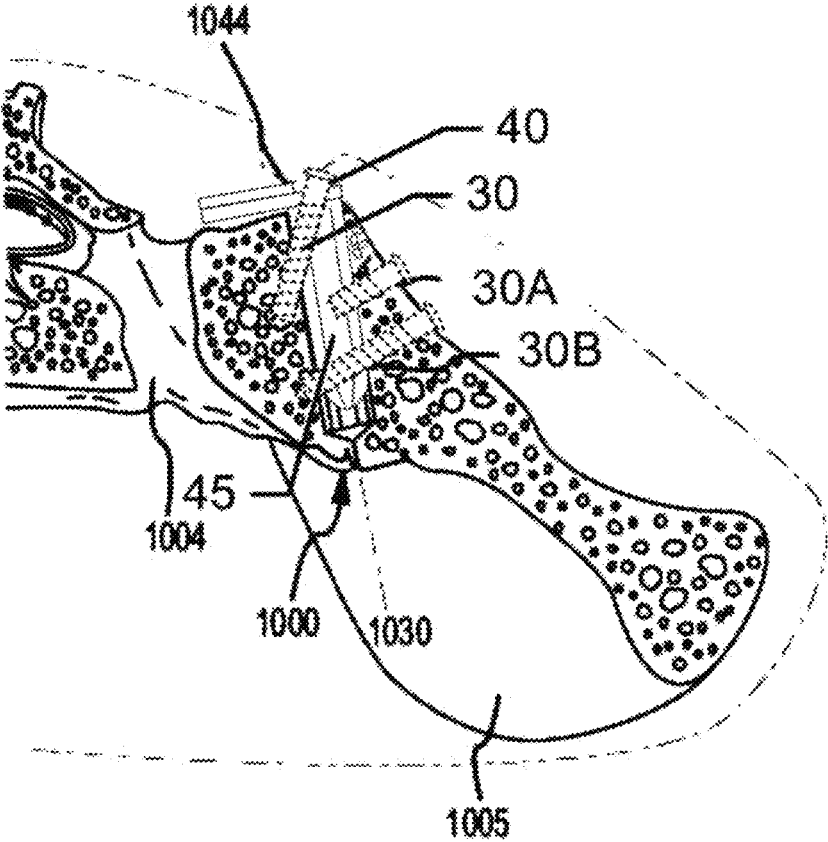


FIG. 47Q

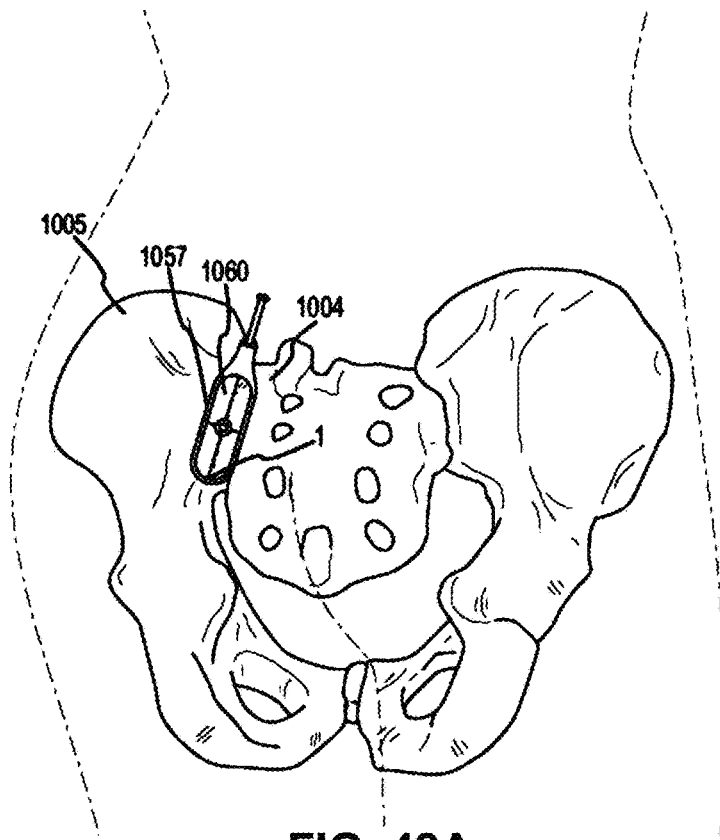


FIG. 48A

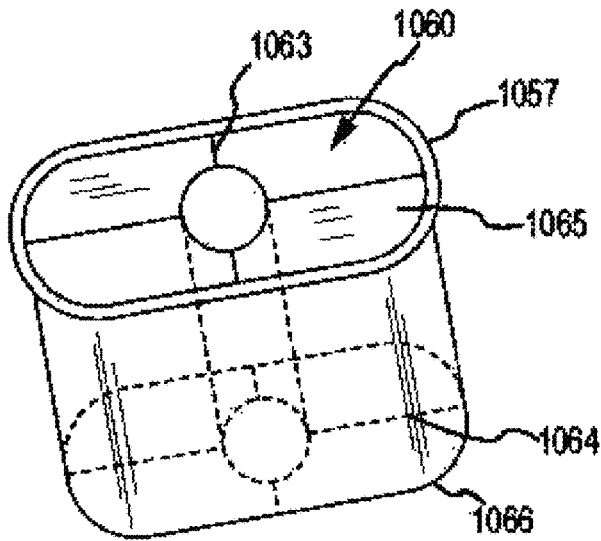


FIG. 48B

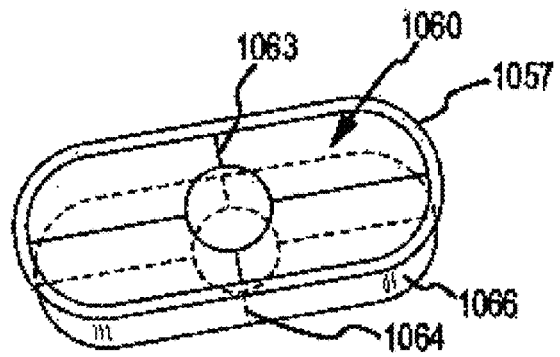


FIG. 48C

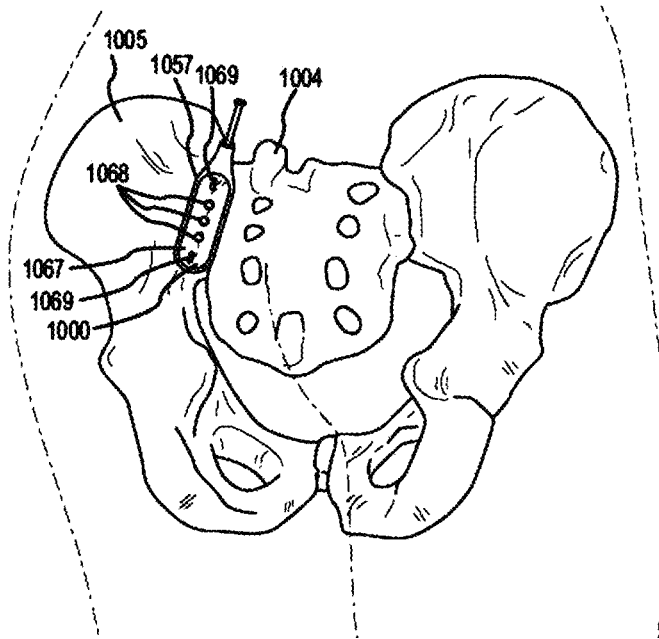


FIG. 49A

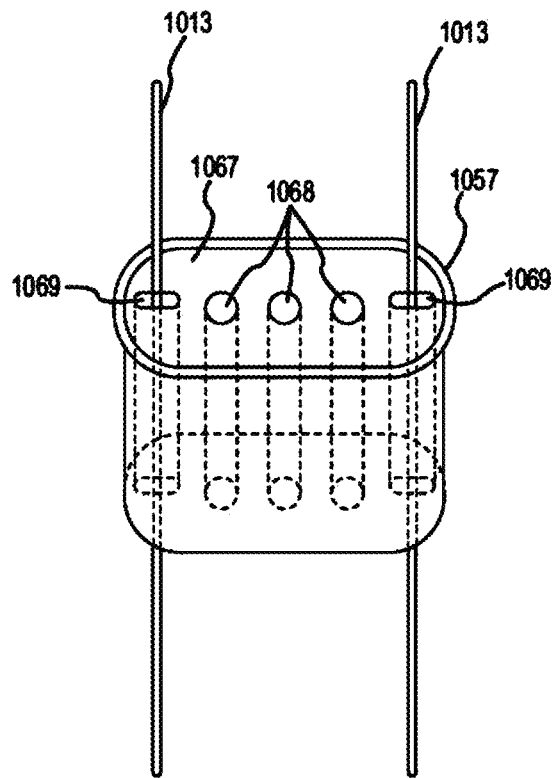


FIG. 49B

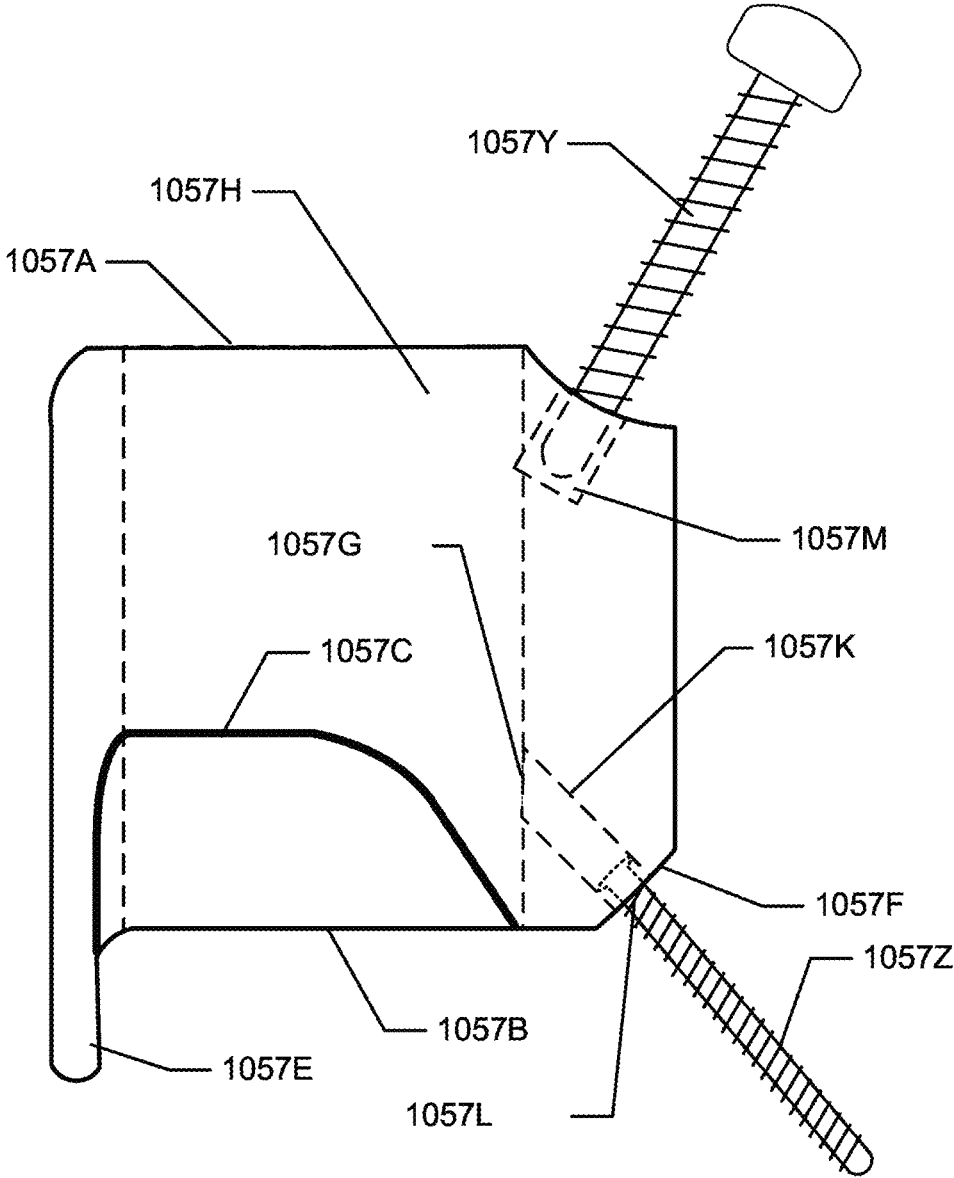
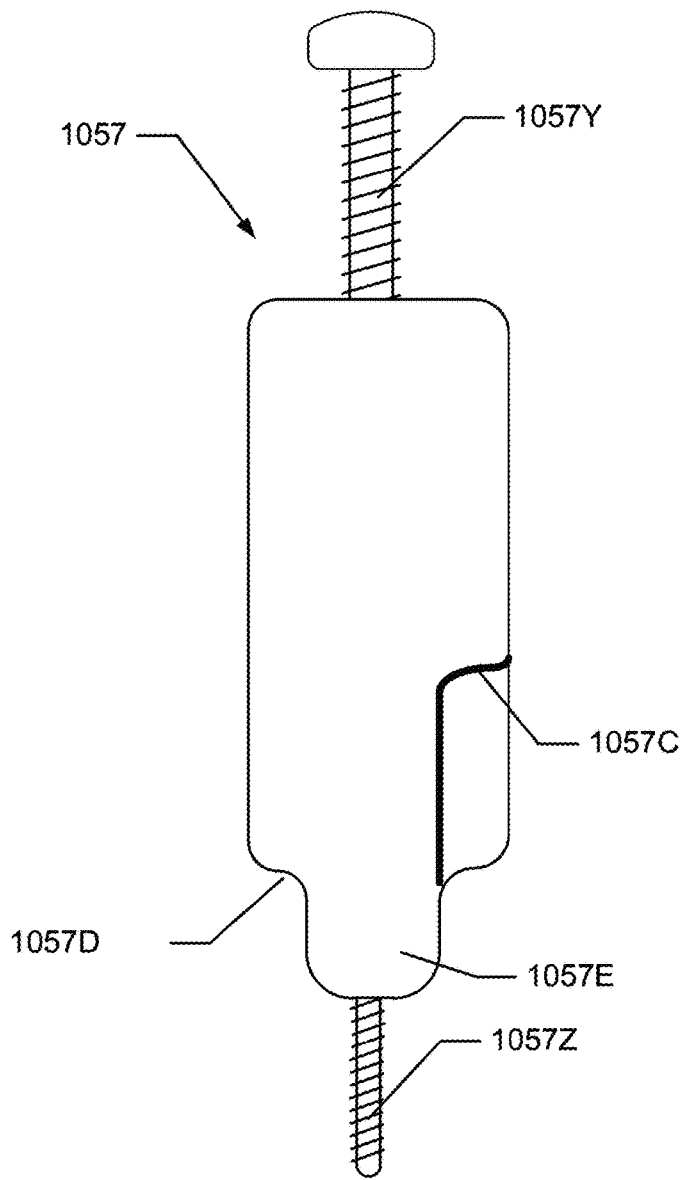
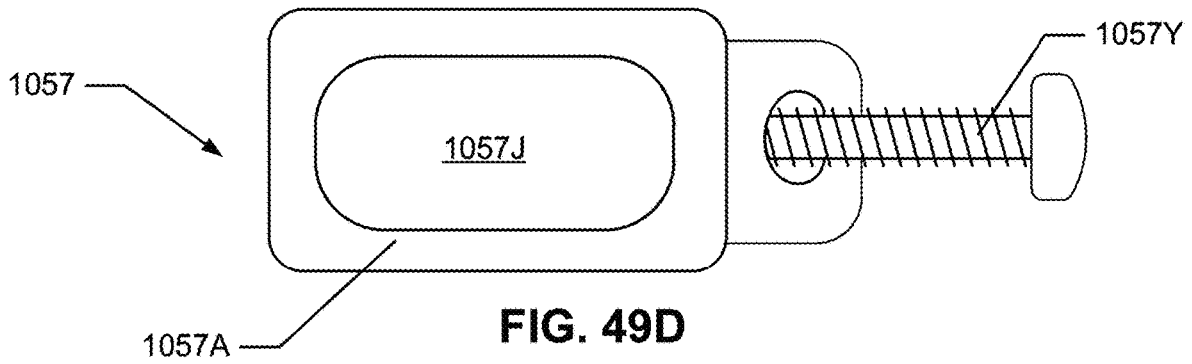


FIG. 49C



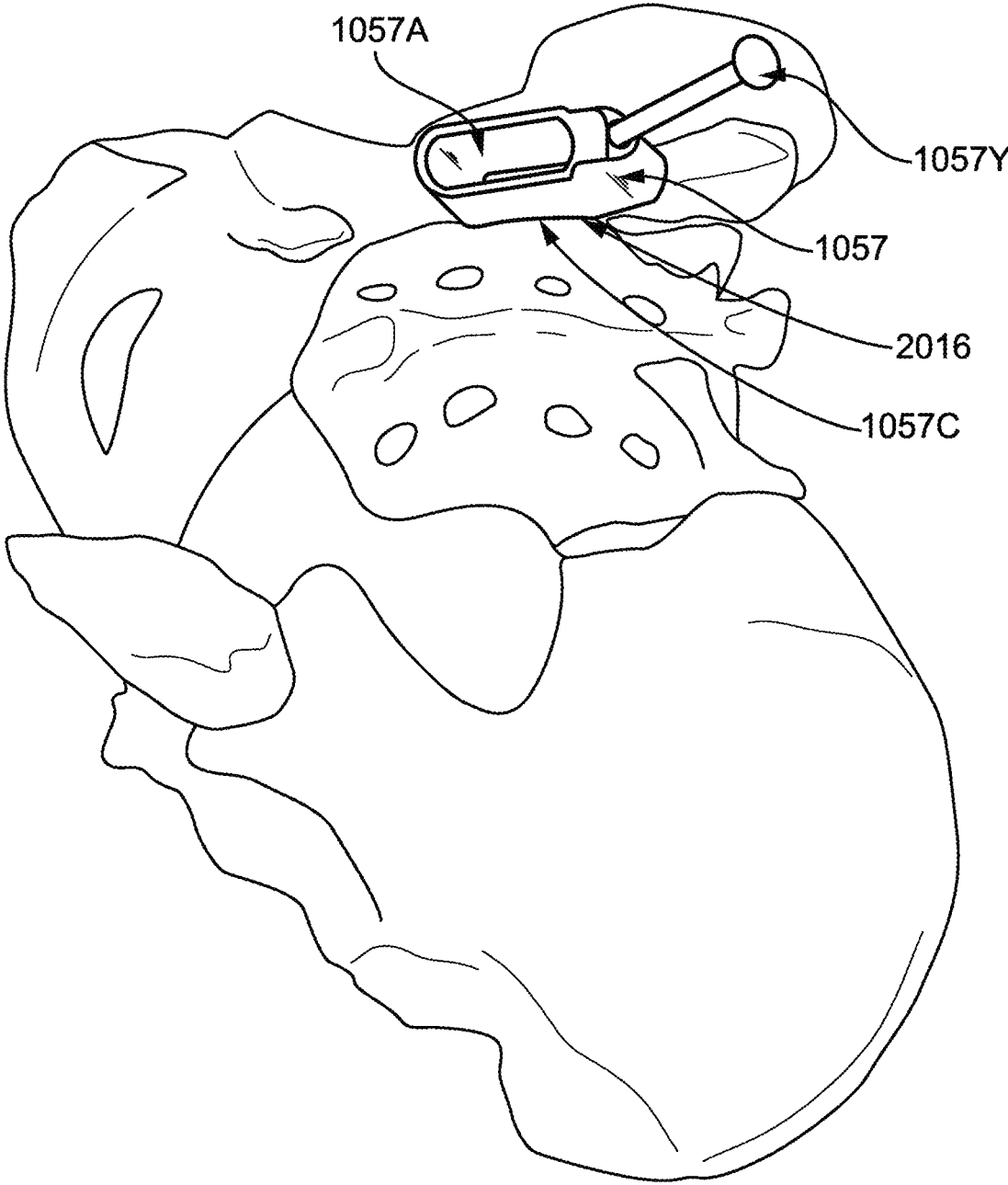


FIG. 49F

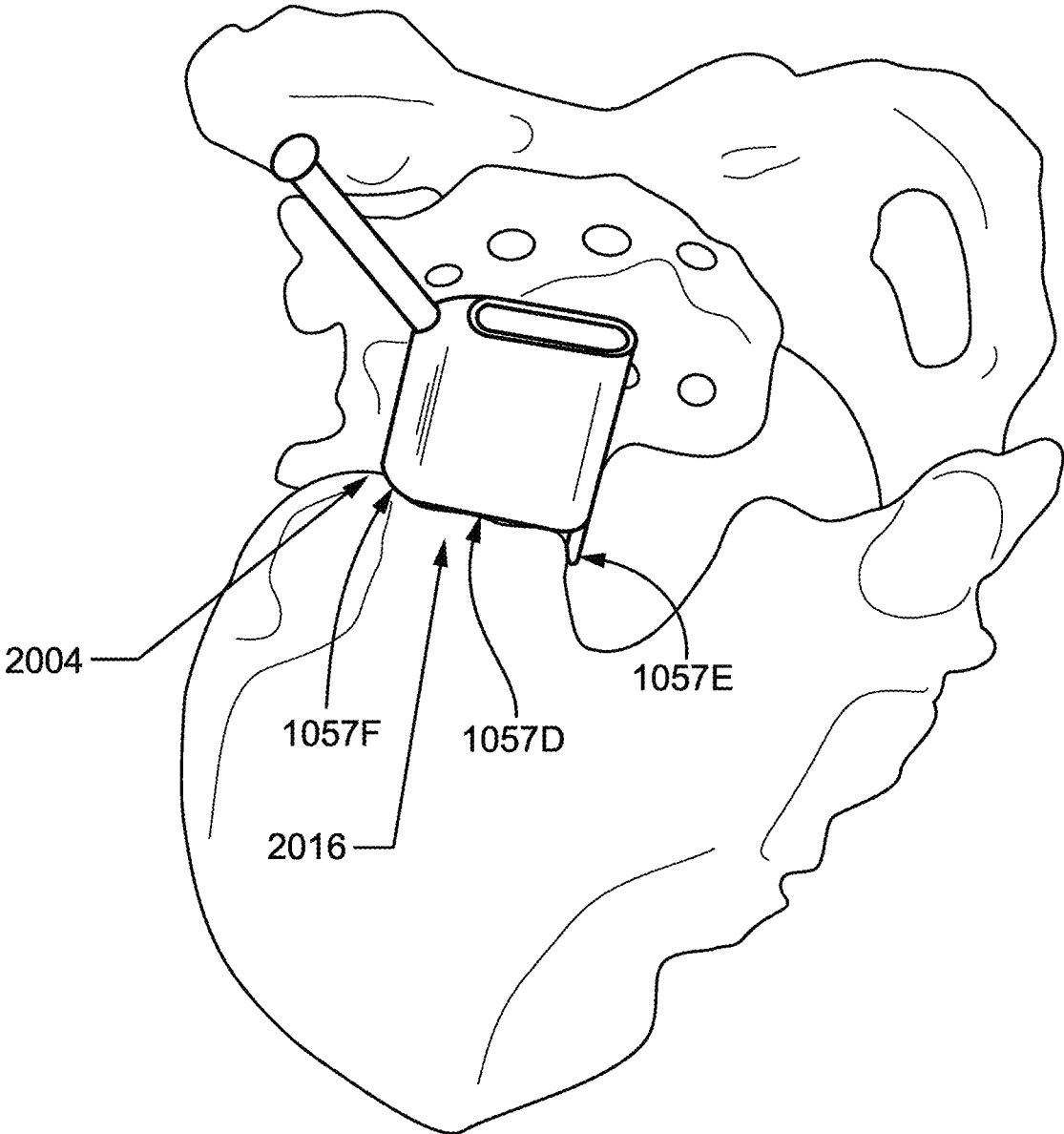


FIG. 49G

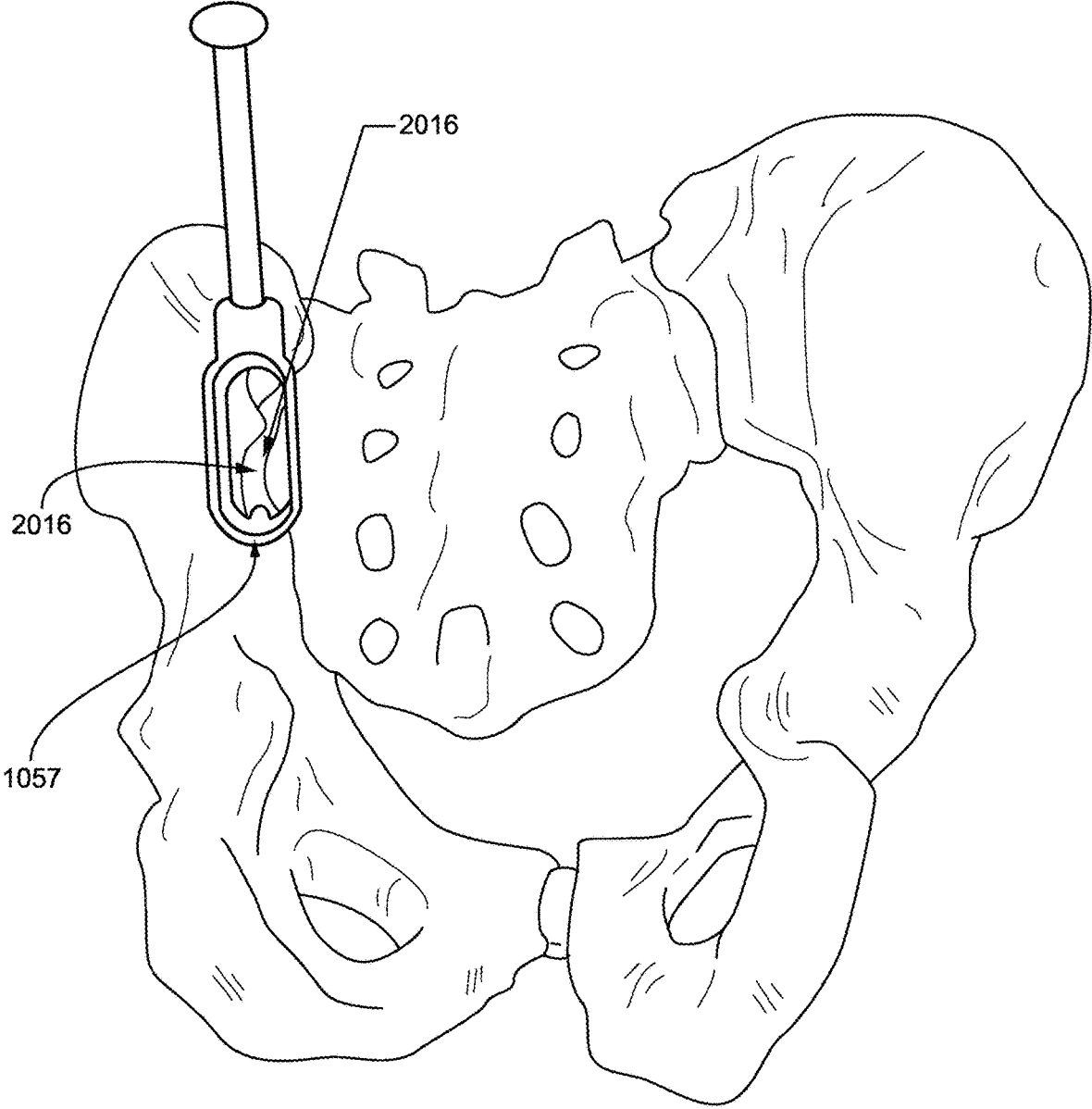


FIG. 49H

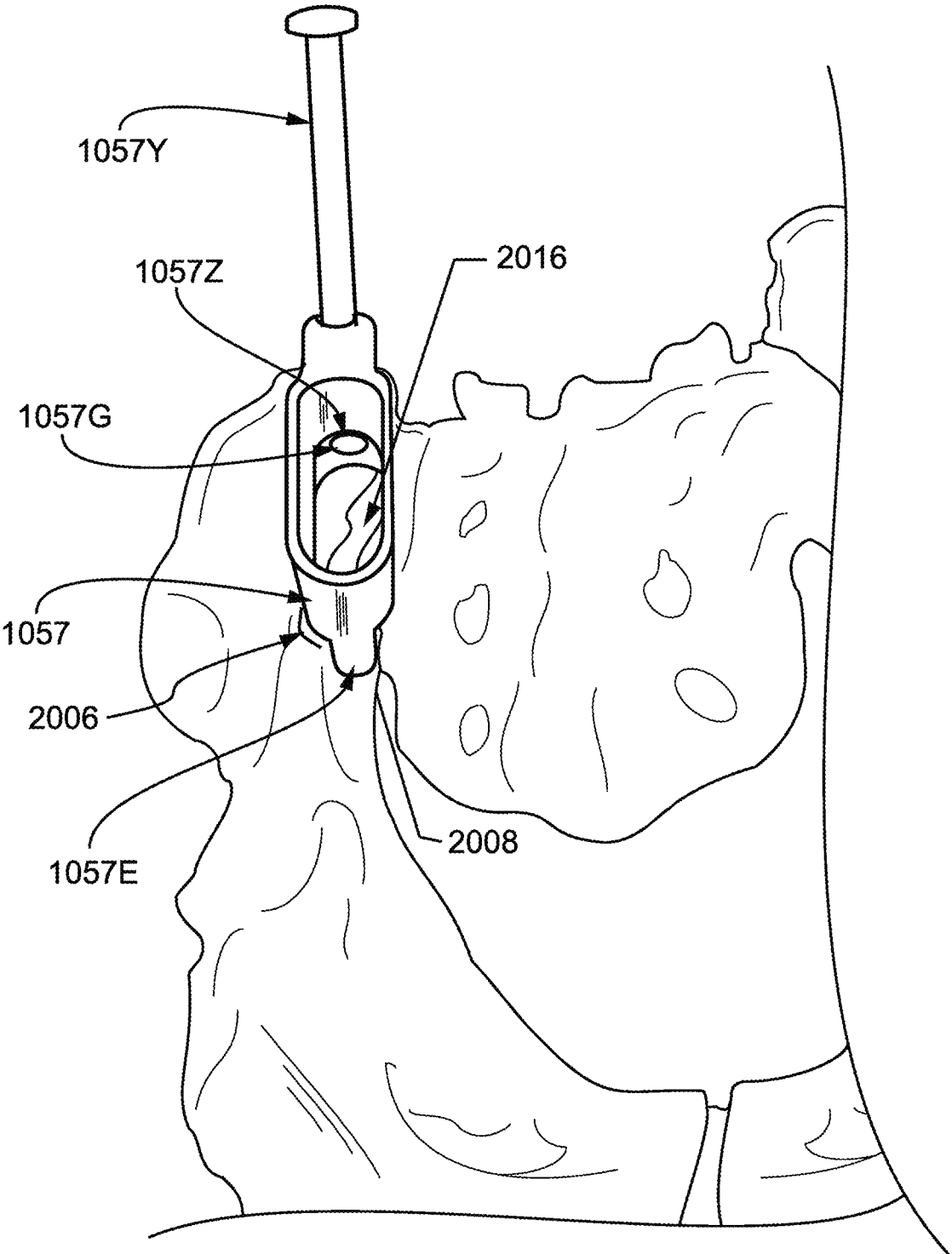


FIG. 49I

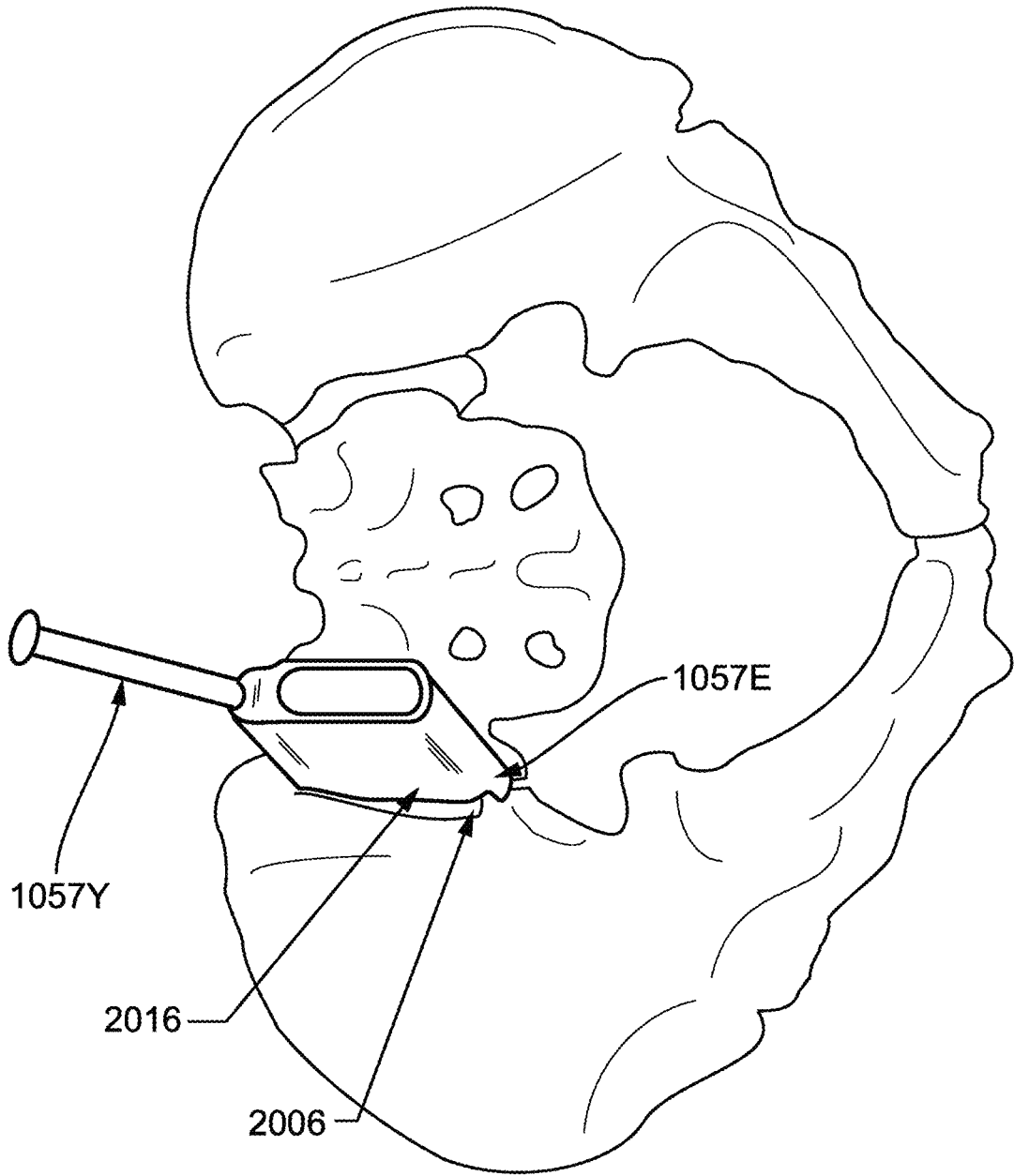


FIG. 49J

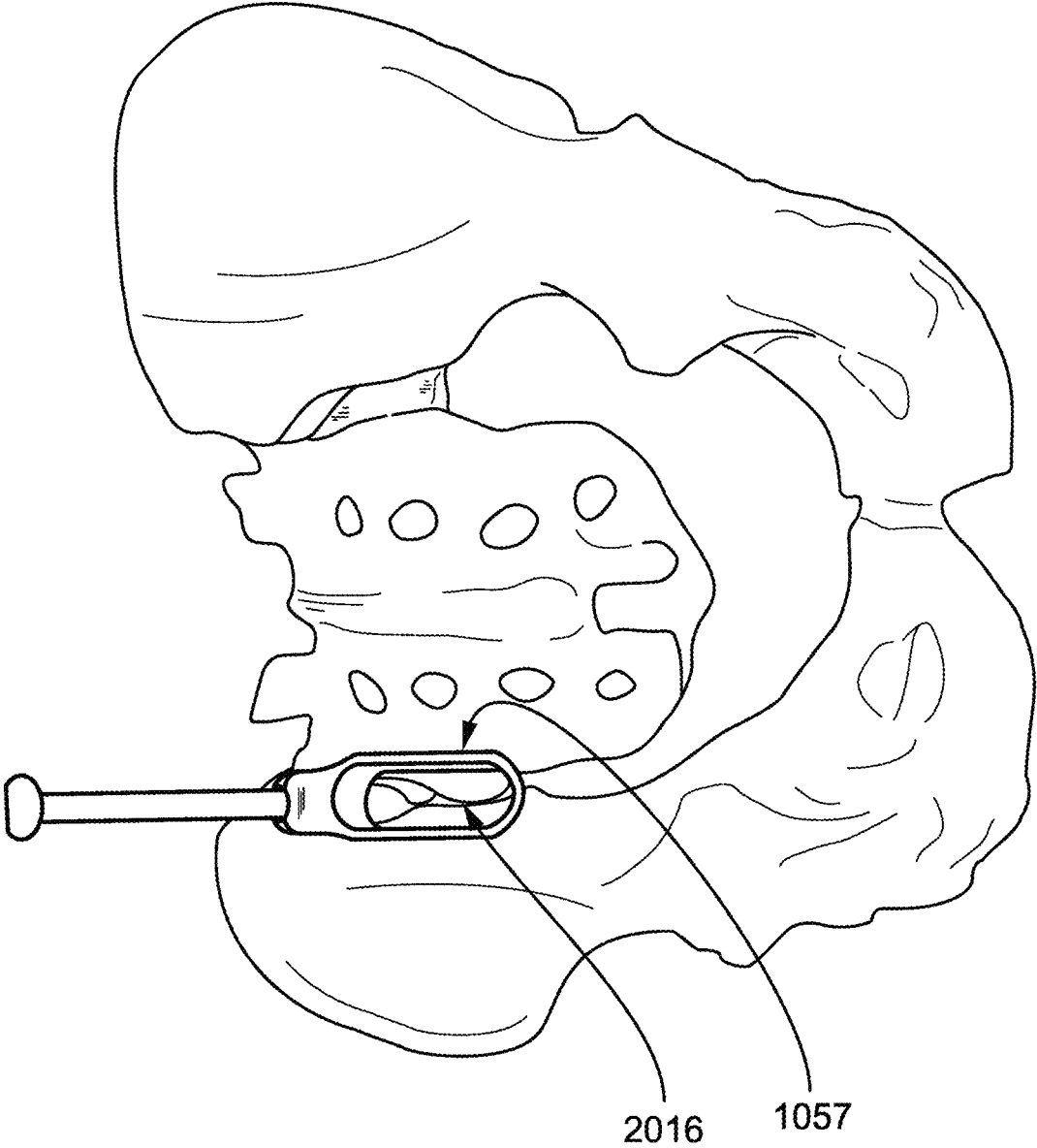


FIG. 49K

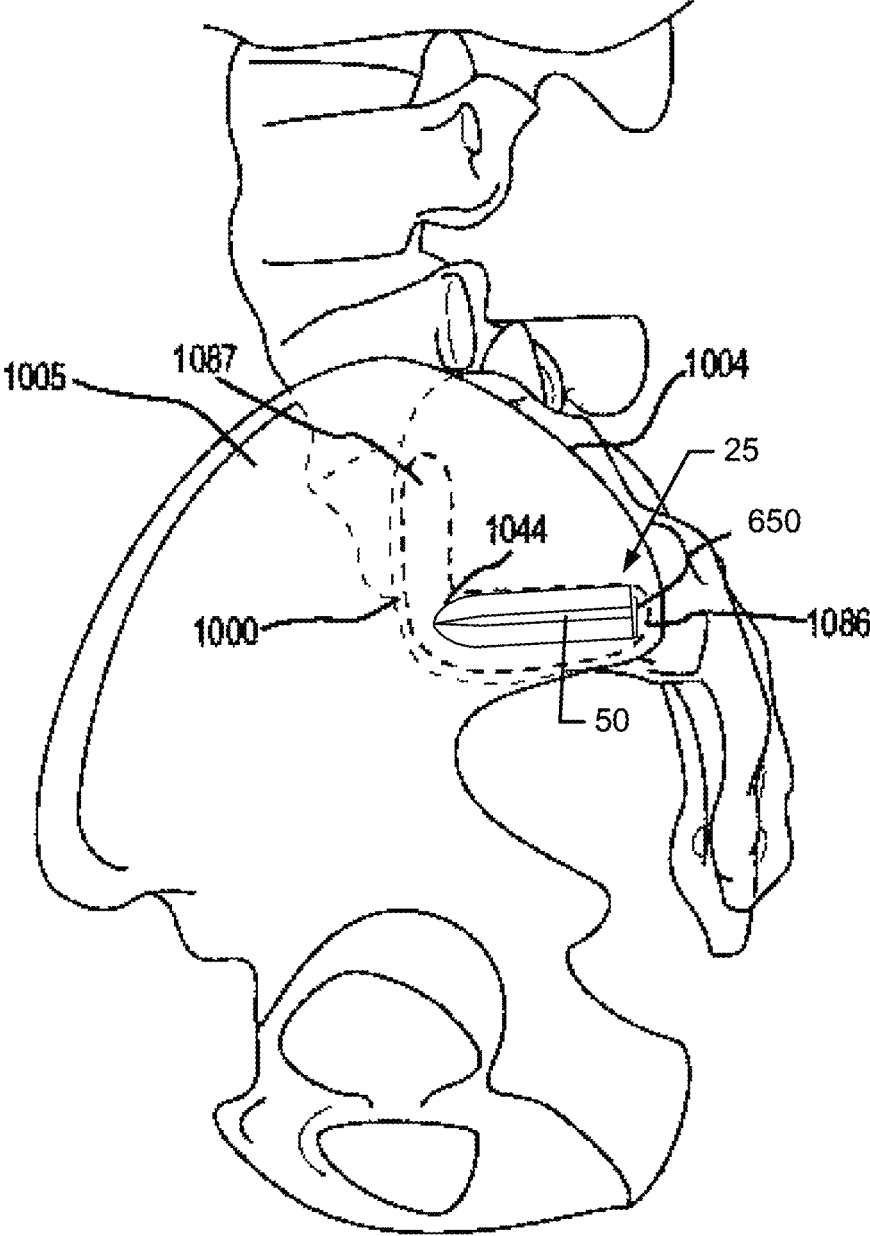


FIG. 50A

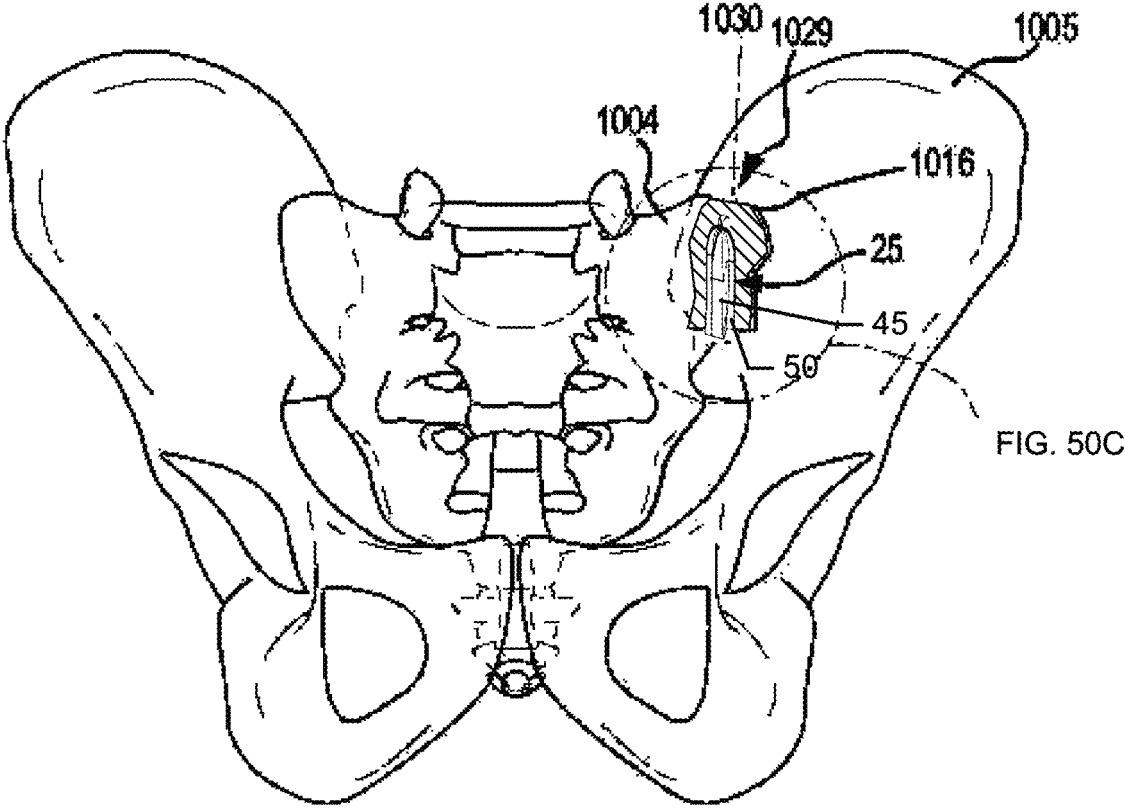


FIG. 50B

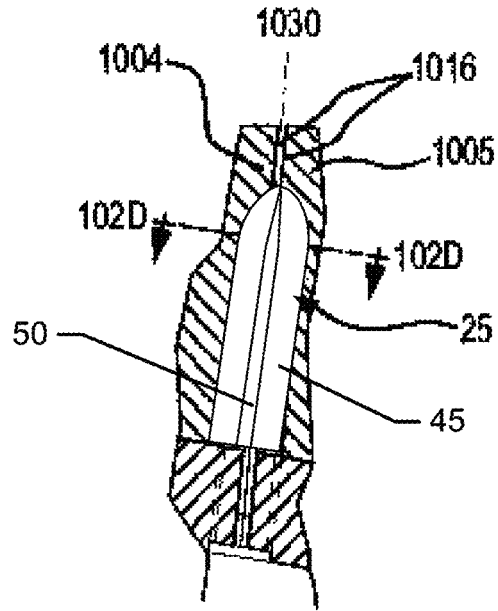


FIG. 50C

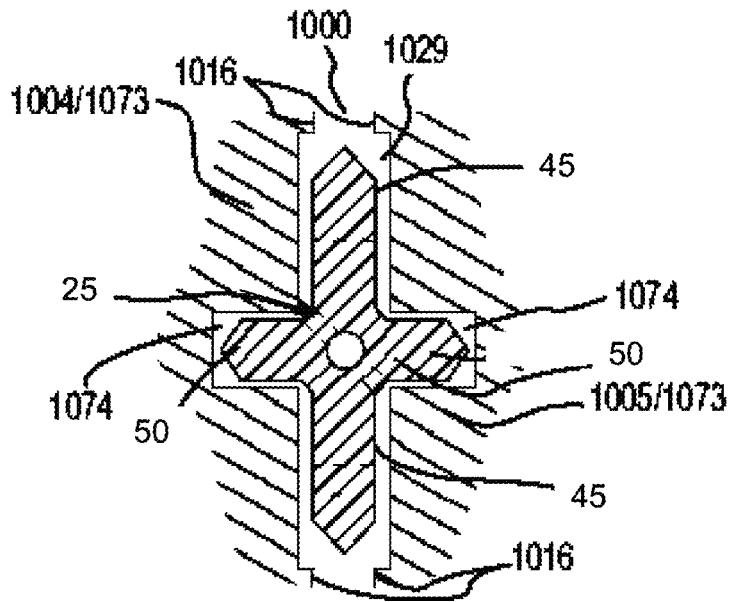


FIG. 50D

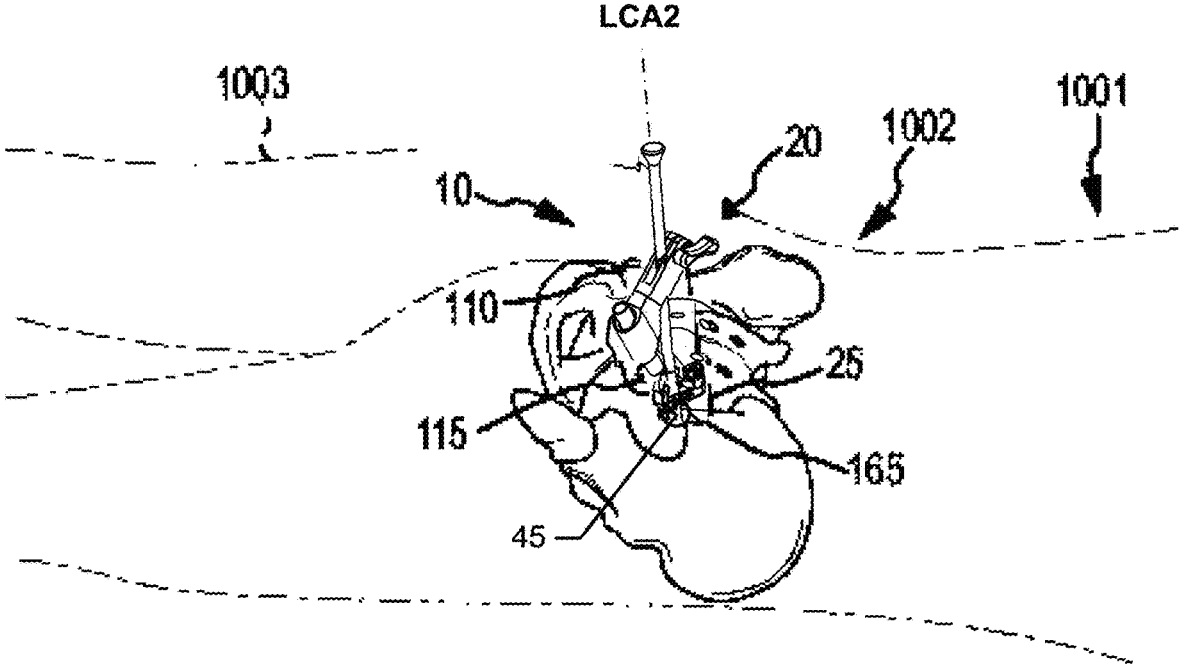


FIG. 51A

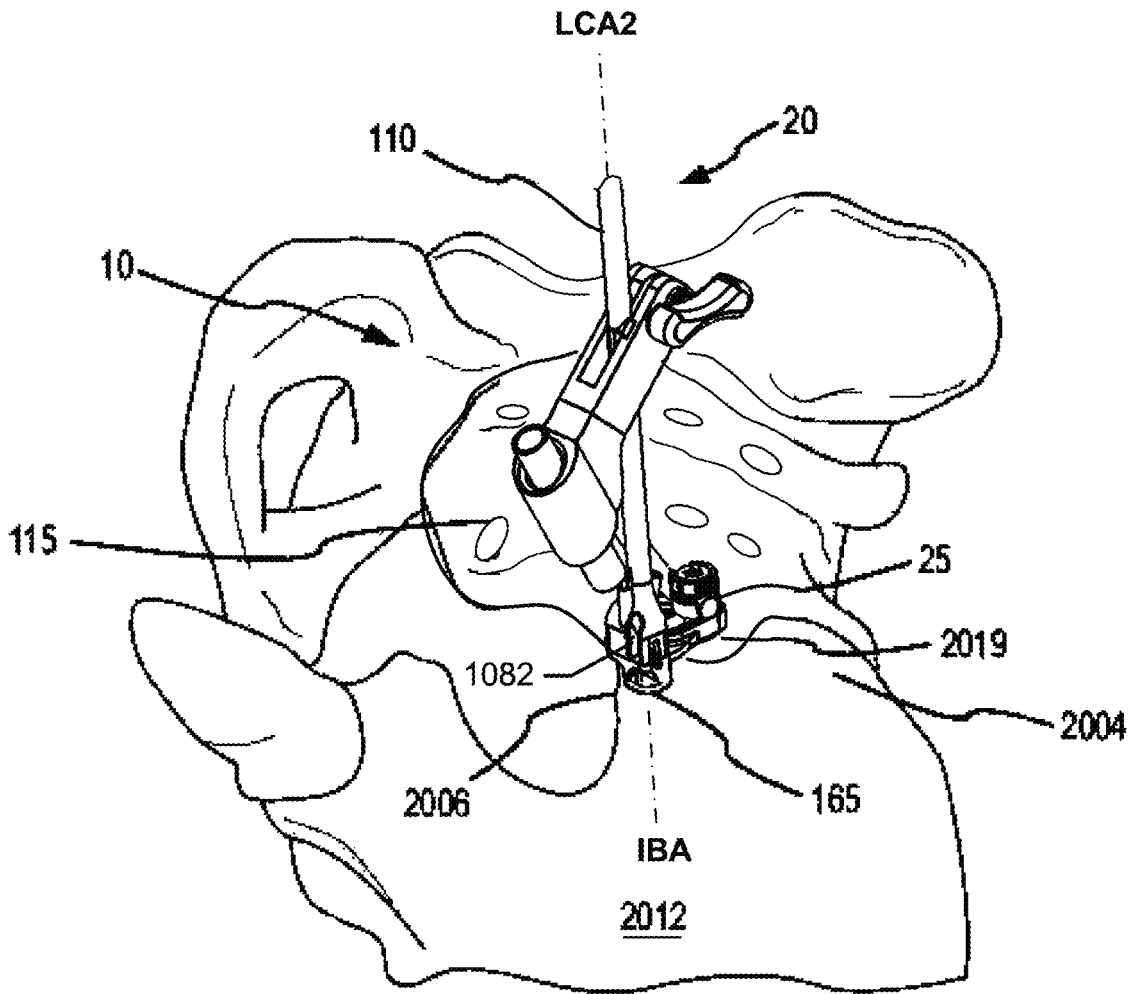


FIG. 51B

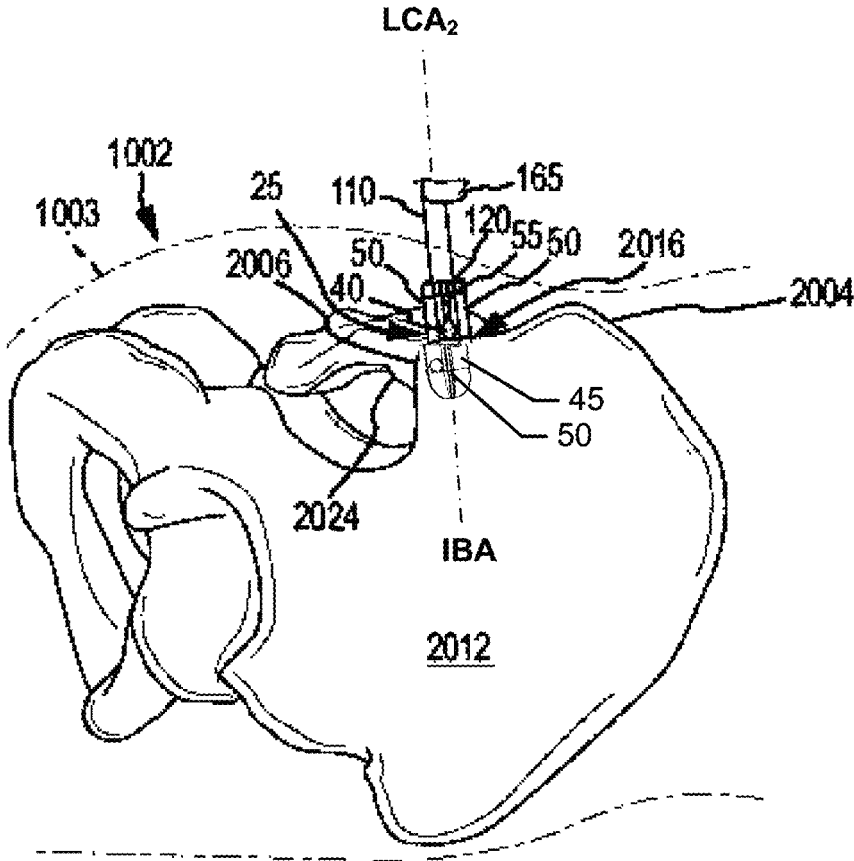


FIG. 52

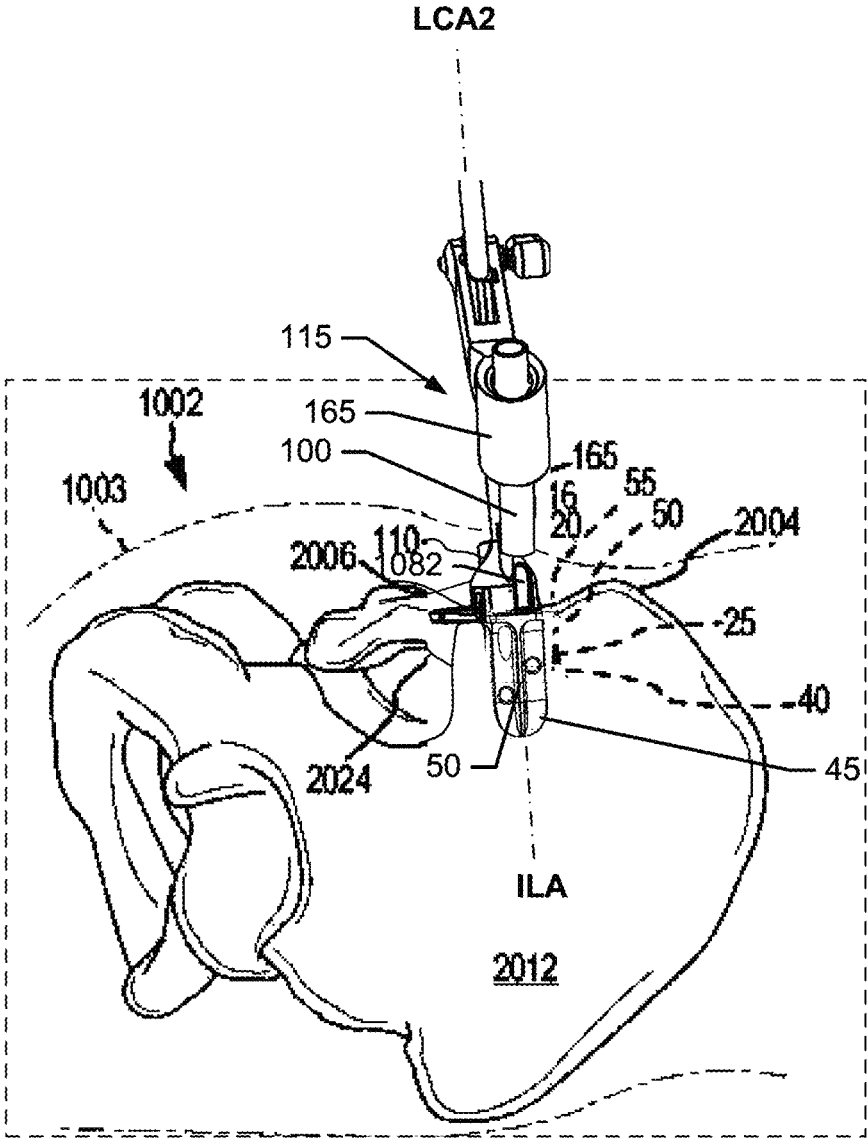
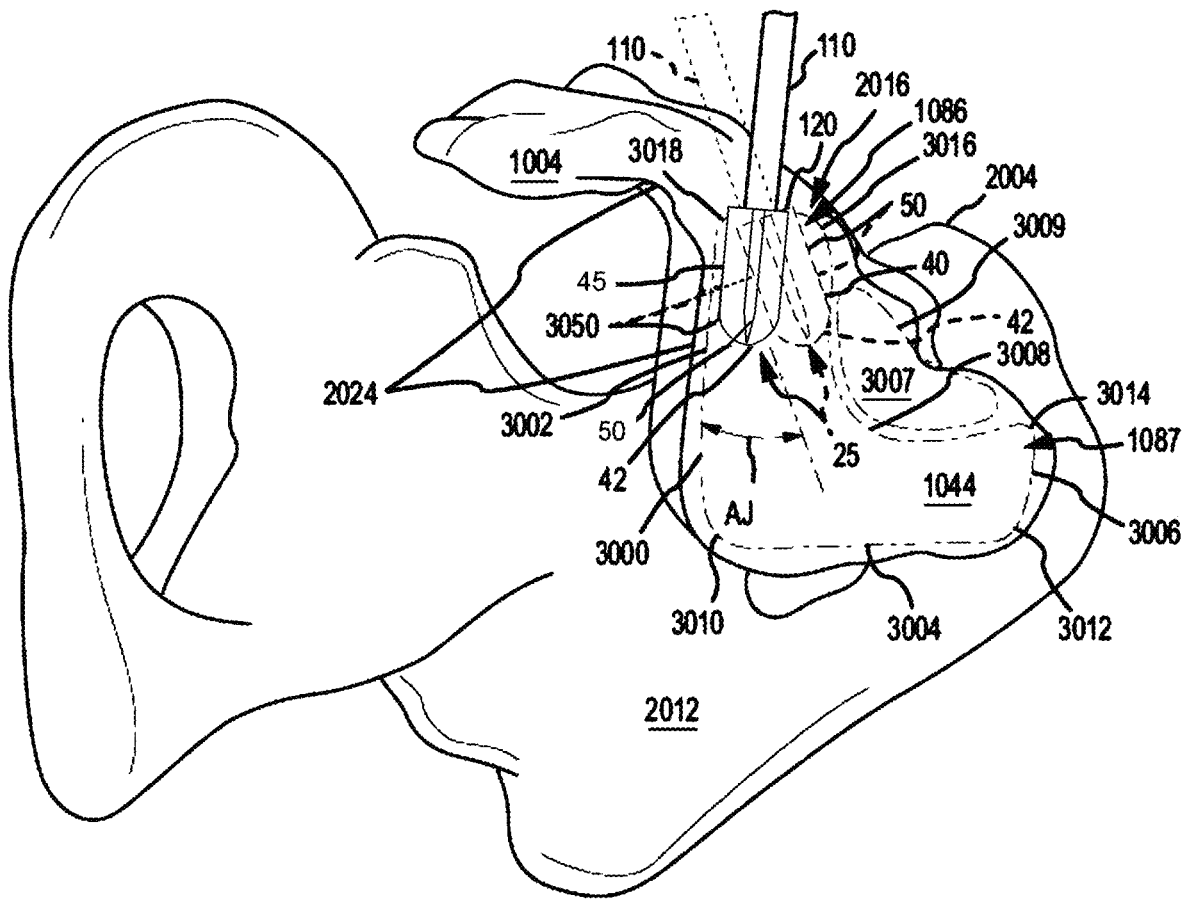


FIG. 53



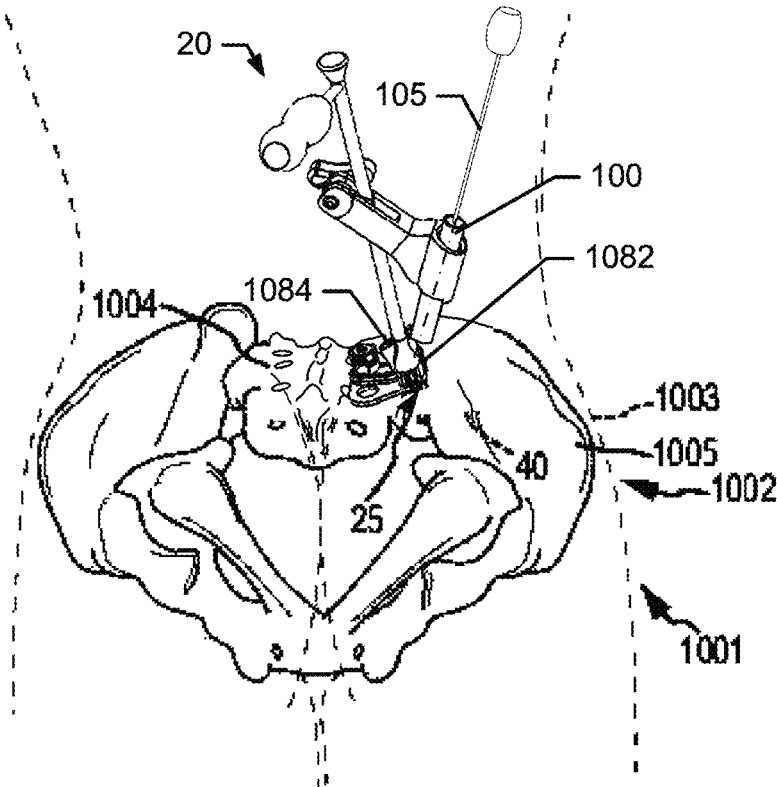


FIG. 55

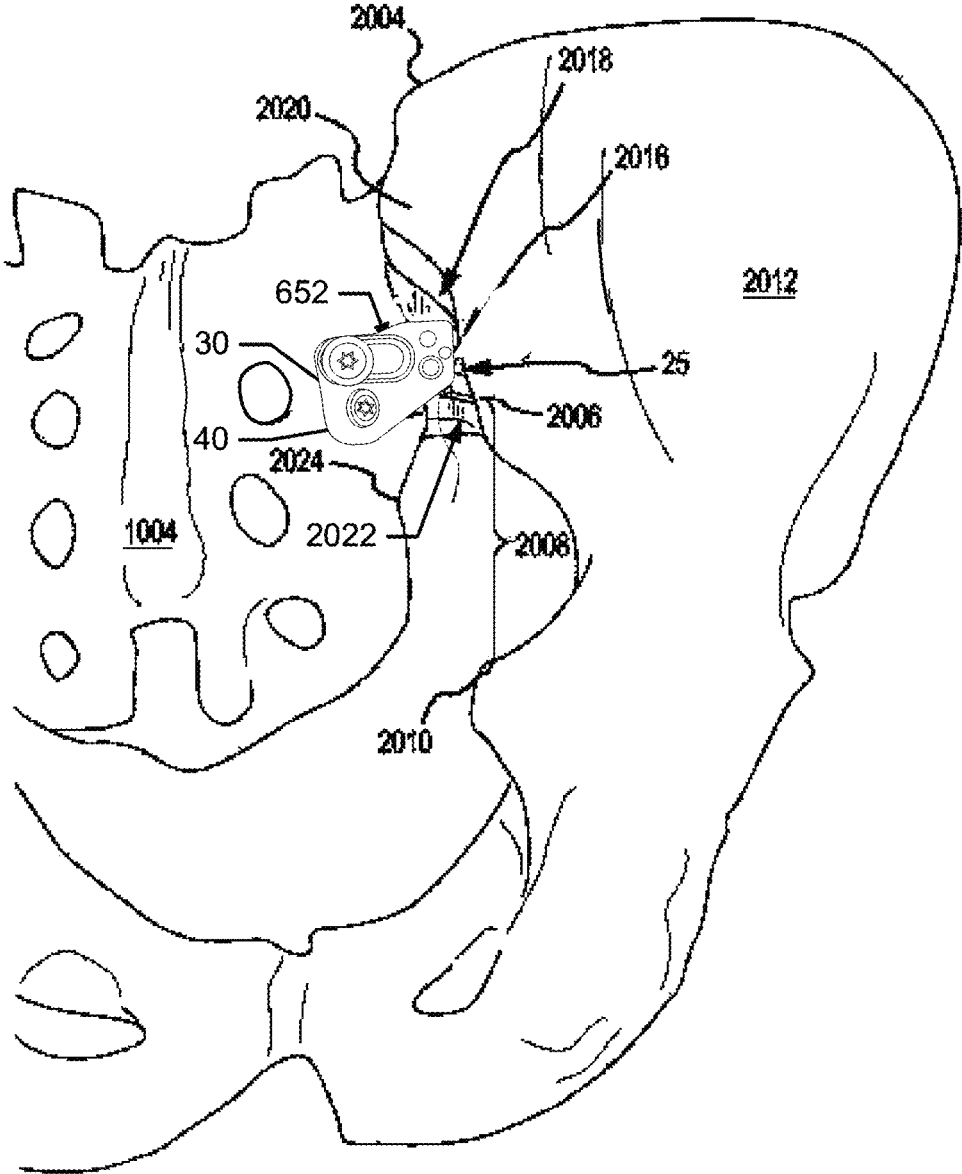


FIG. 56

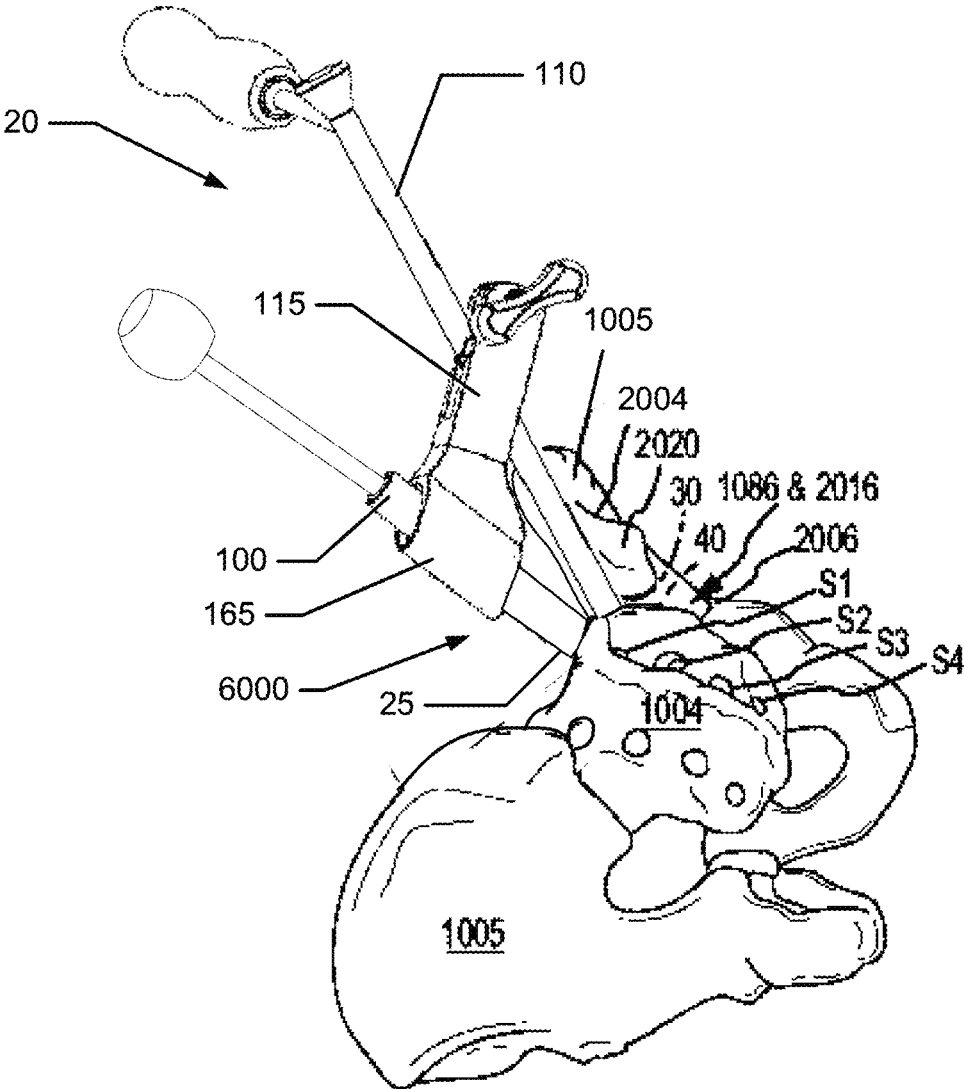


FIG. 57

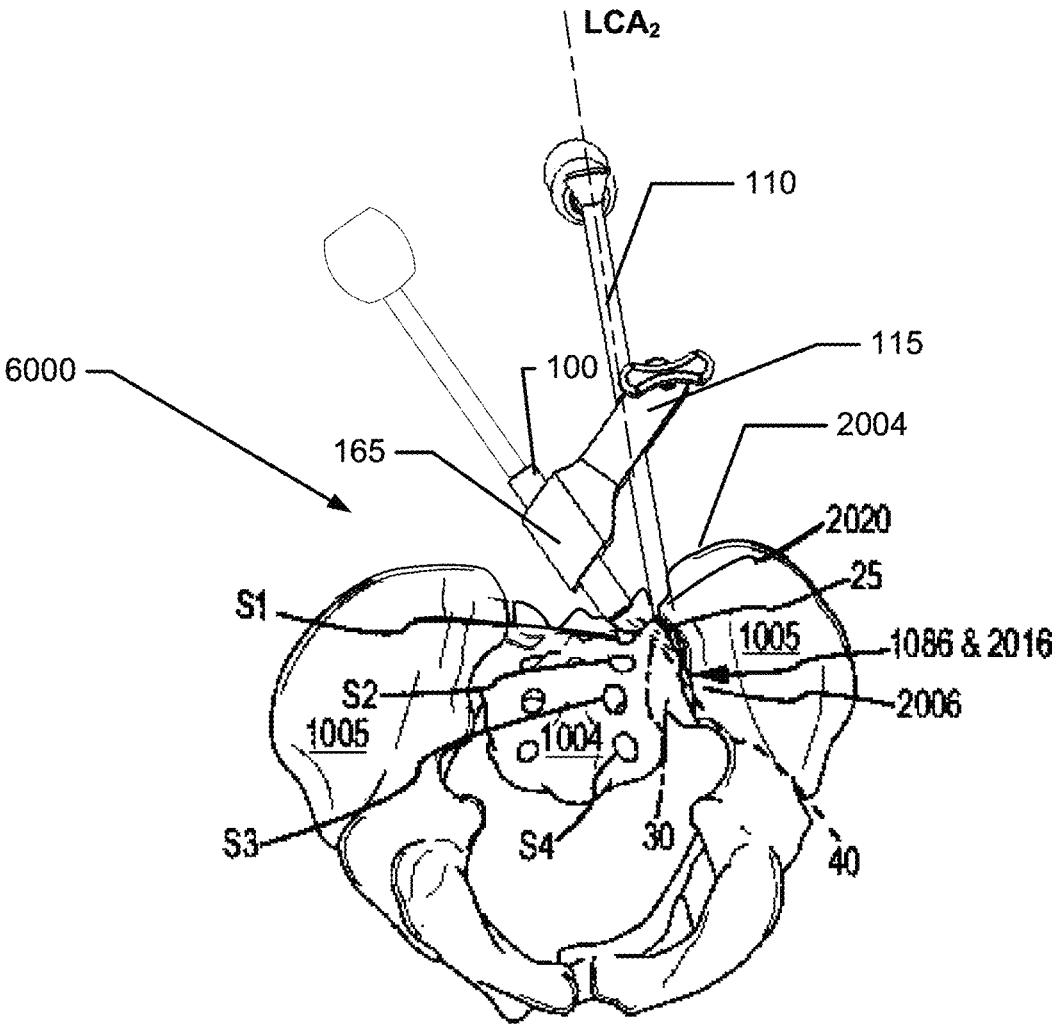


FIG. 58

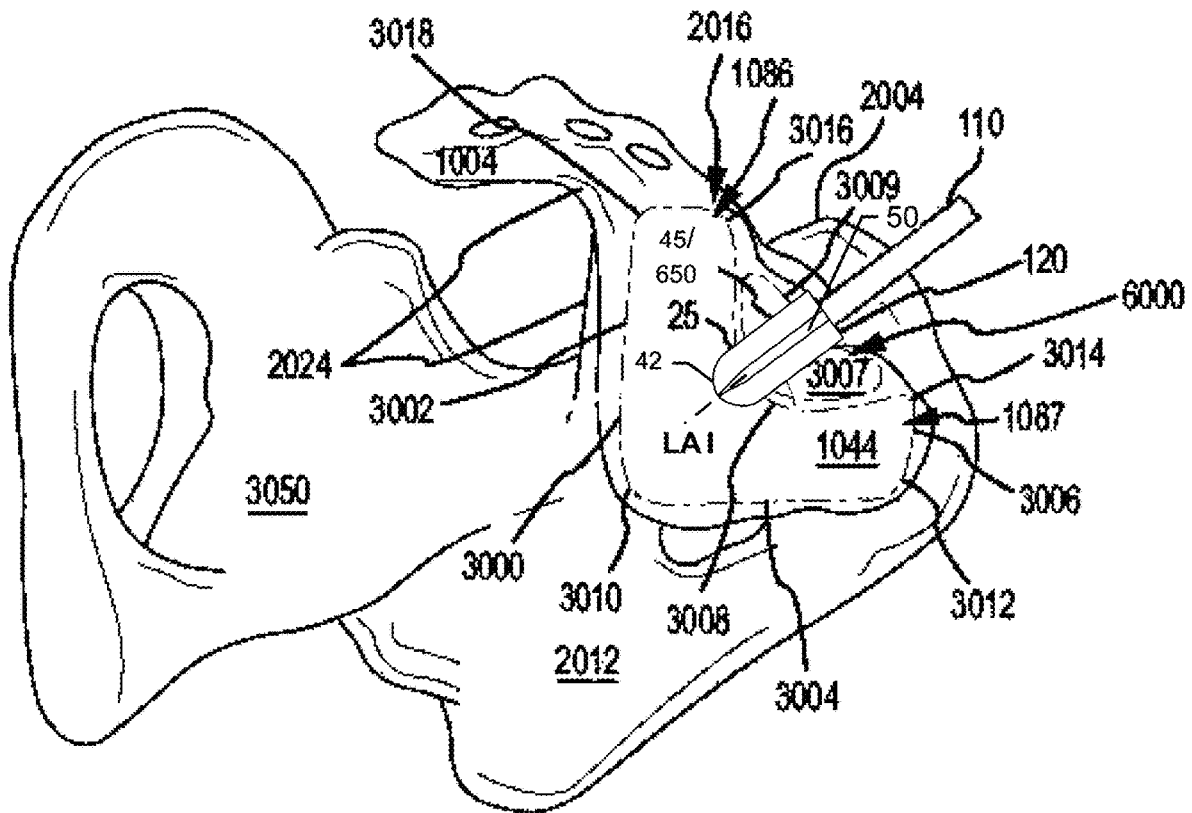


FIG. 59

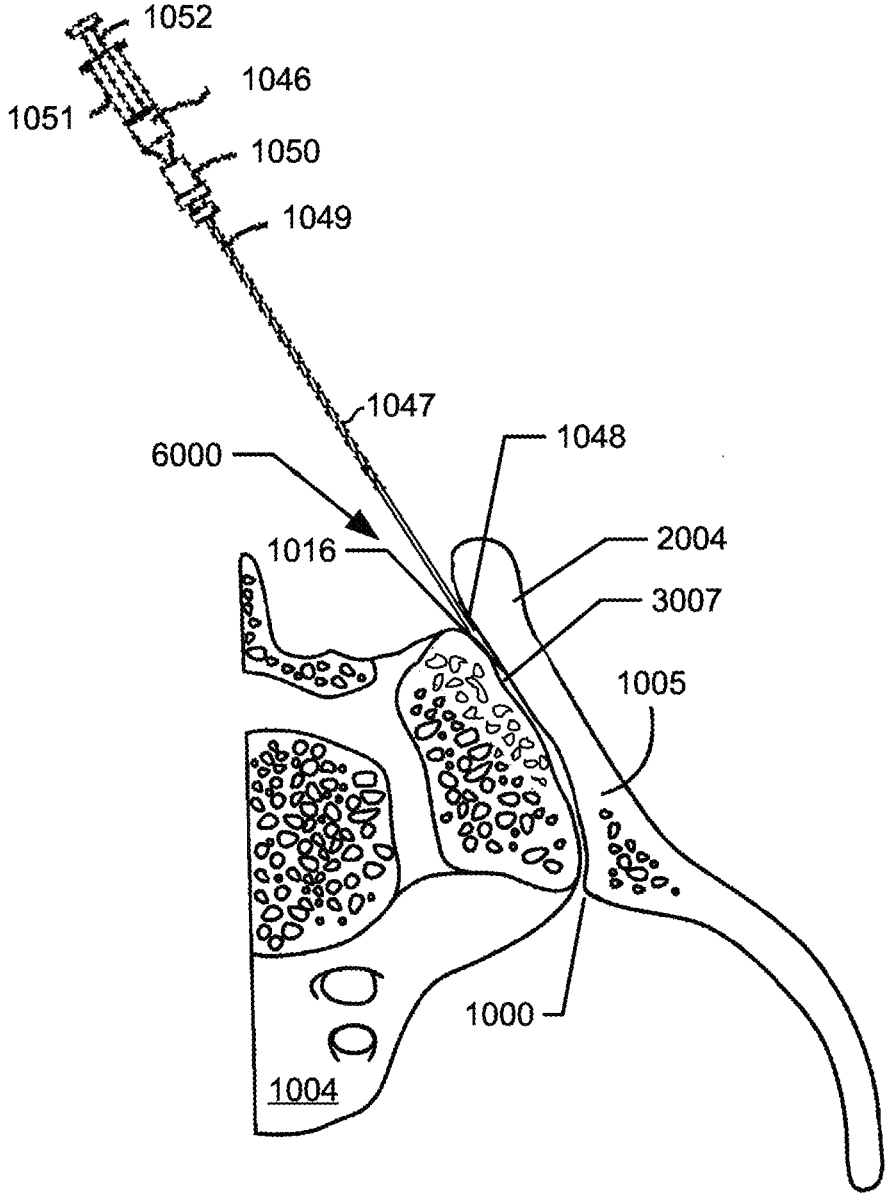


FIG. 60A

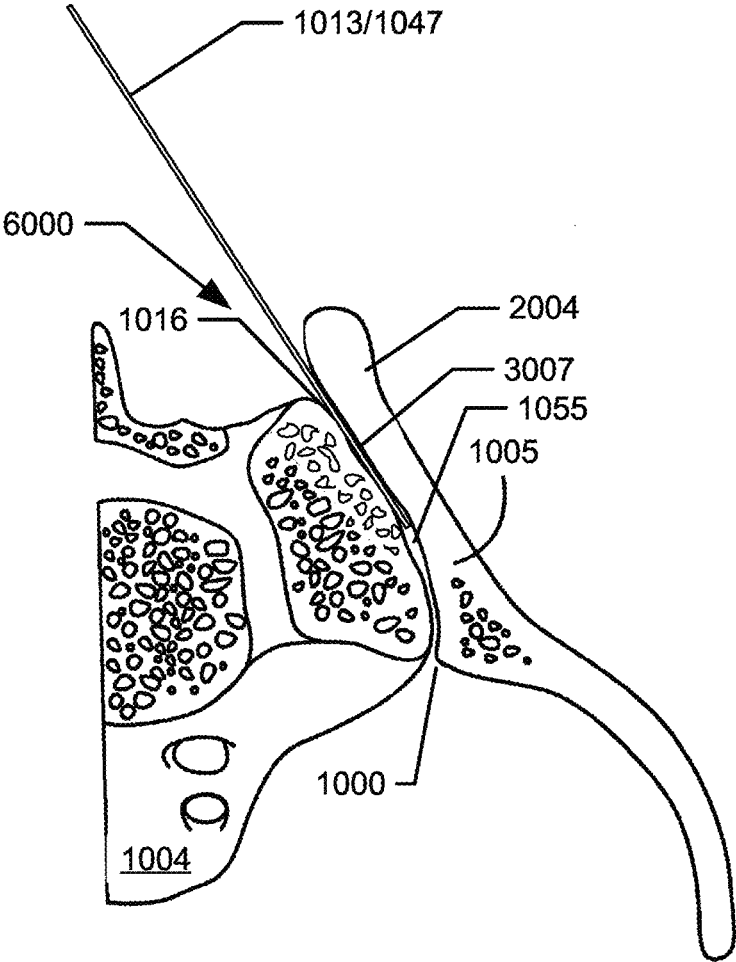


FIG. 60B

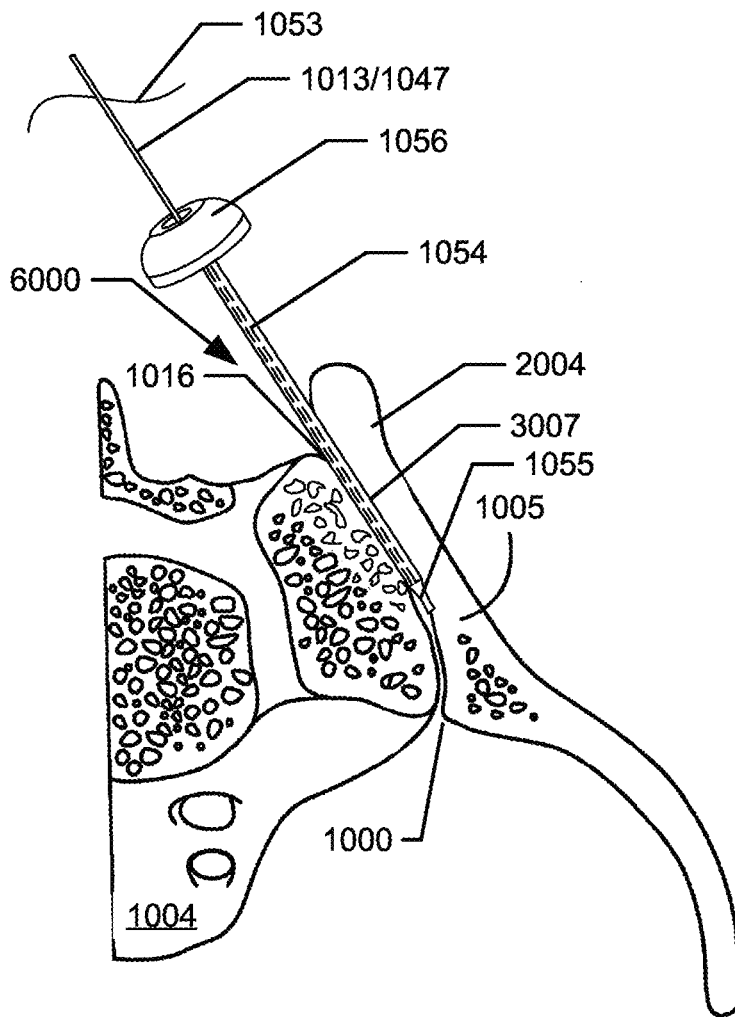


FIG. 60C

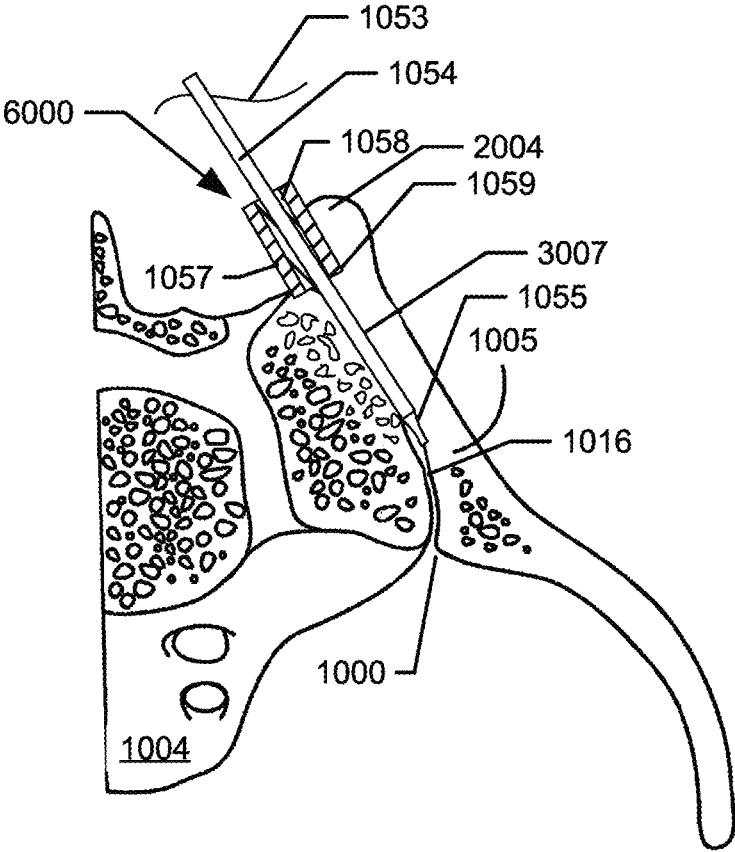


FIG. 60D

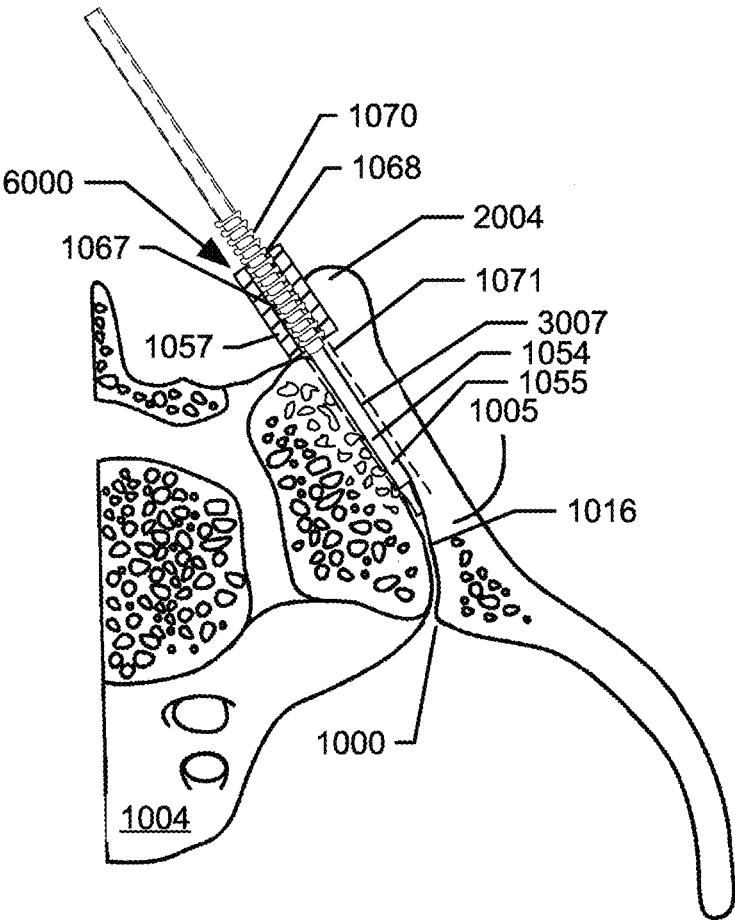


FIG. 60E

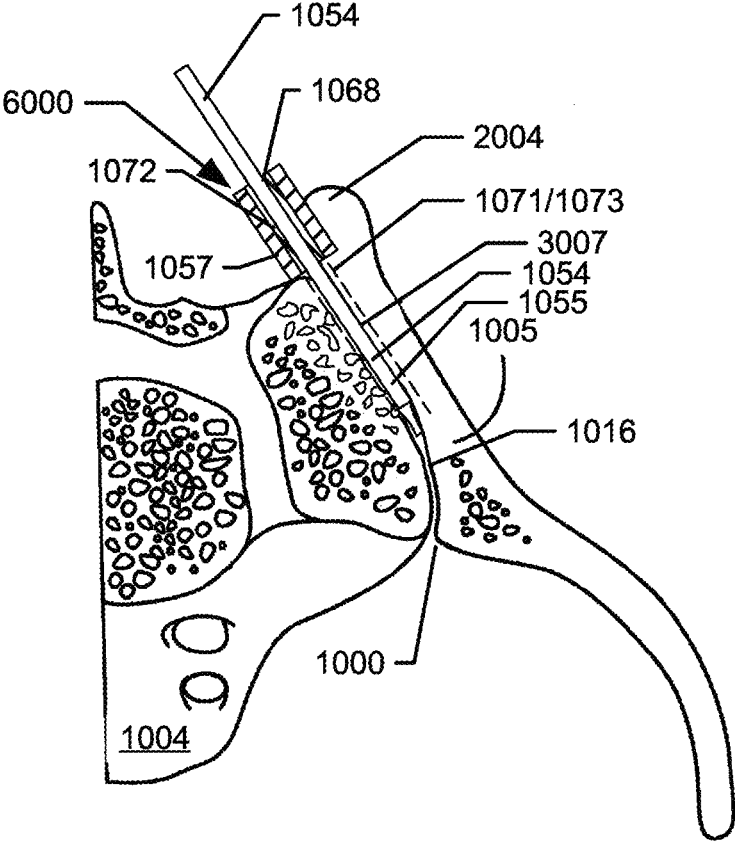


FIG. 60F

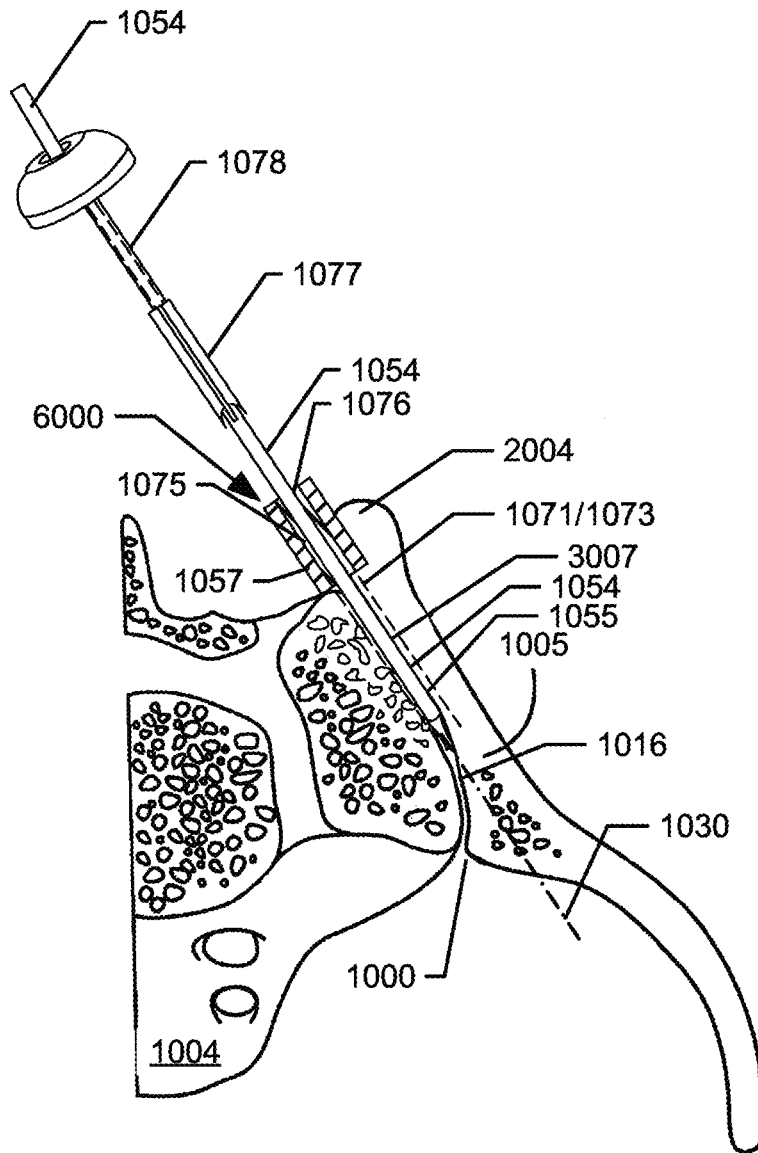


FIG. 60G

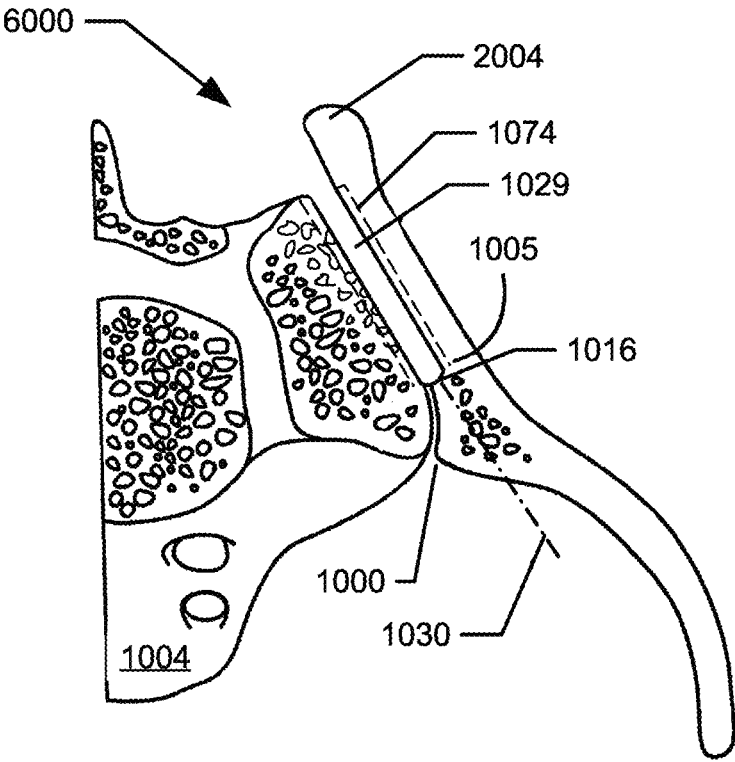


FIG. 60H

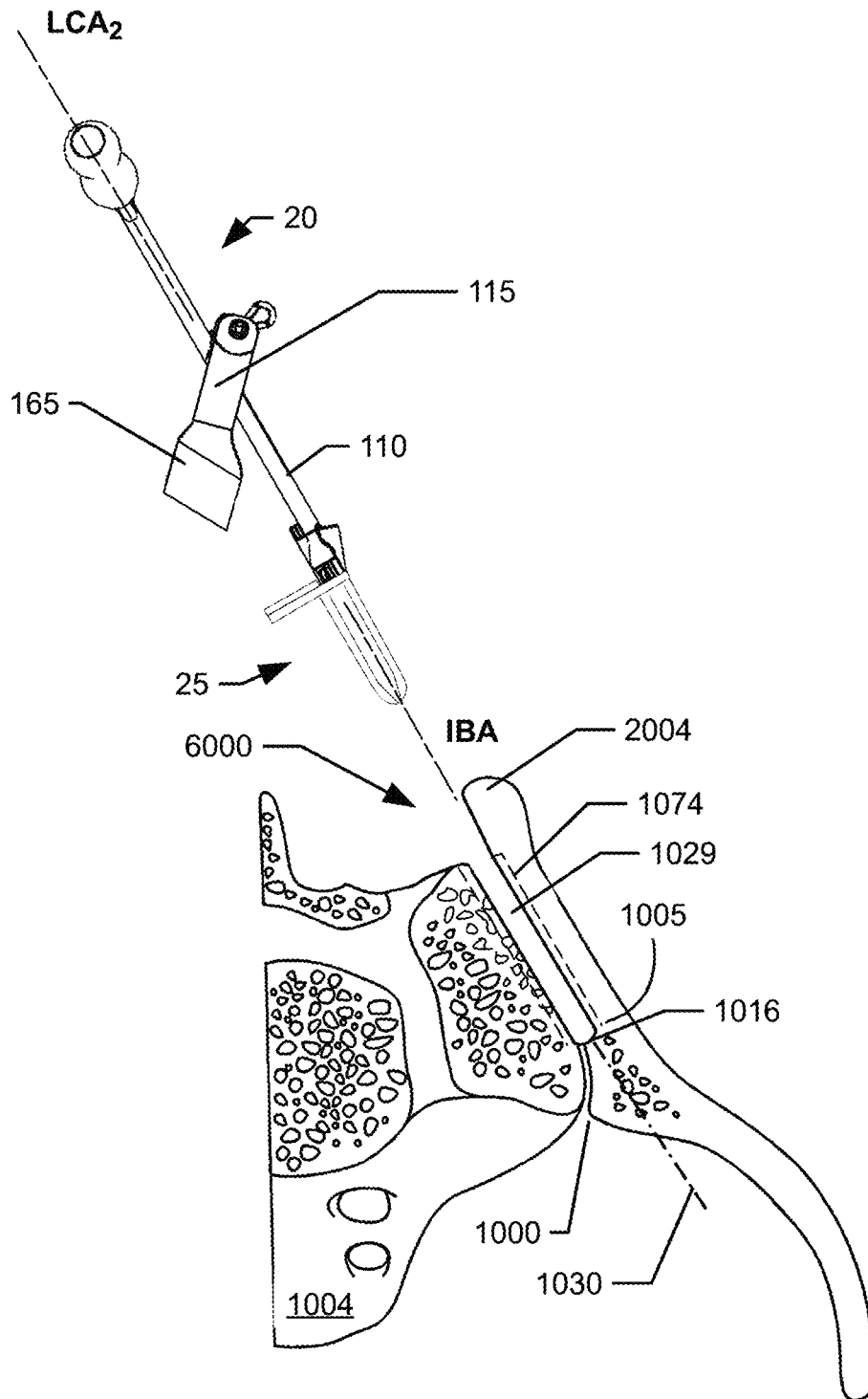


FIG. 60I

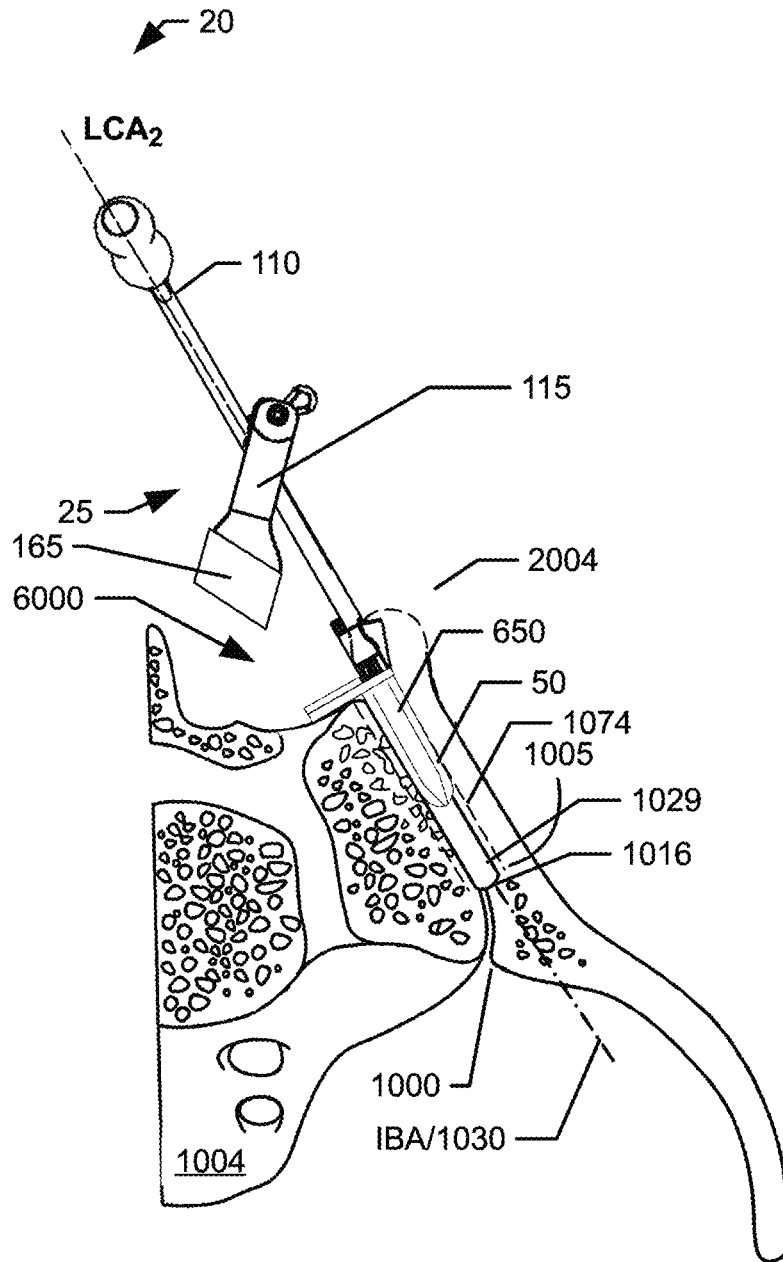


FIG. 60J

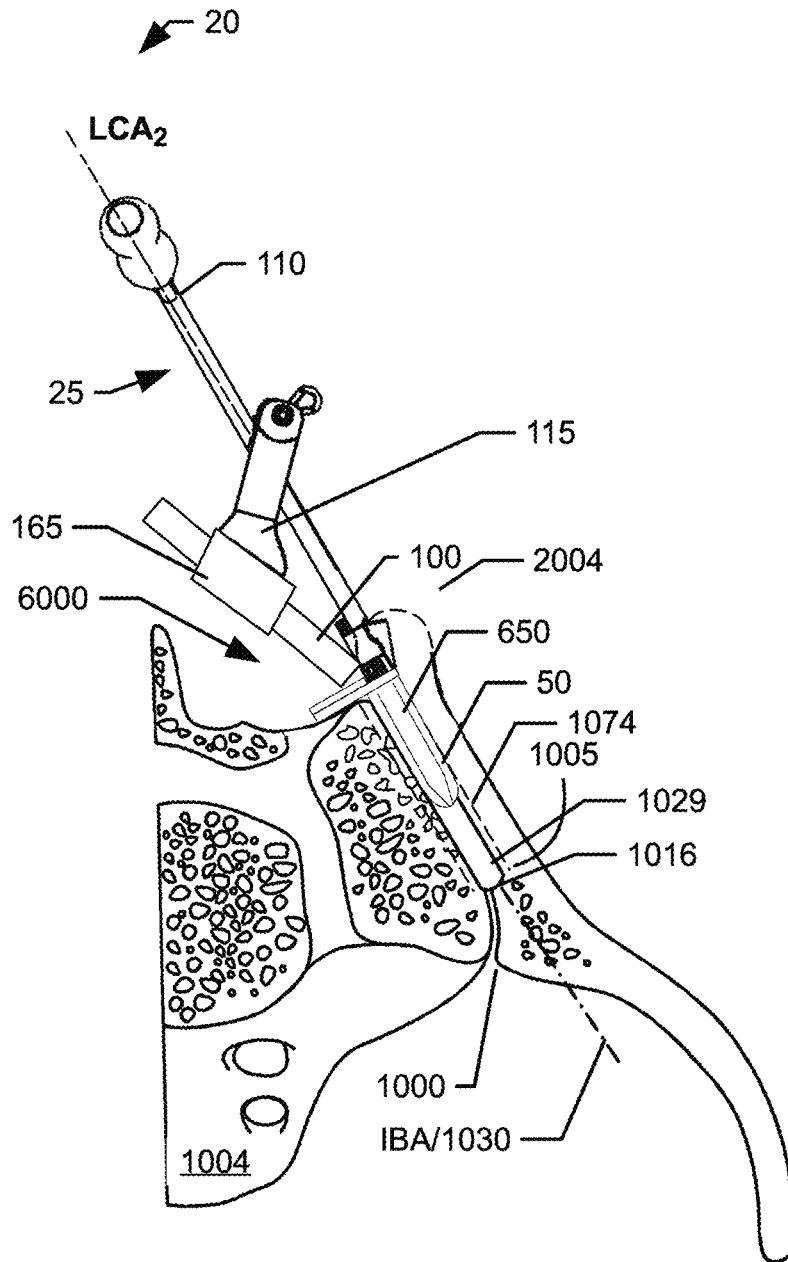


FIG. 60K

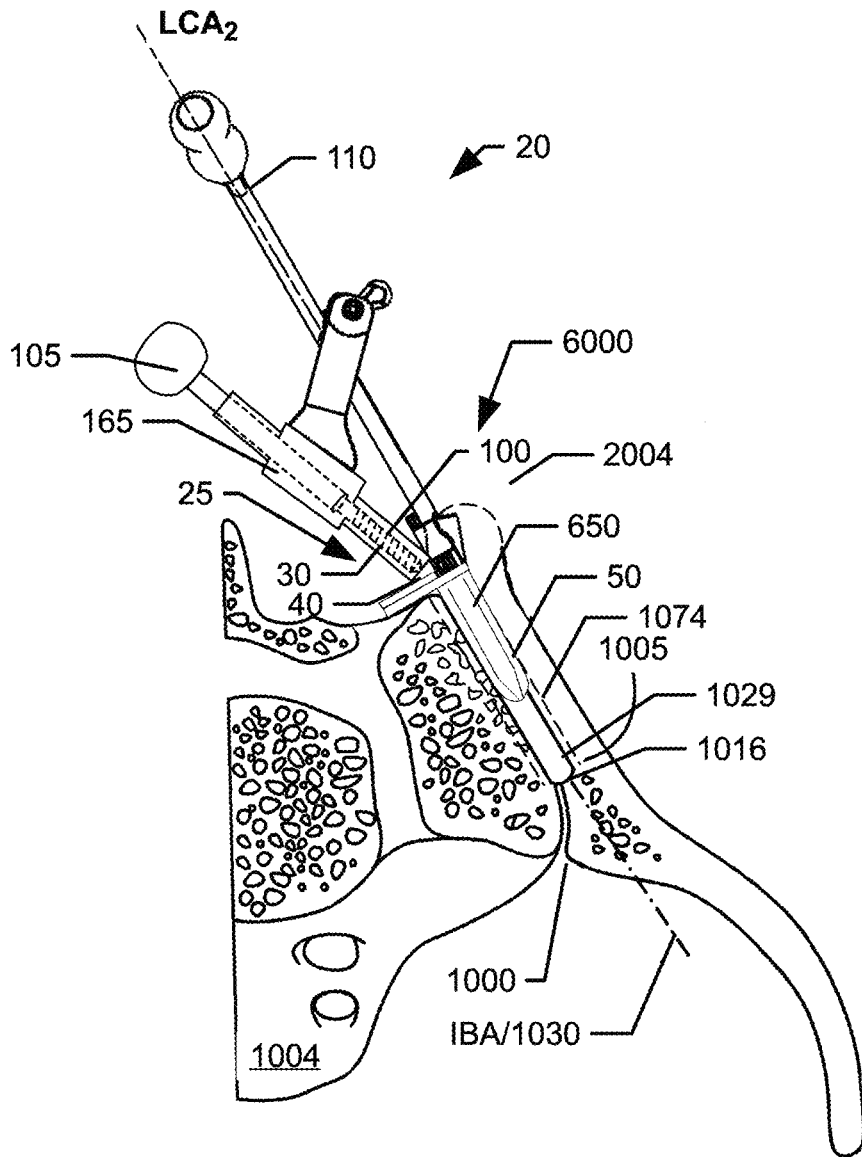


FIG. 60L

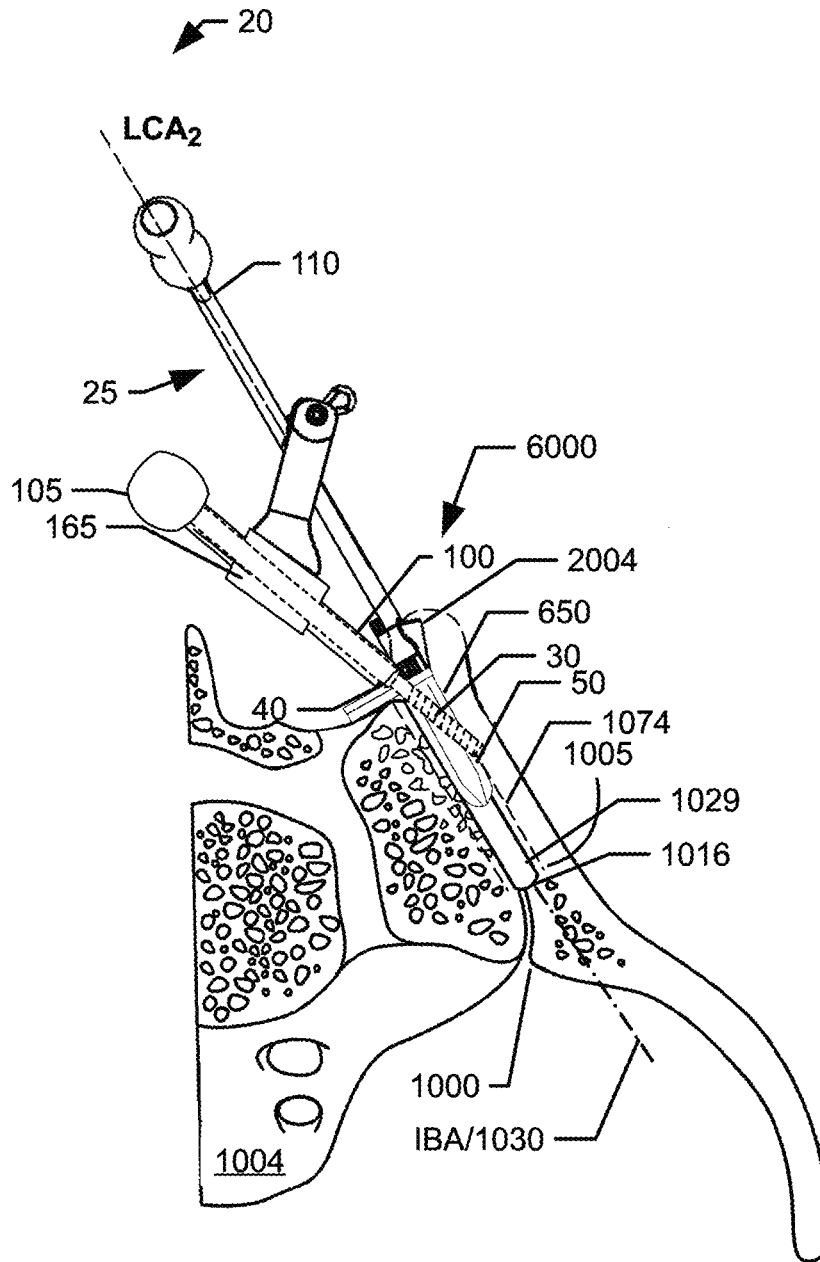


FIG. 60M

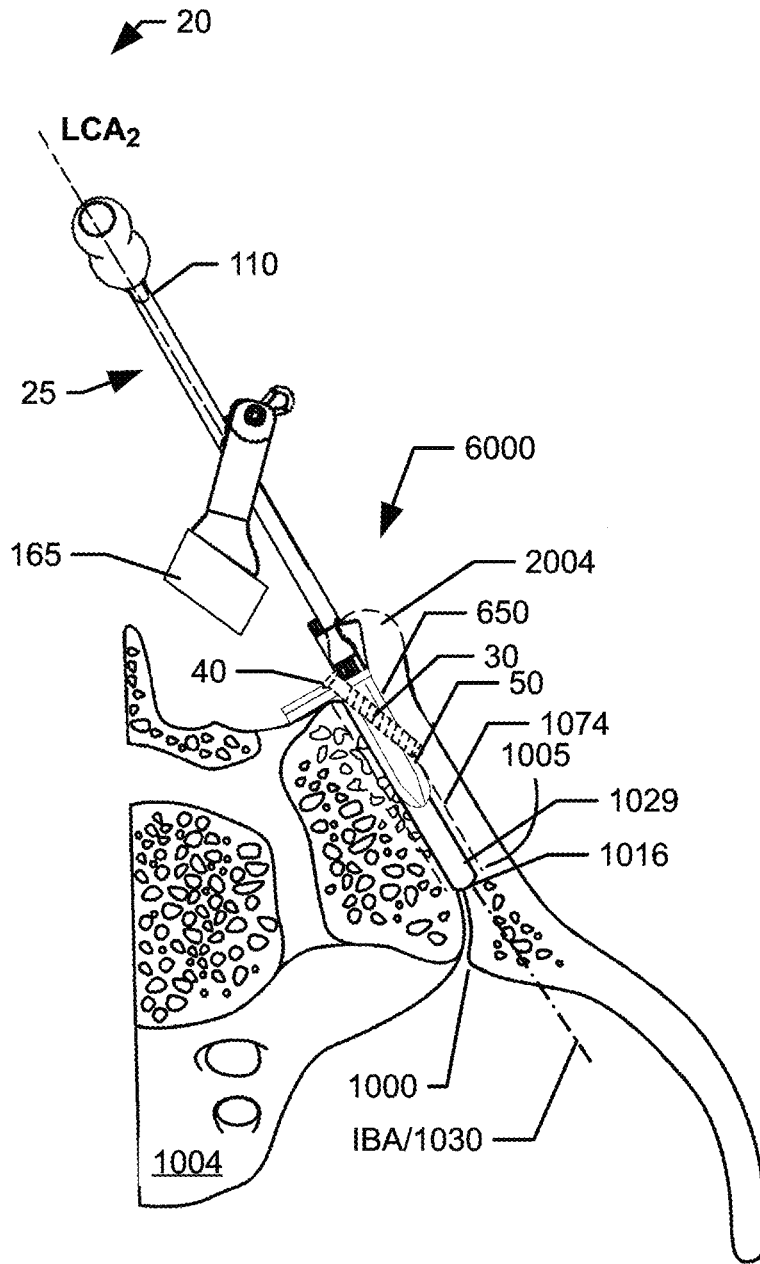


FIG. 60N

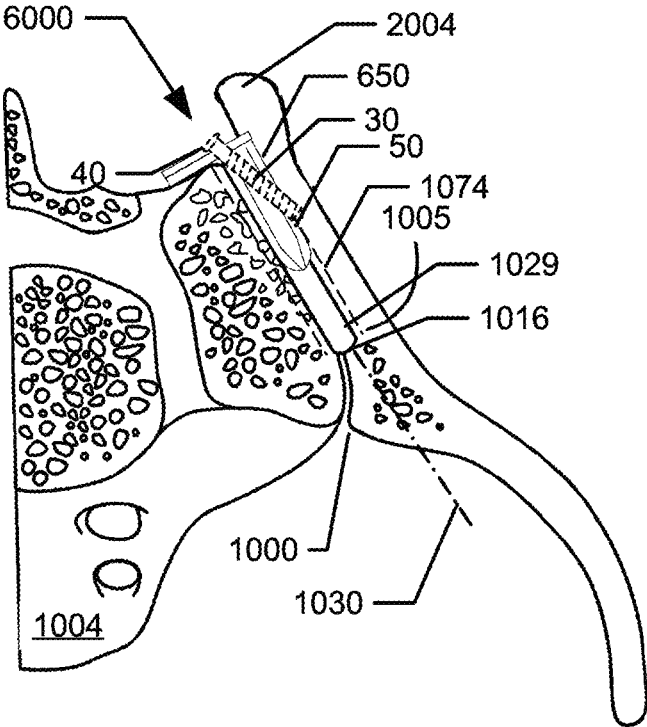


FIG. 600

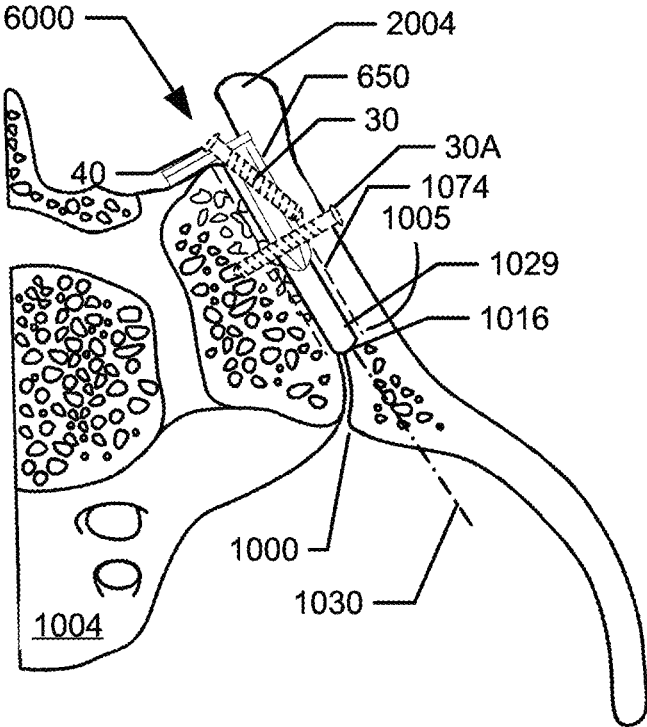


FIG. 60P

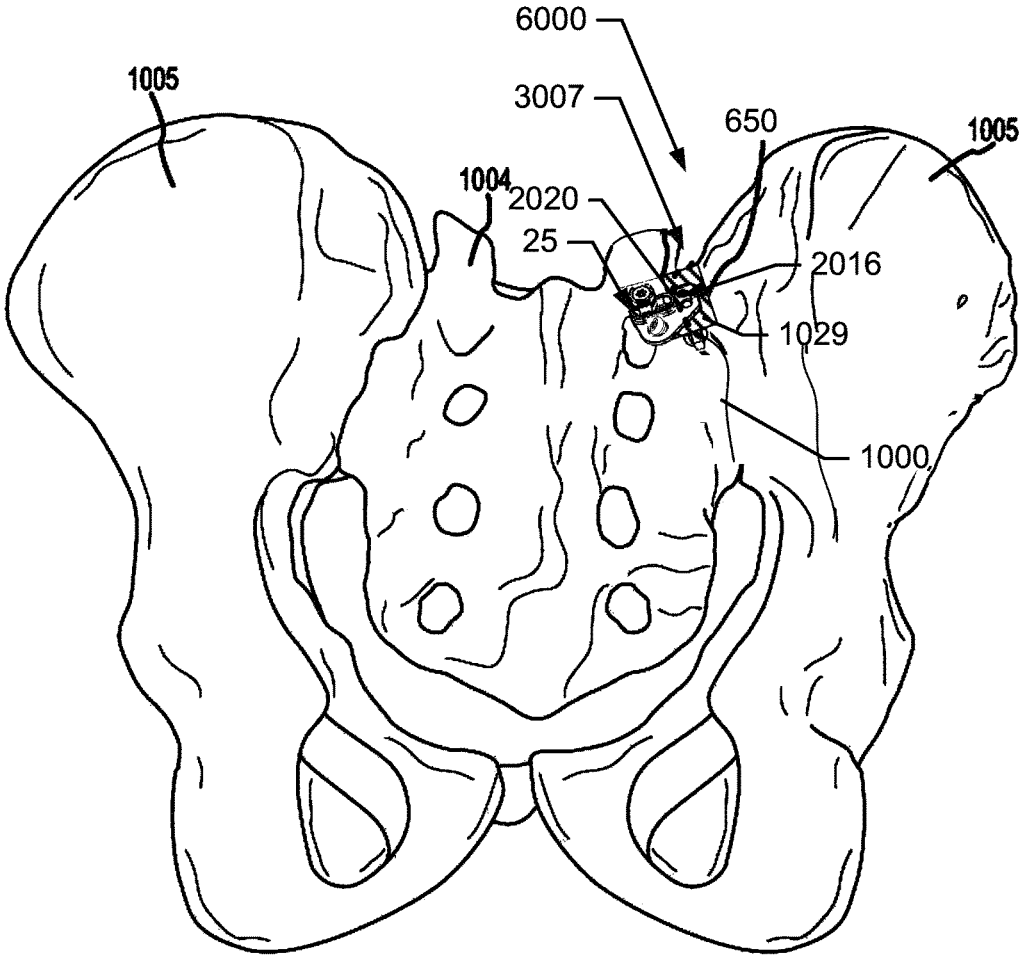


FIG. 61

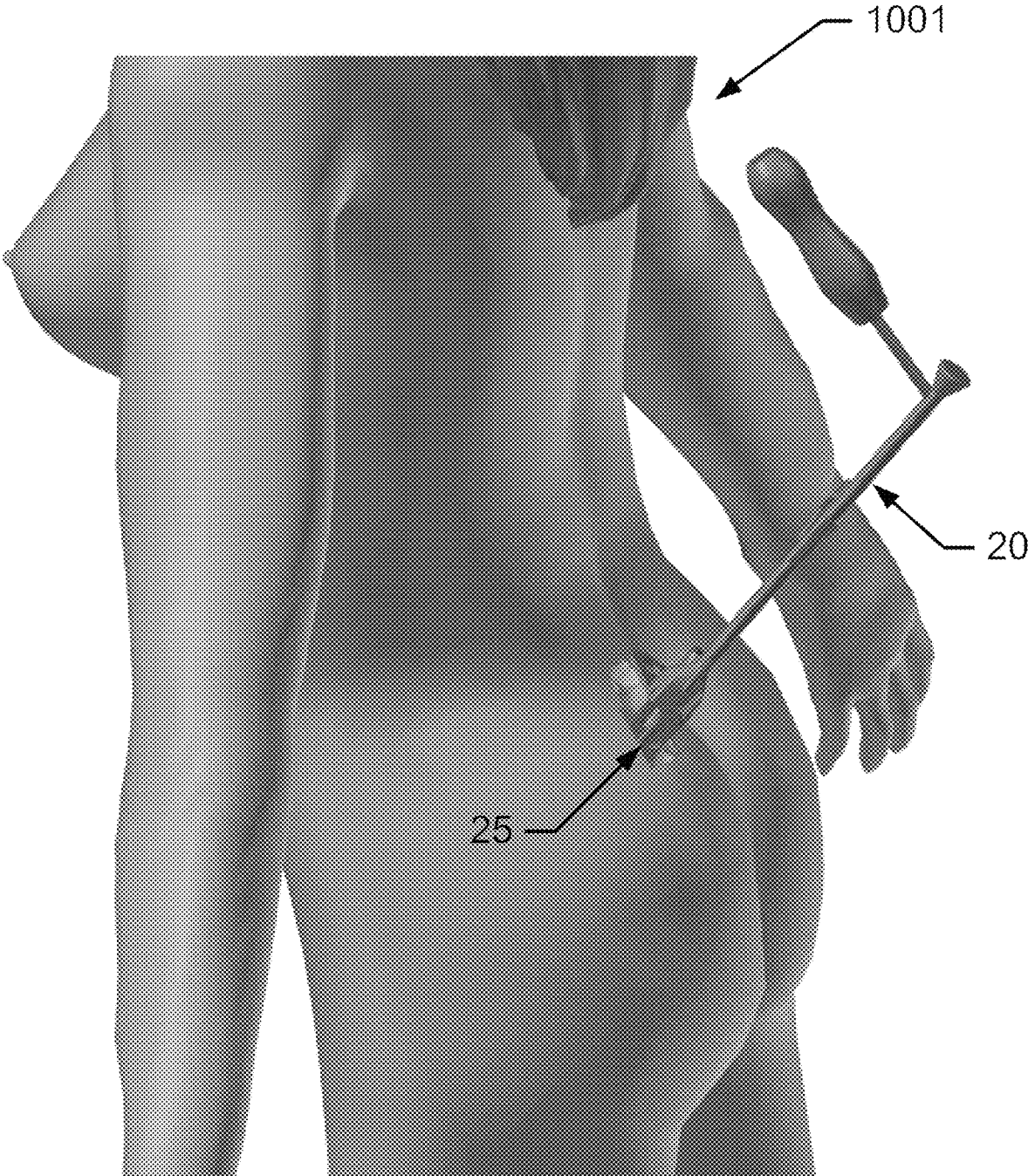


FIG. 62

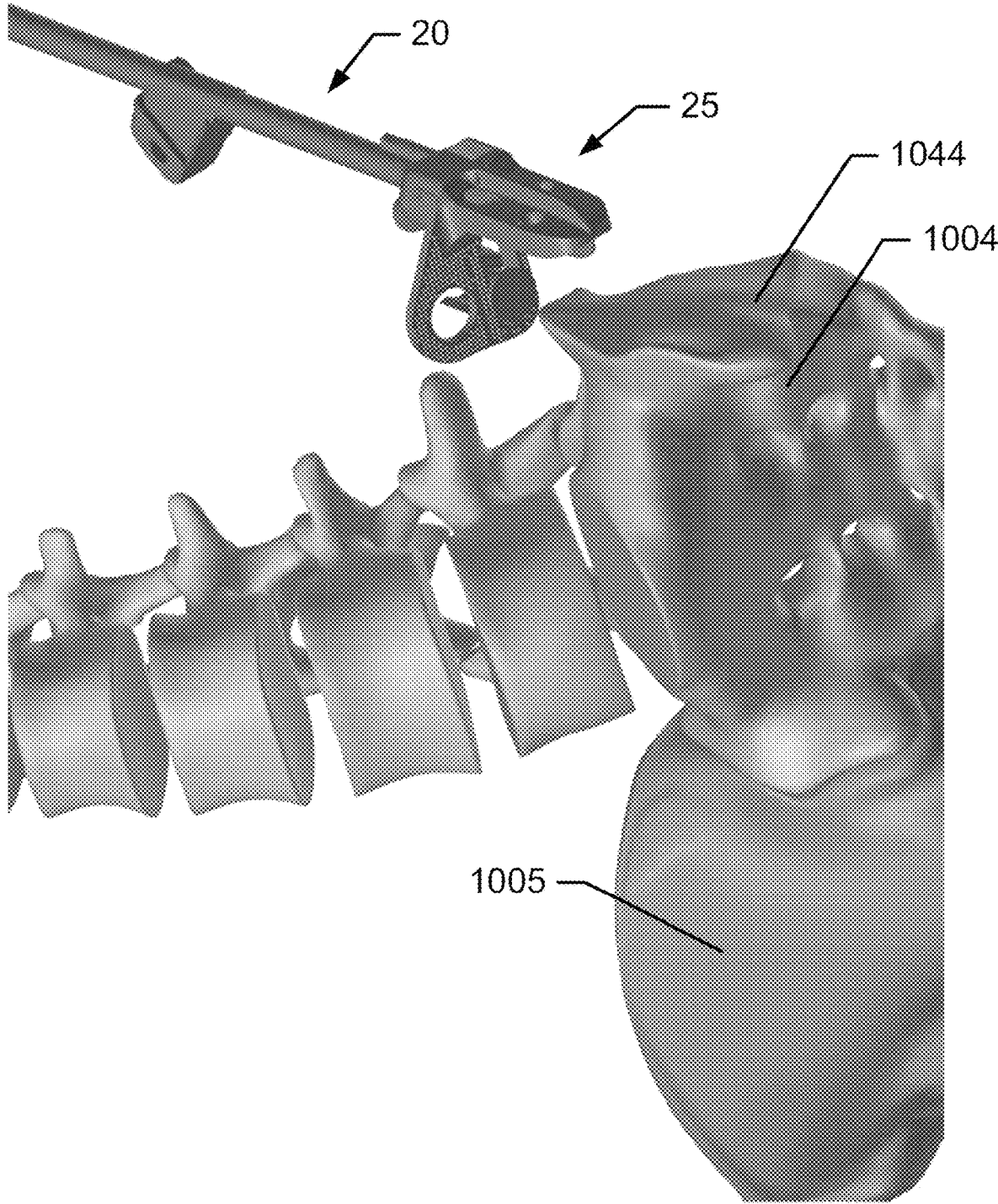


FIG. 63

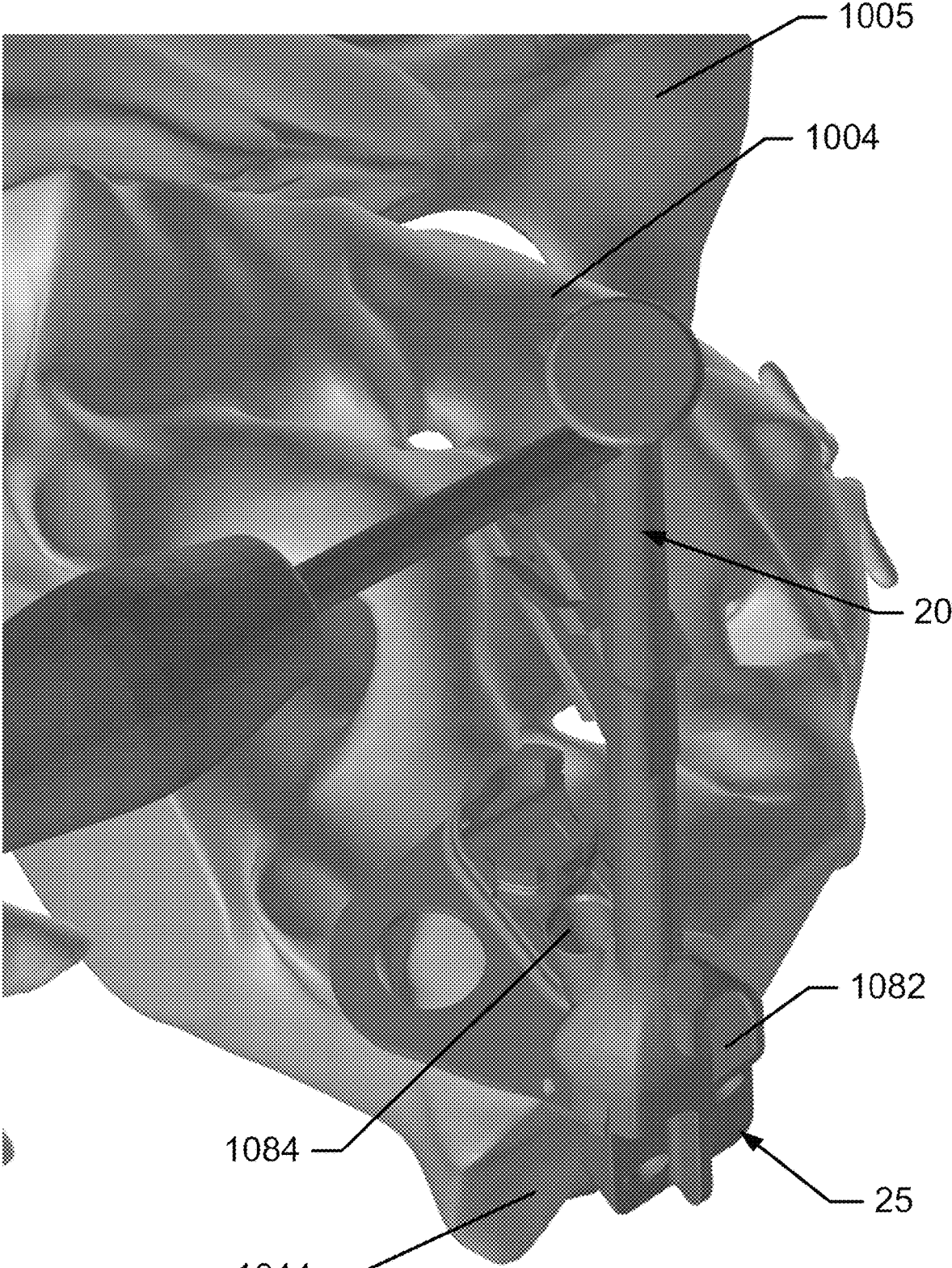
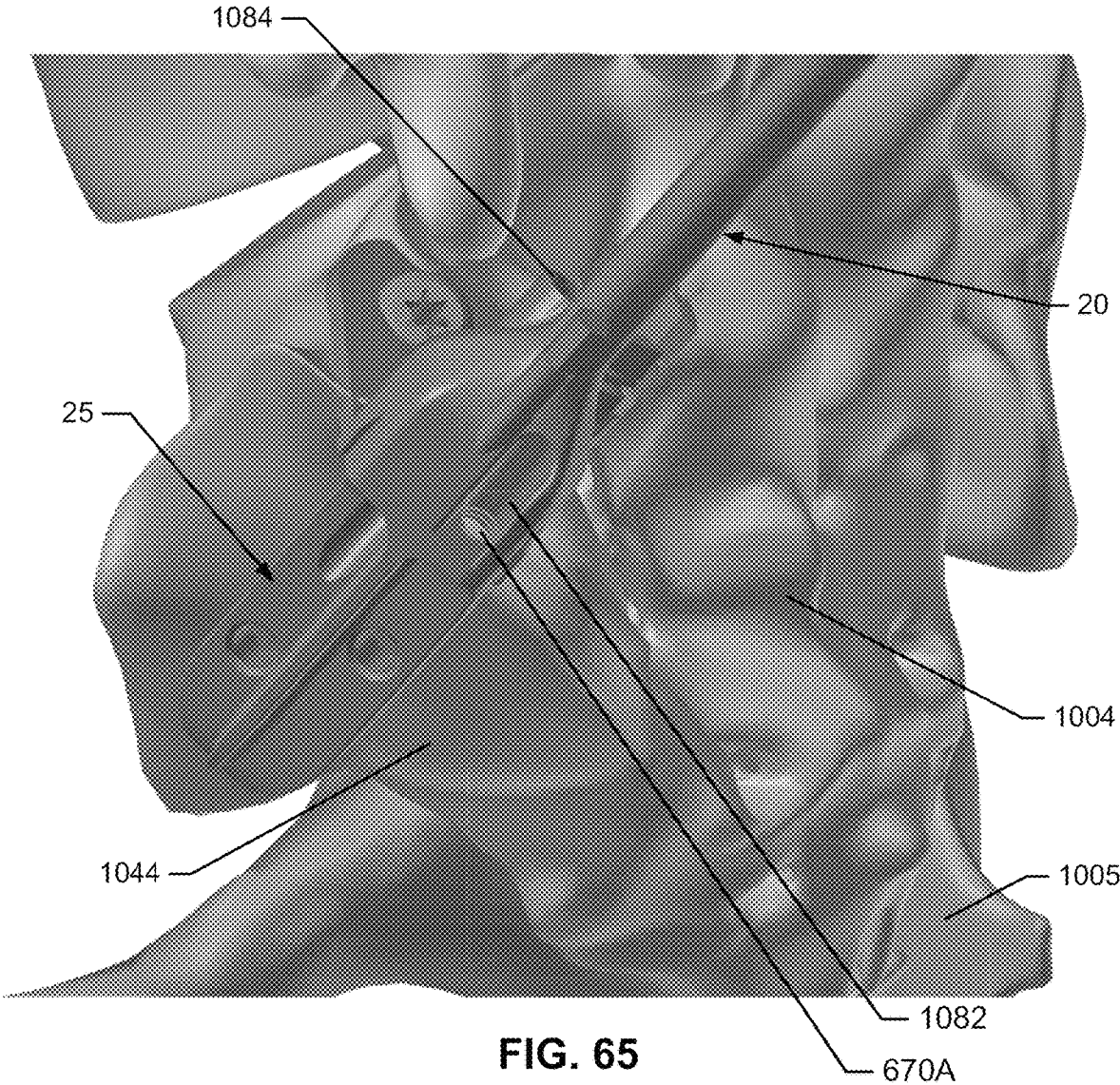


FIG. 64



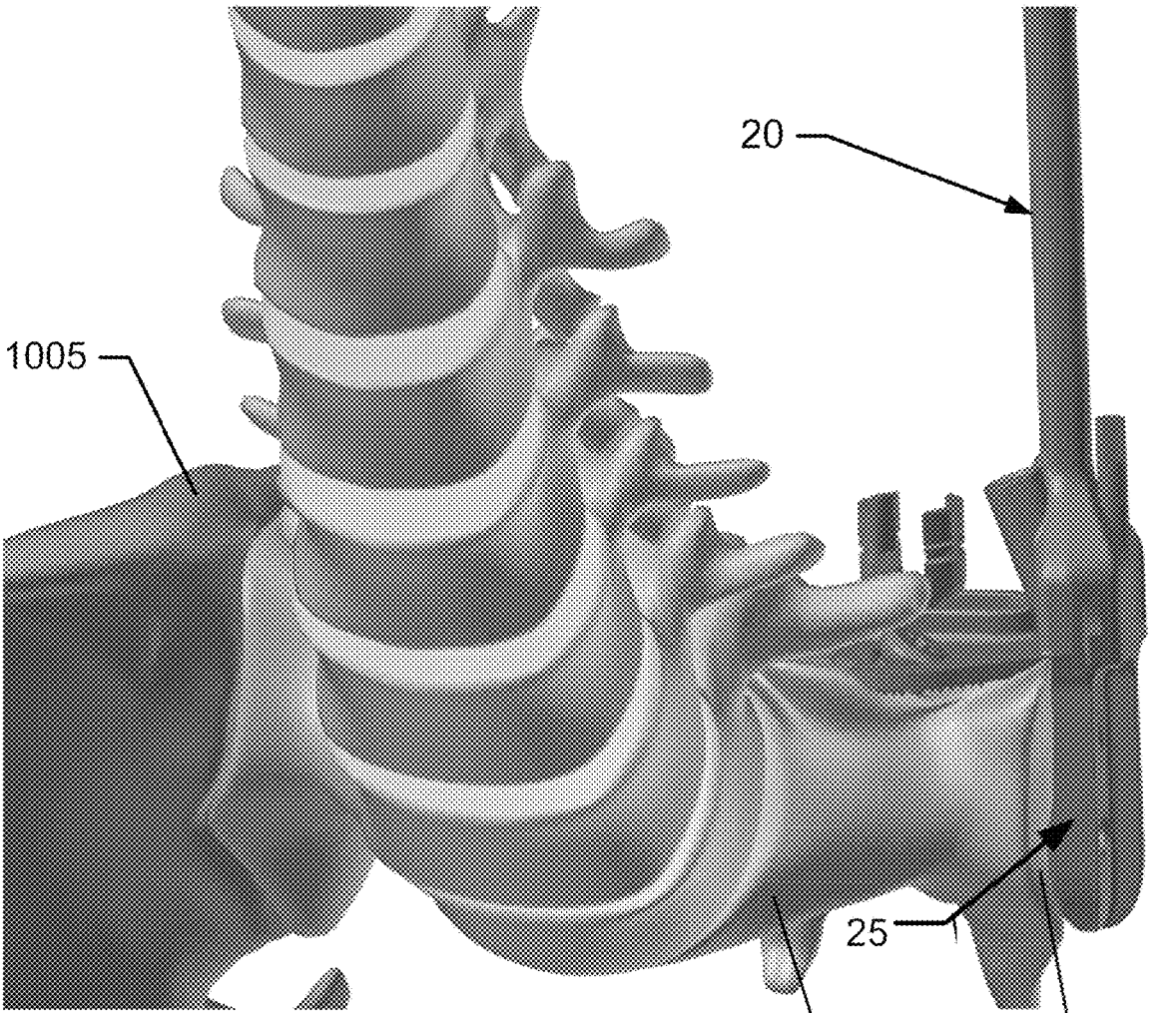


FIG. 66

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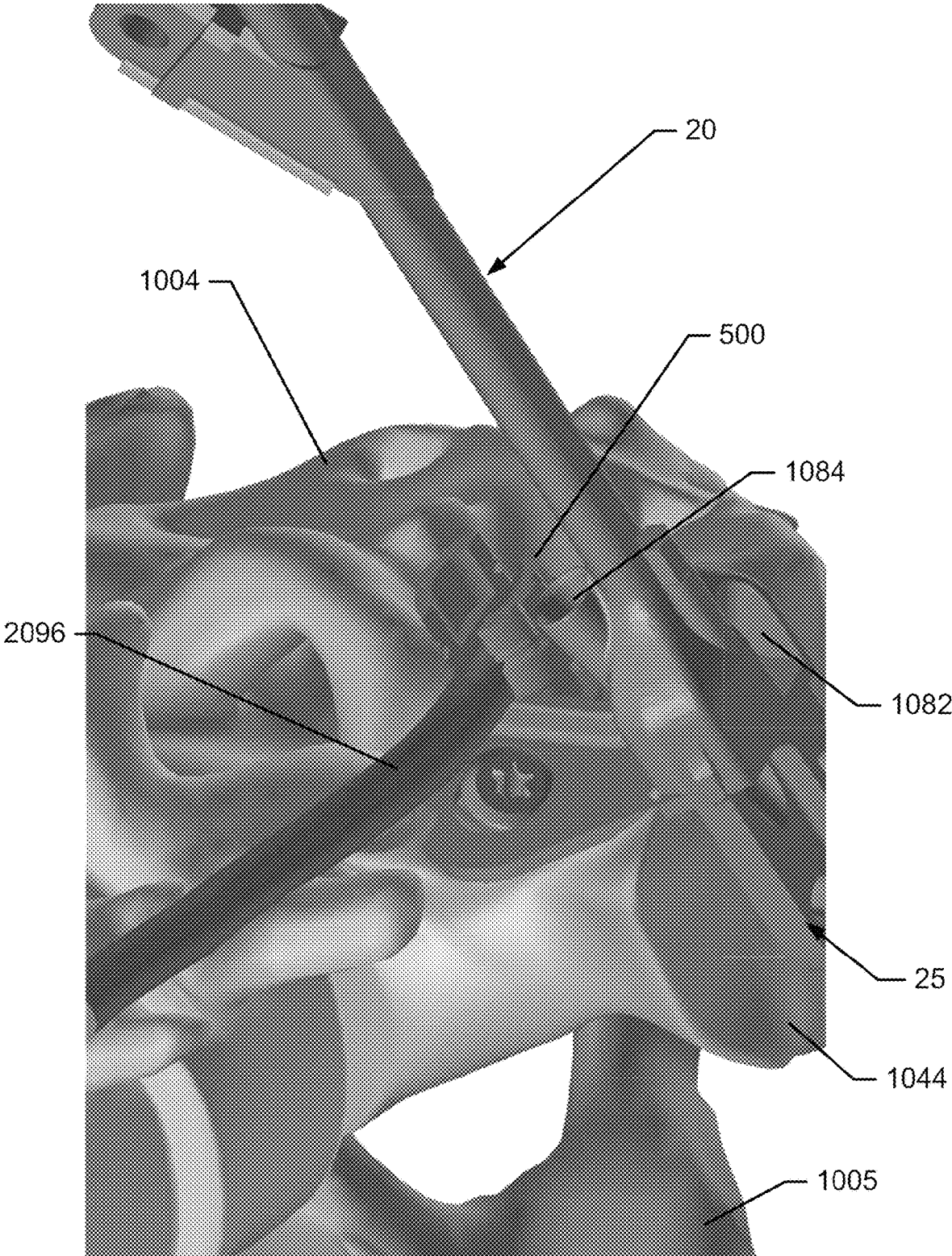


FIG. 67

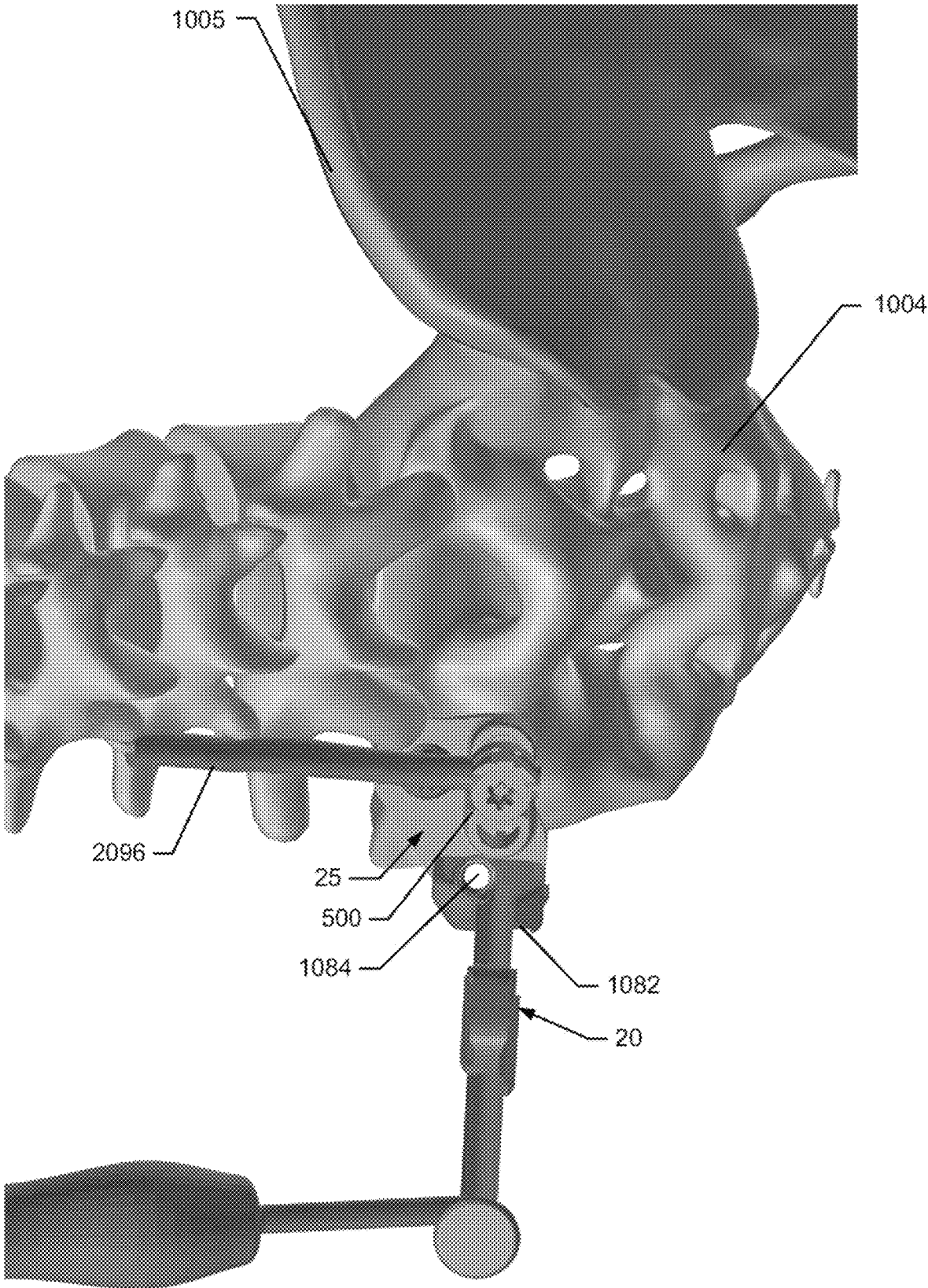


FIG. 68

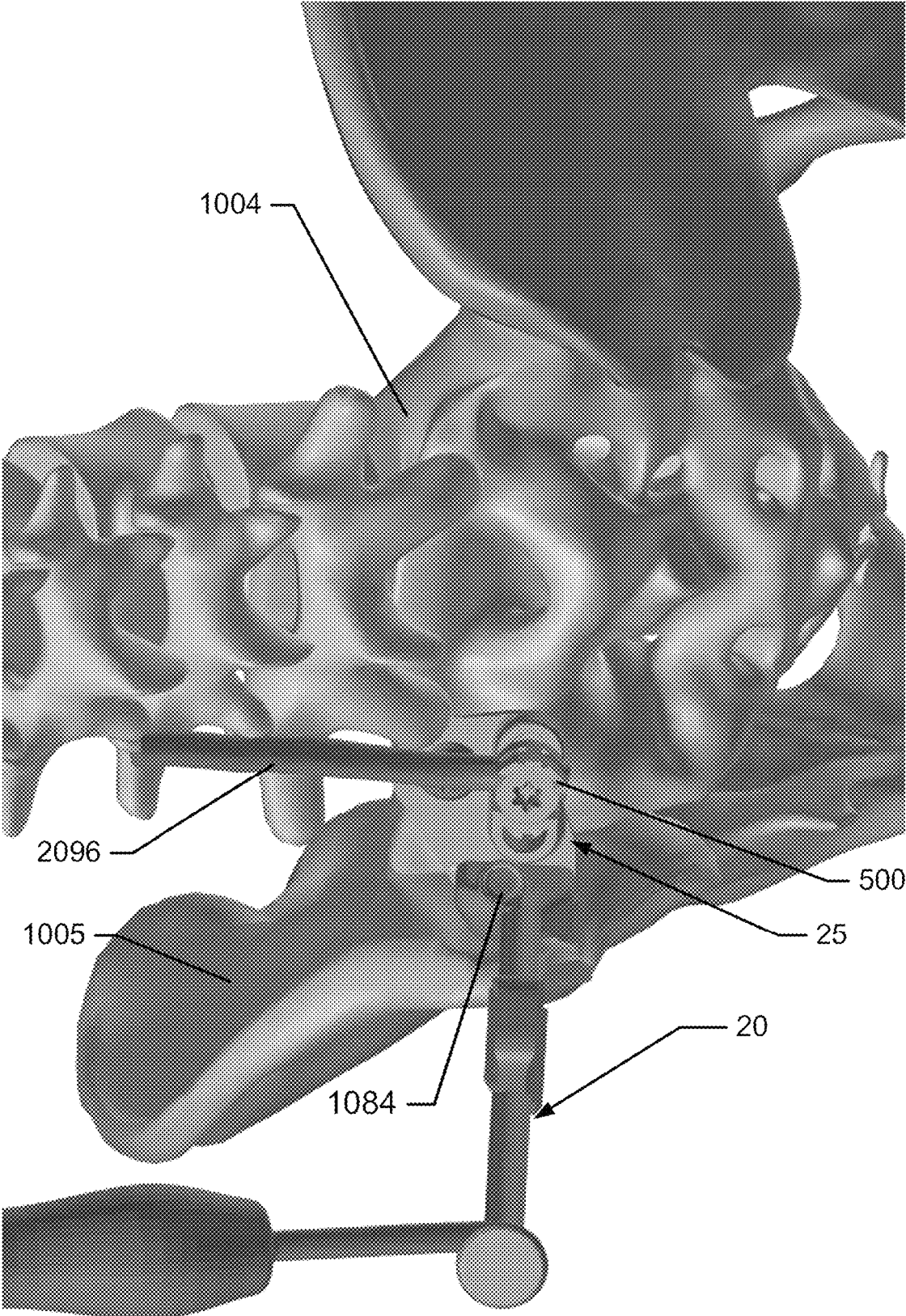


FIG. 69

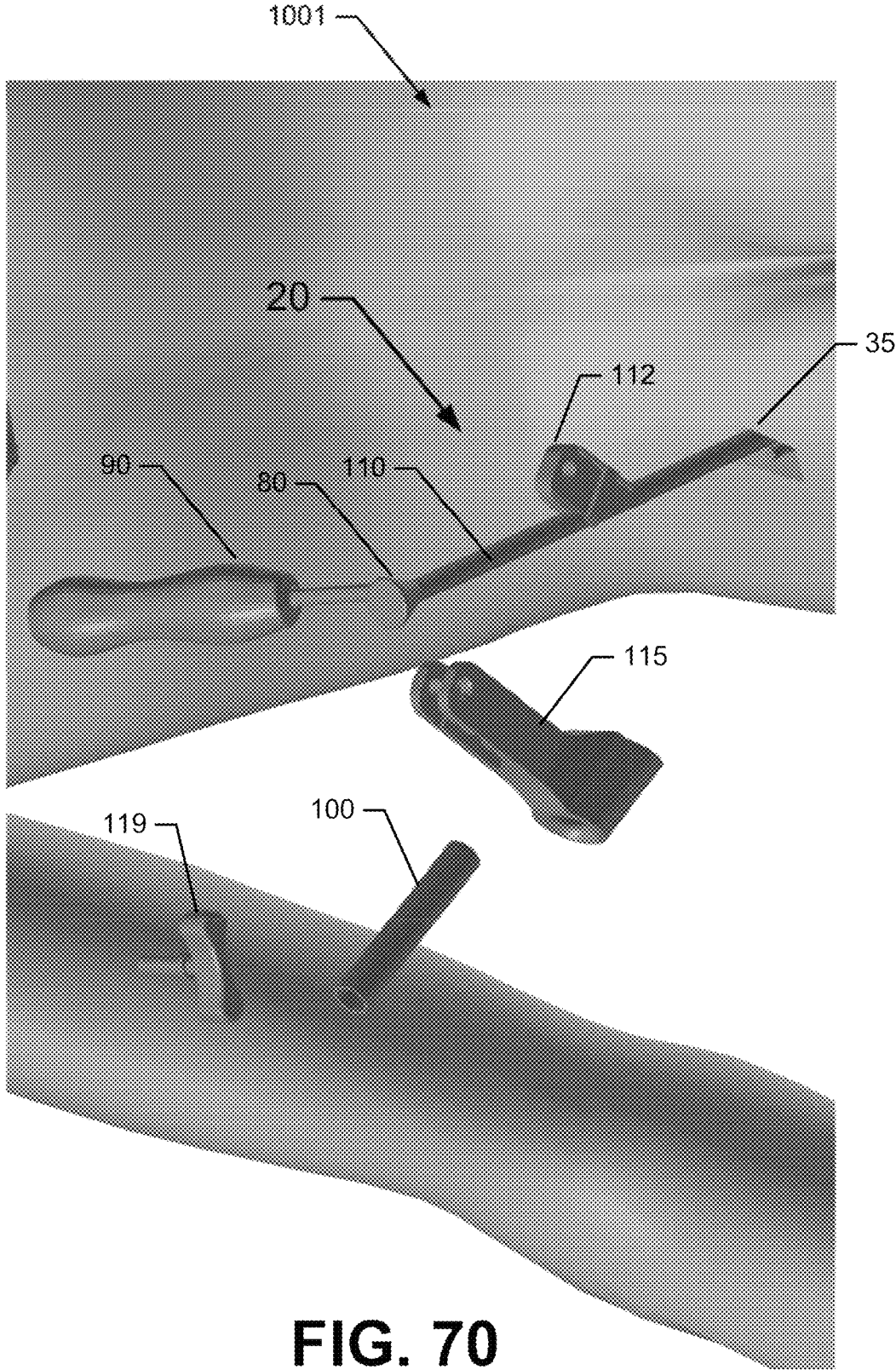


FIG. 70

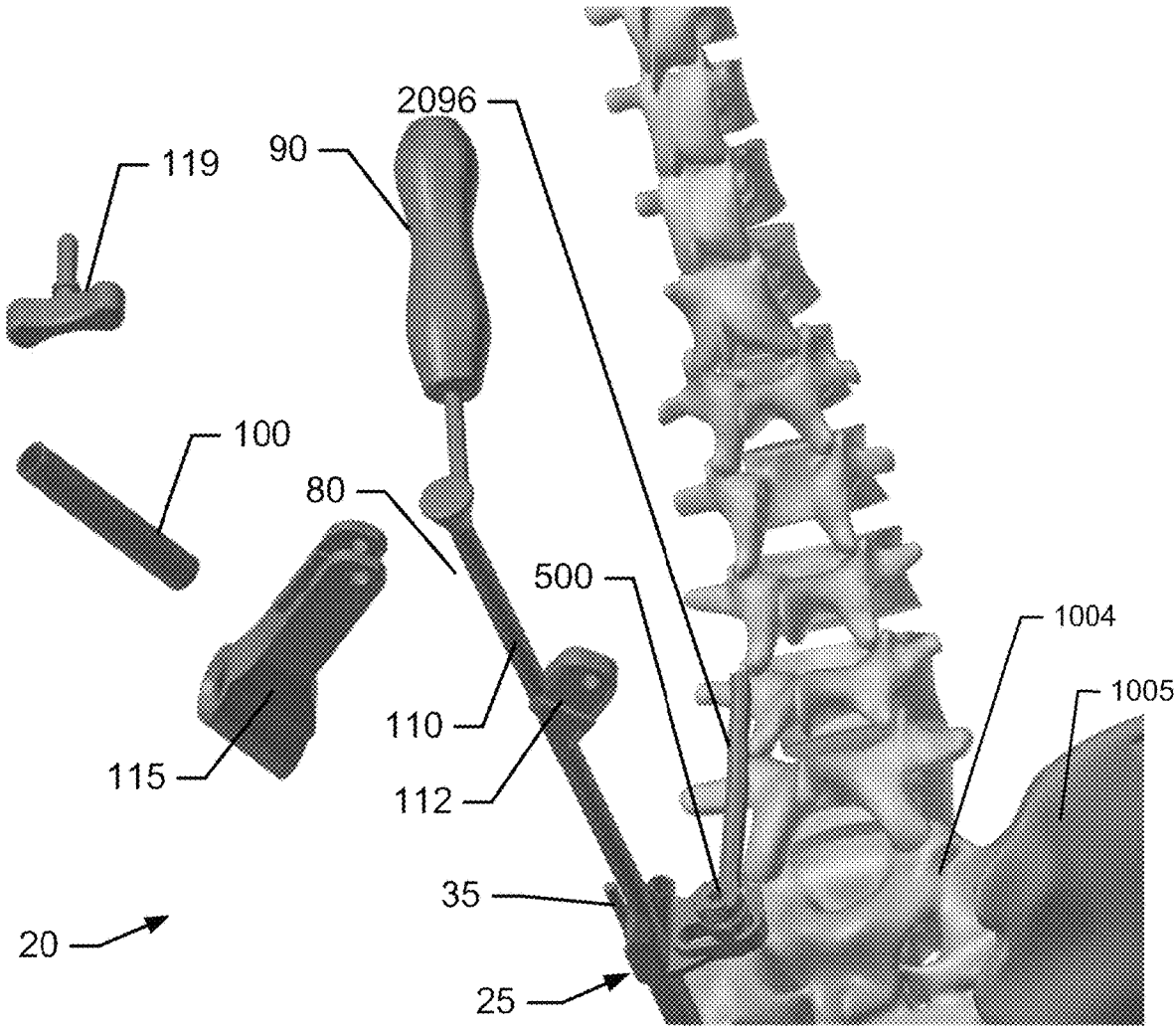


FIG. 71

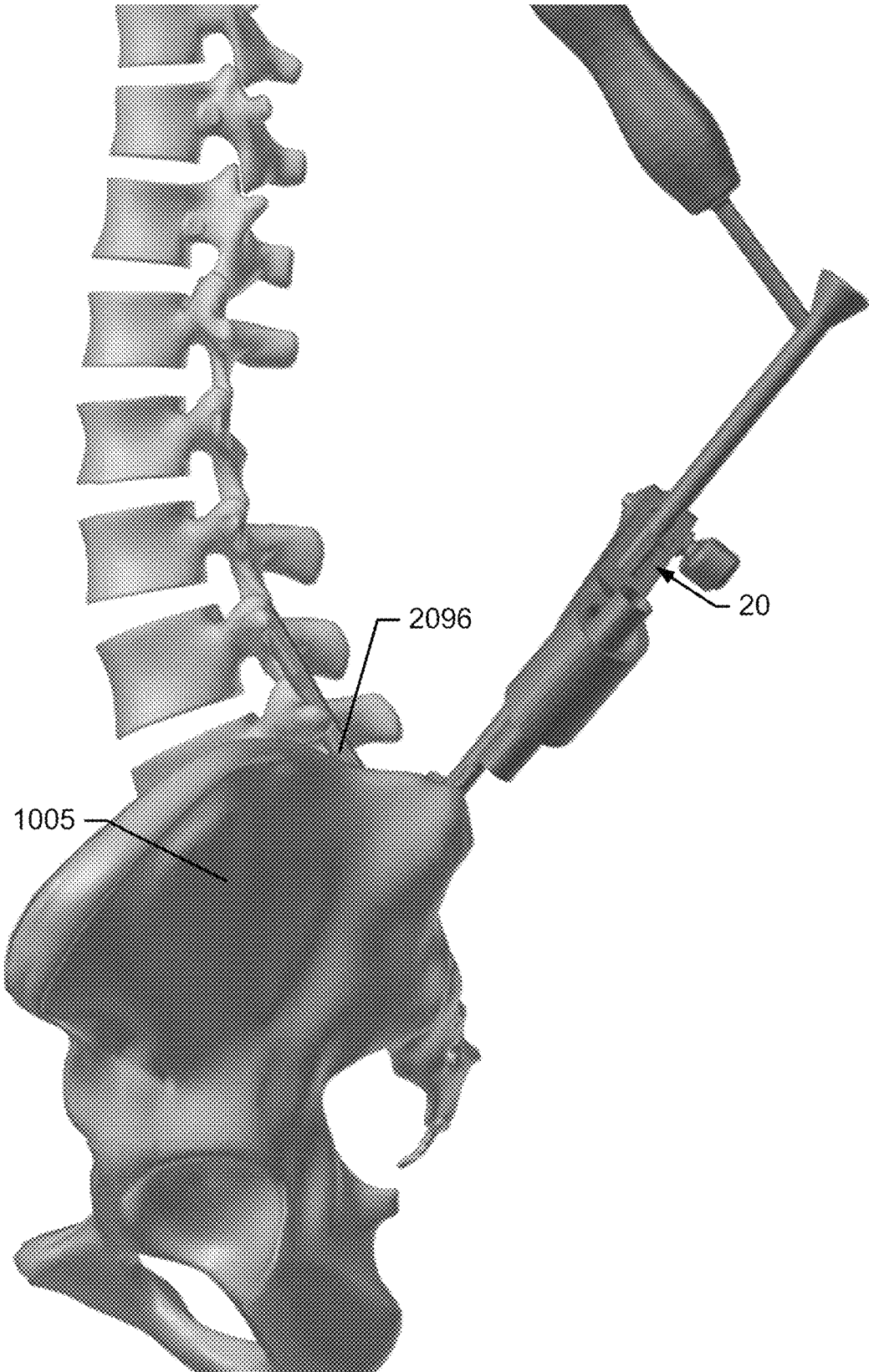


FIG. 72

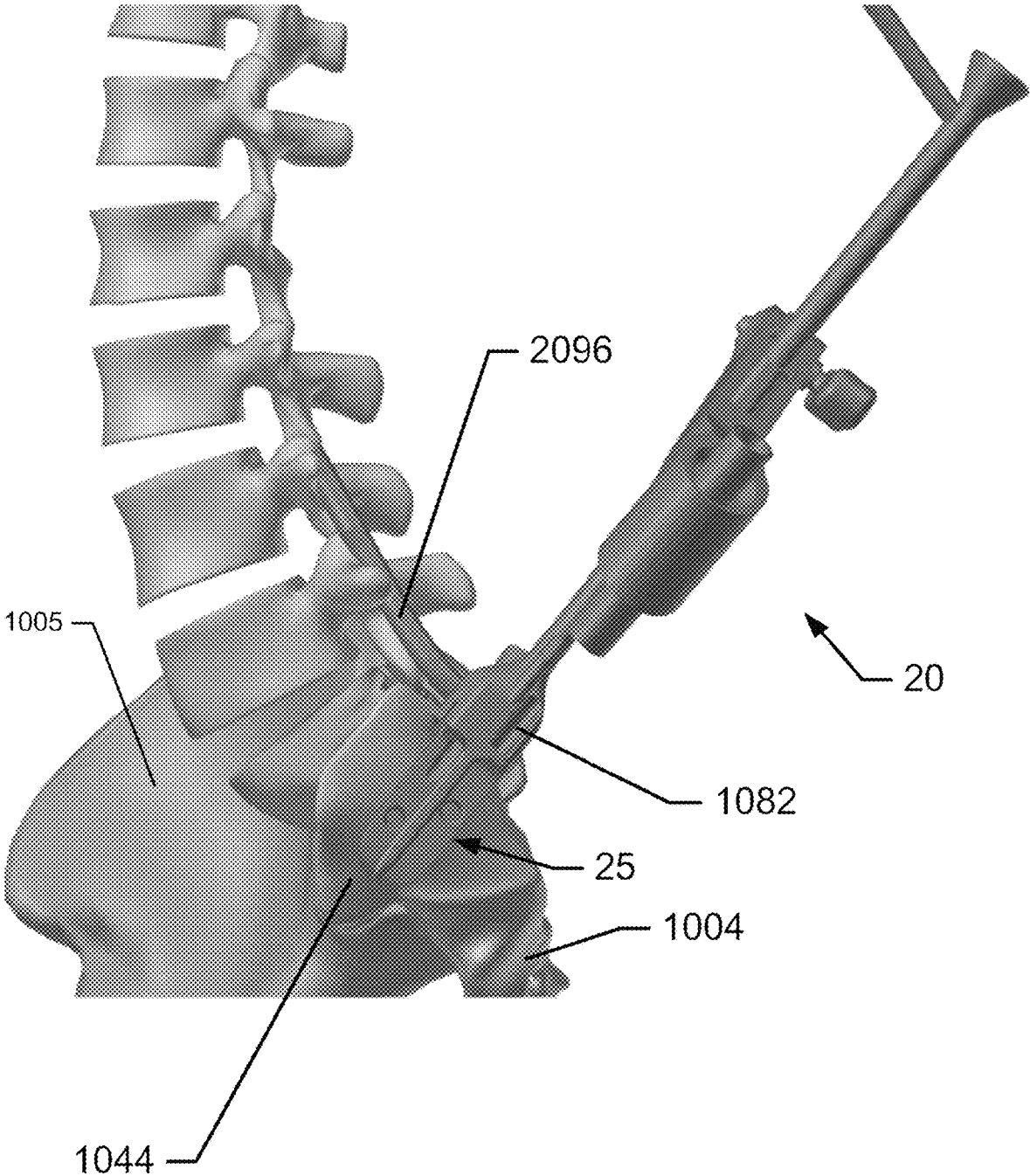


FIG. 73

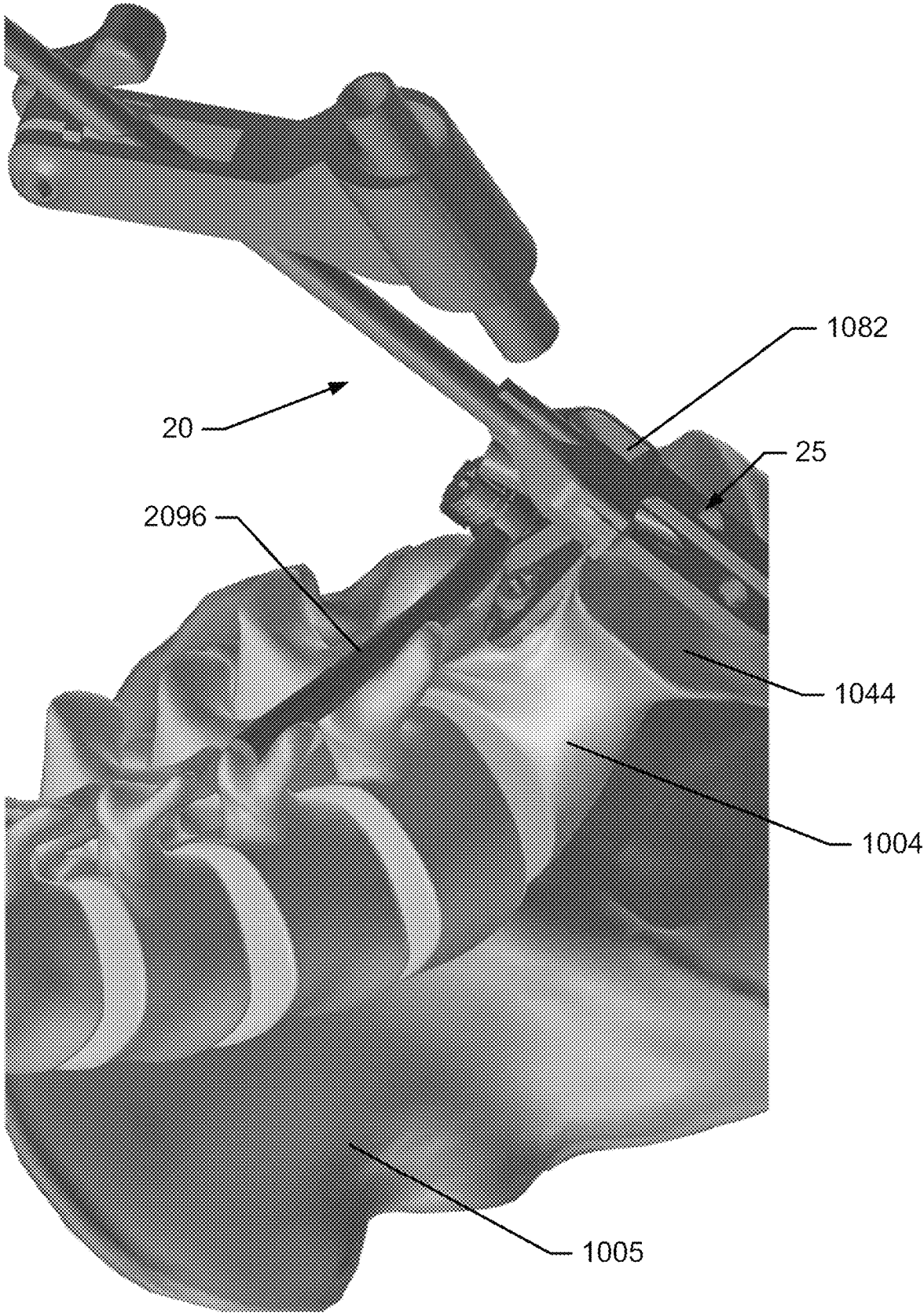


FIG. 74

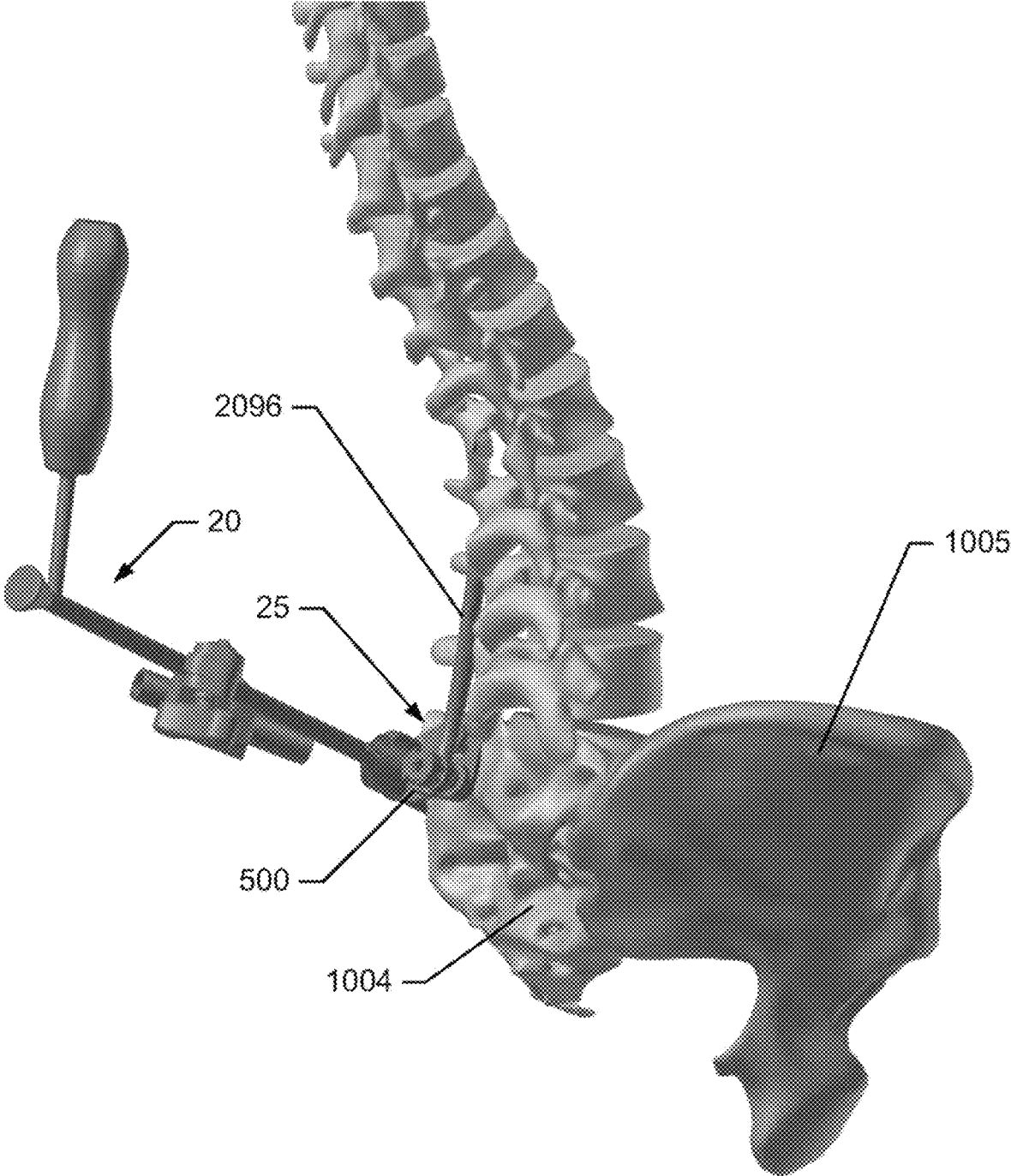


FIG. 75

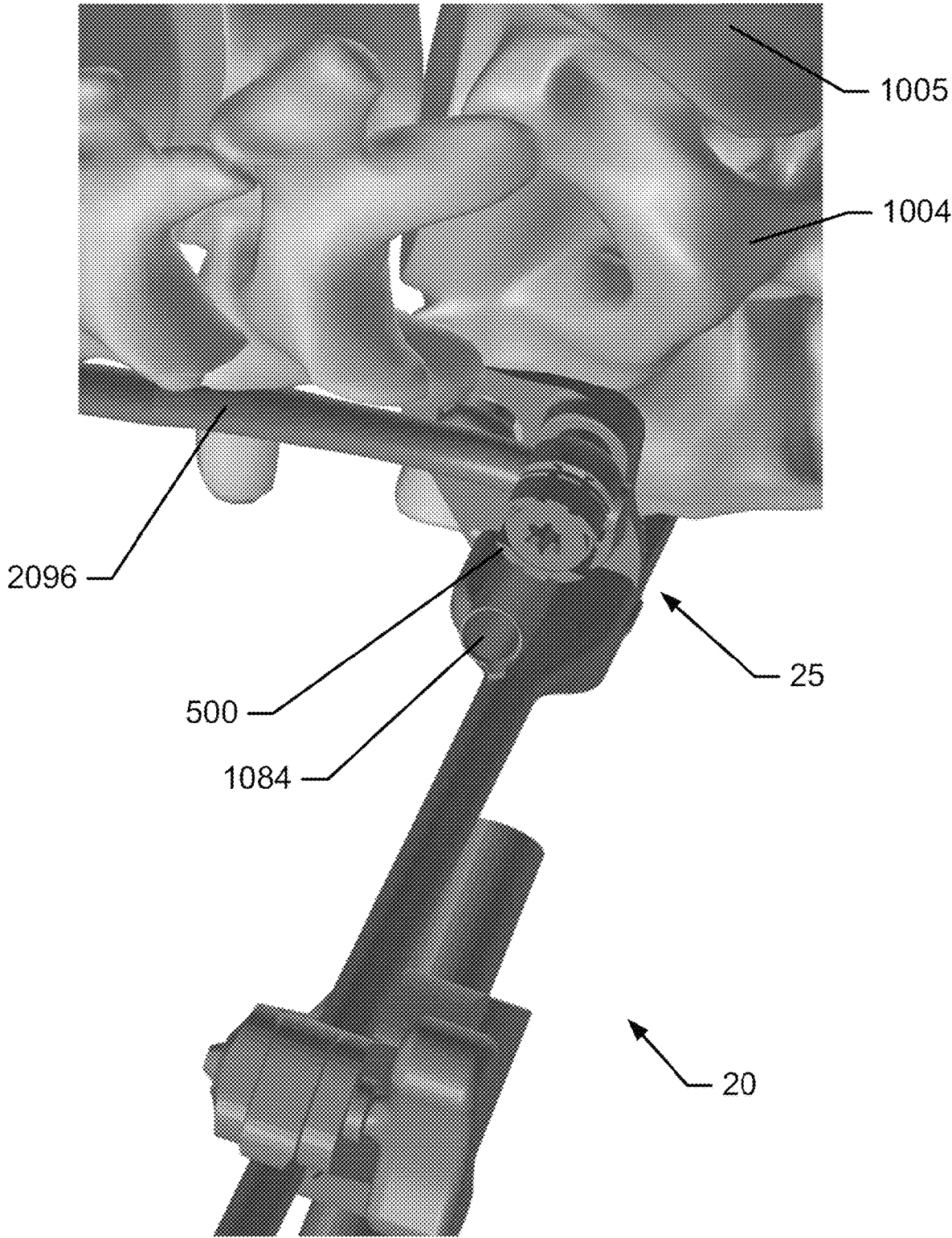


FIG. 76

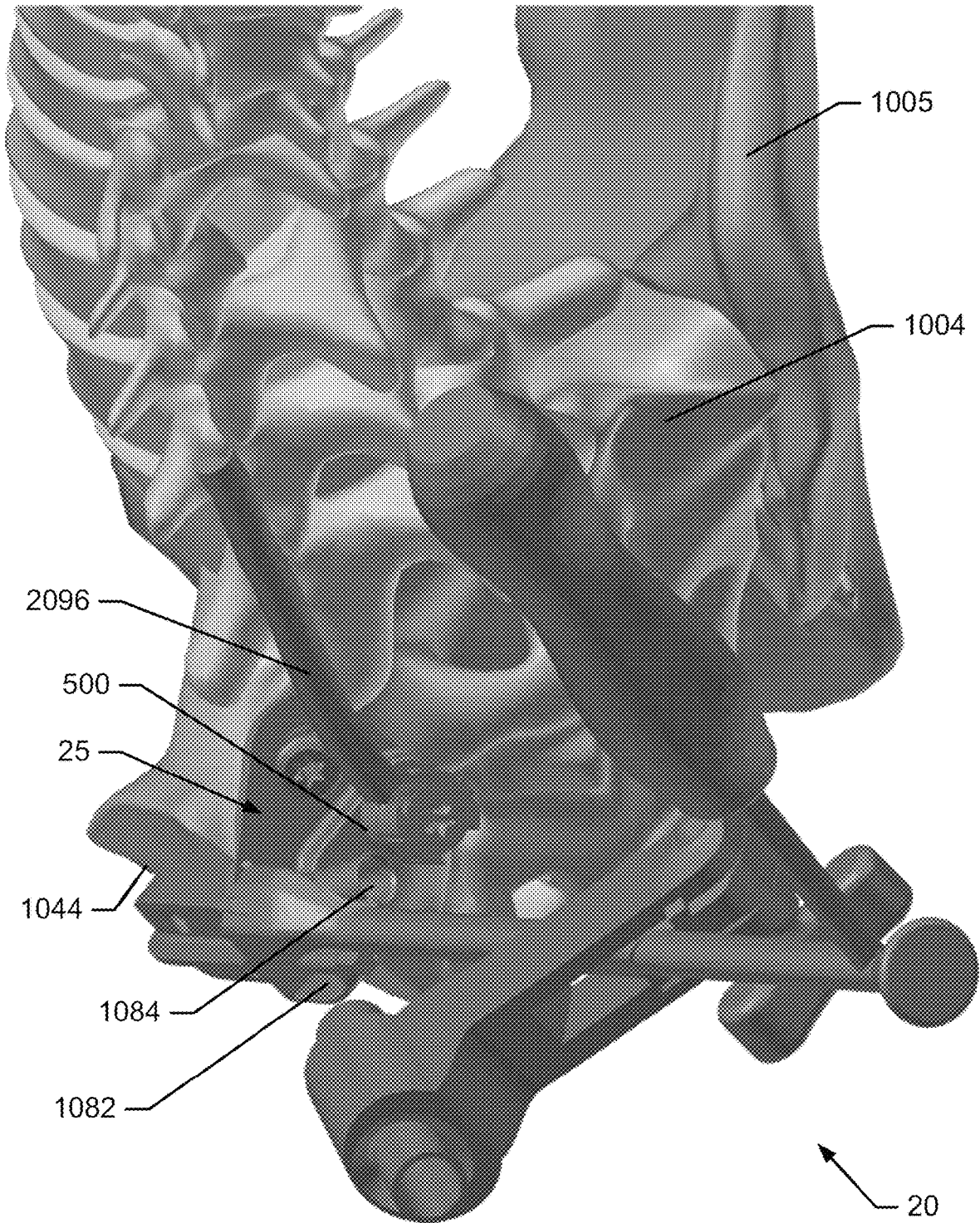


FIG. 77

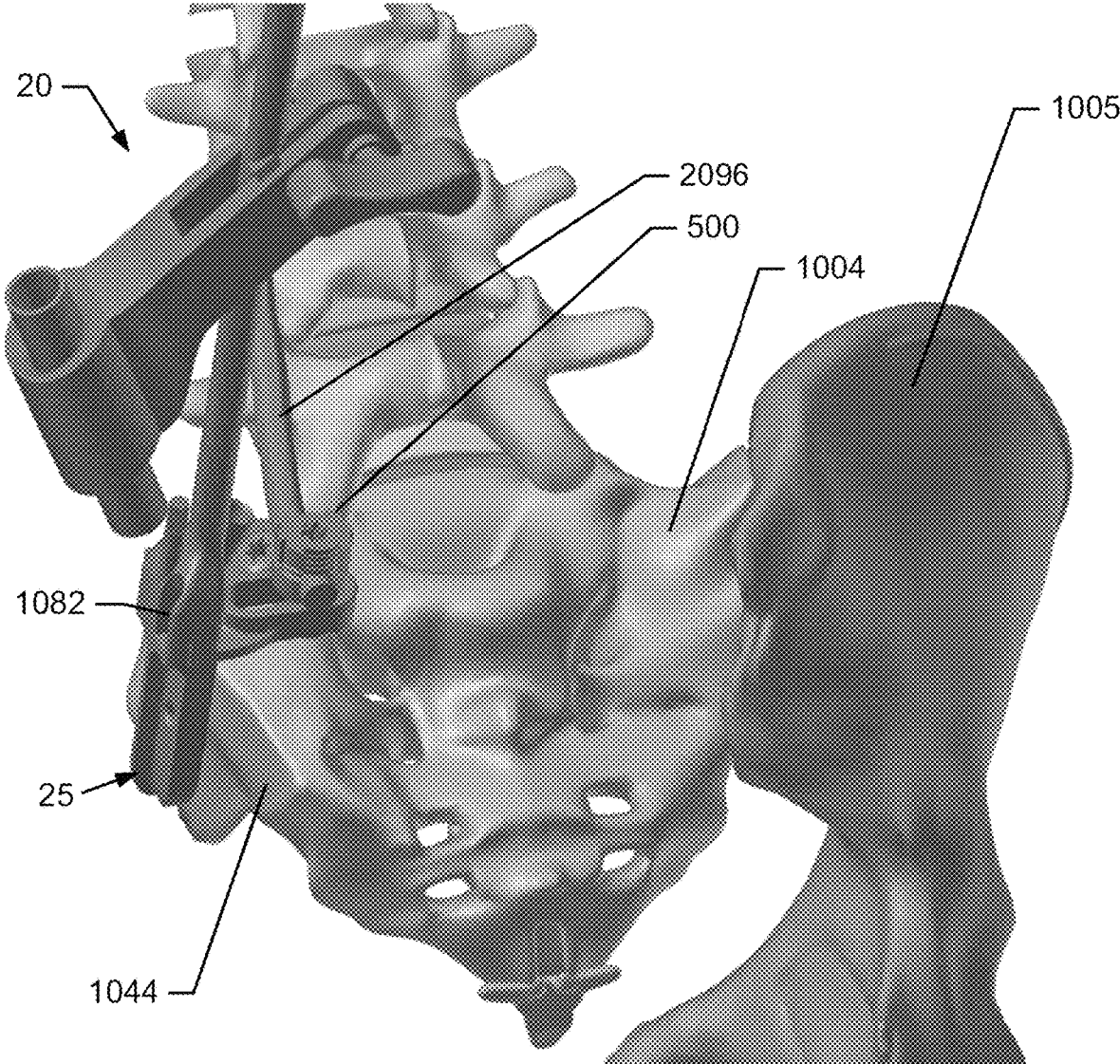


FIG. 78

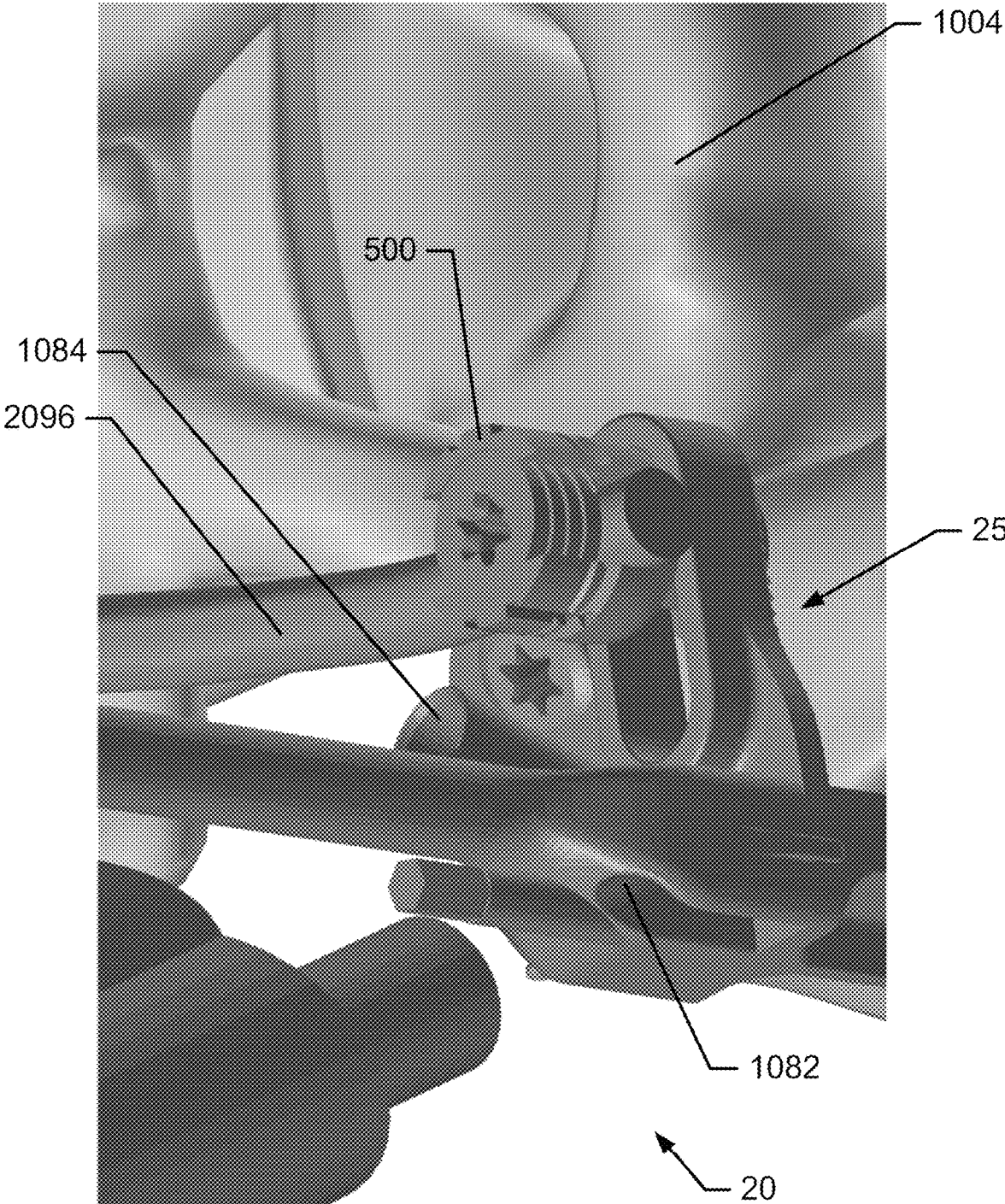


FIG. 79

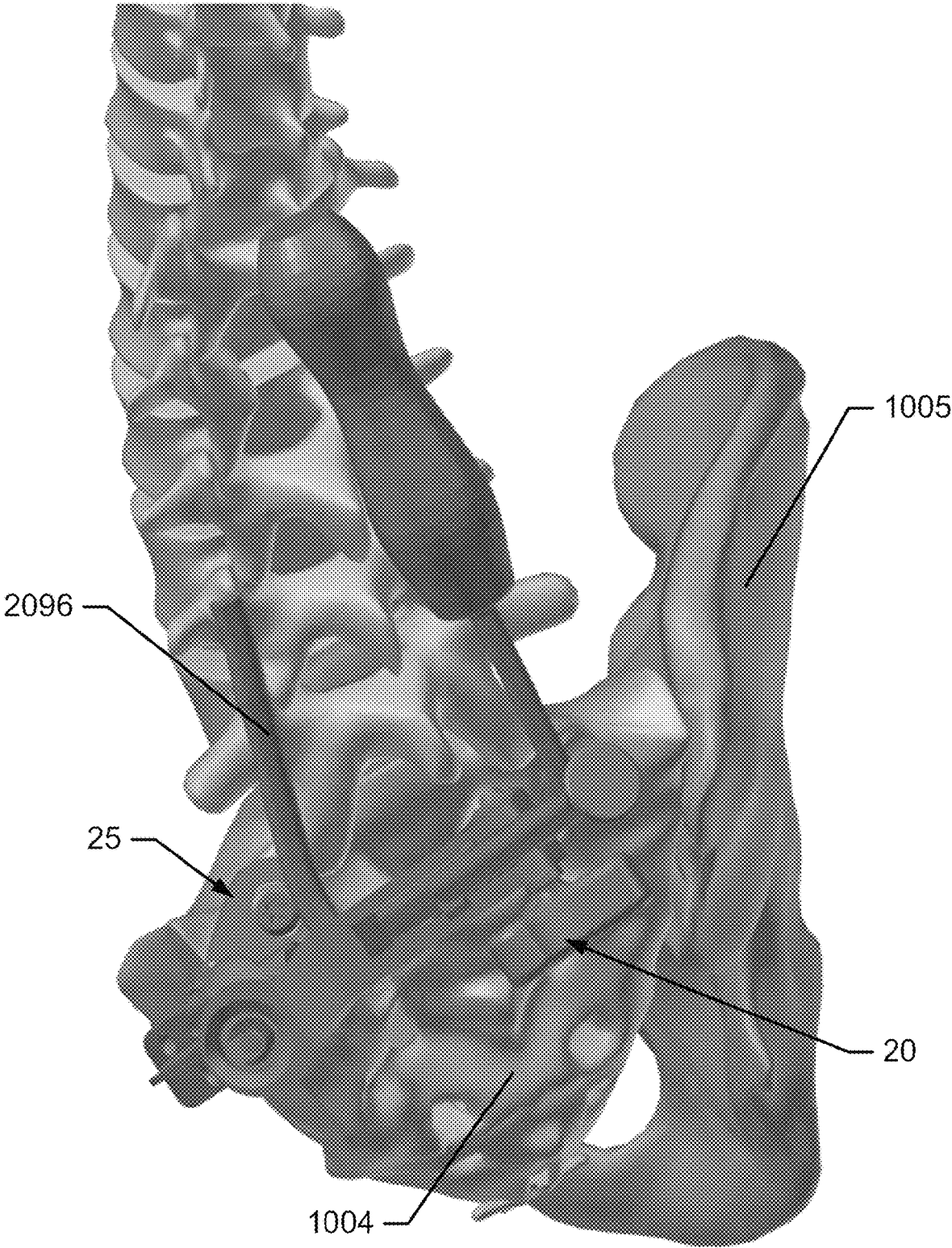


FIG. 80

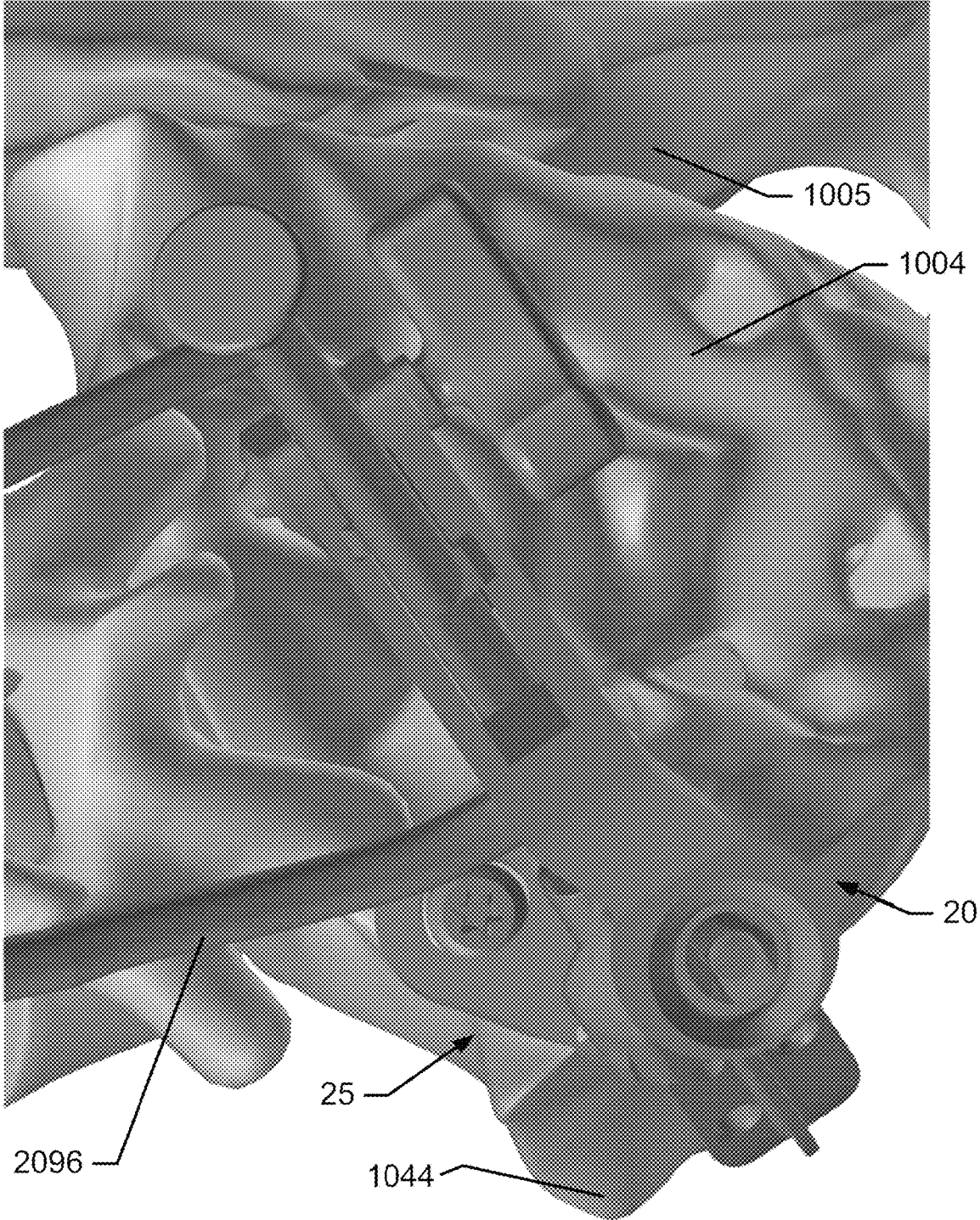


FIG. 81

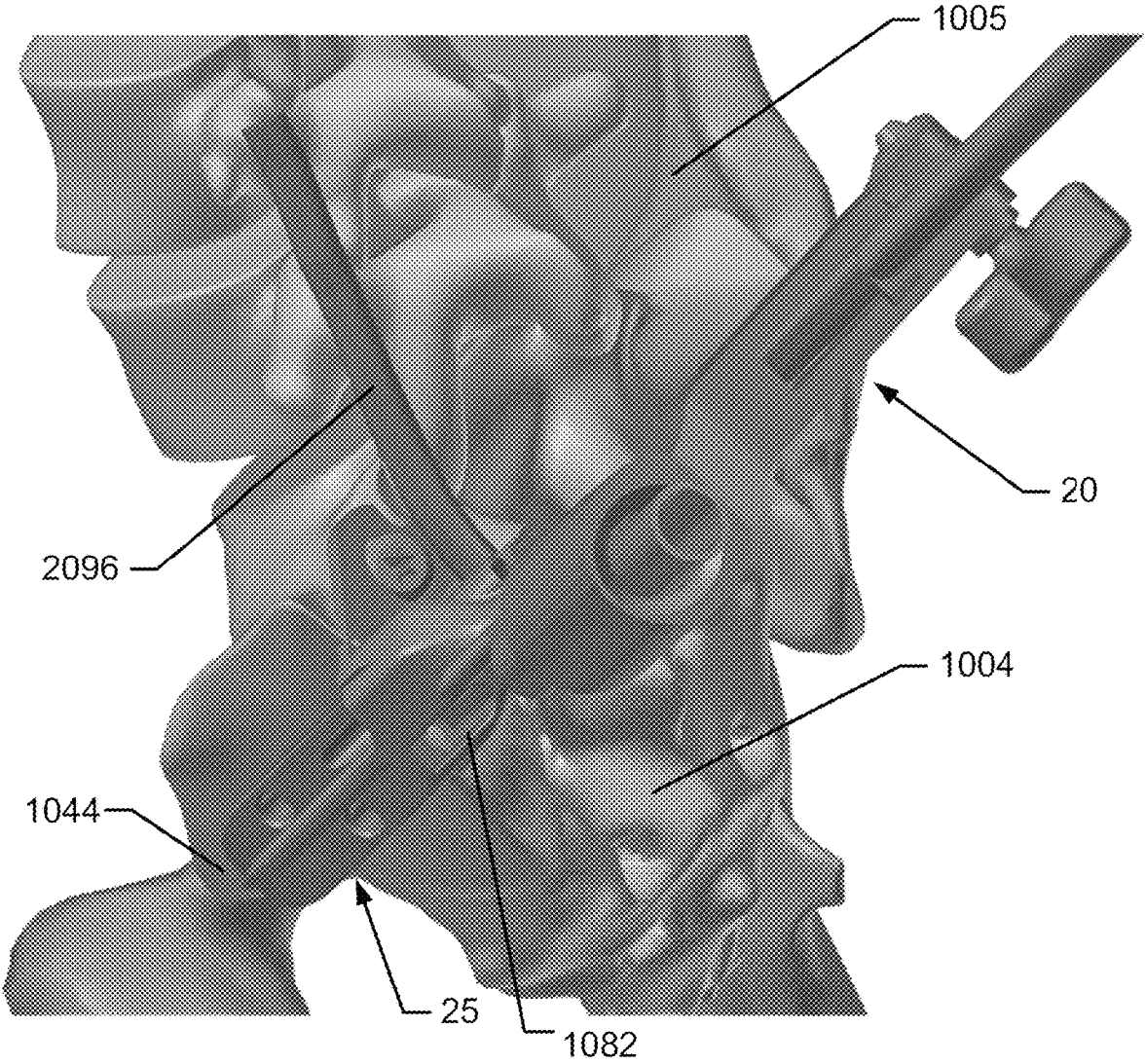


FIG. 82

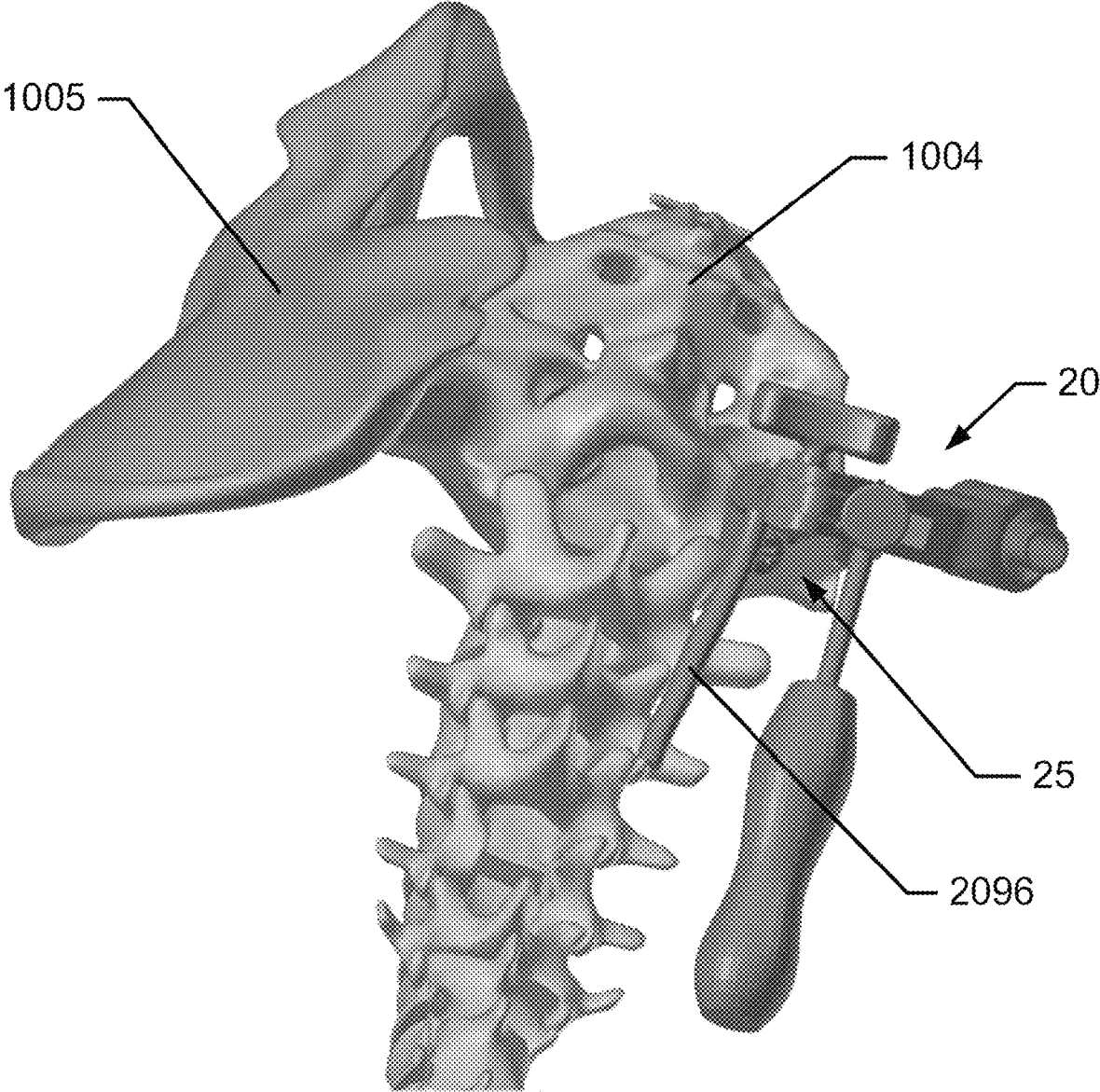


FIG. 83

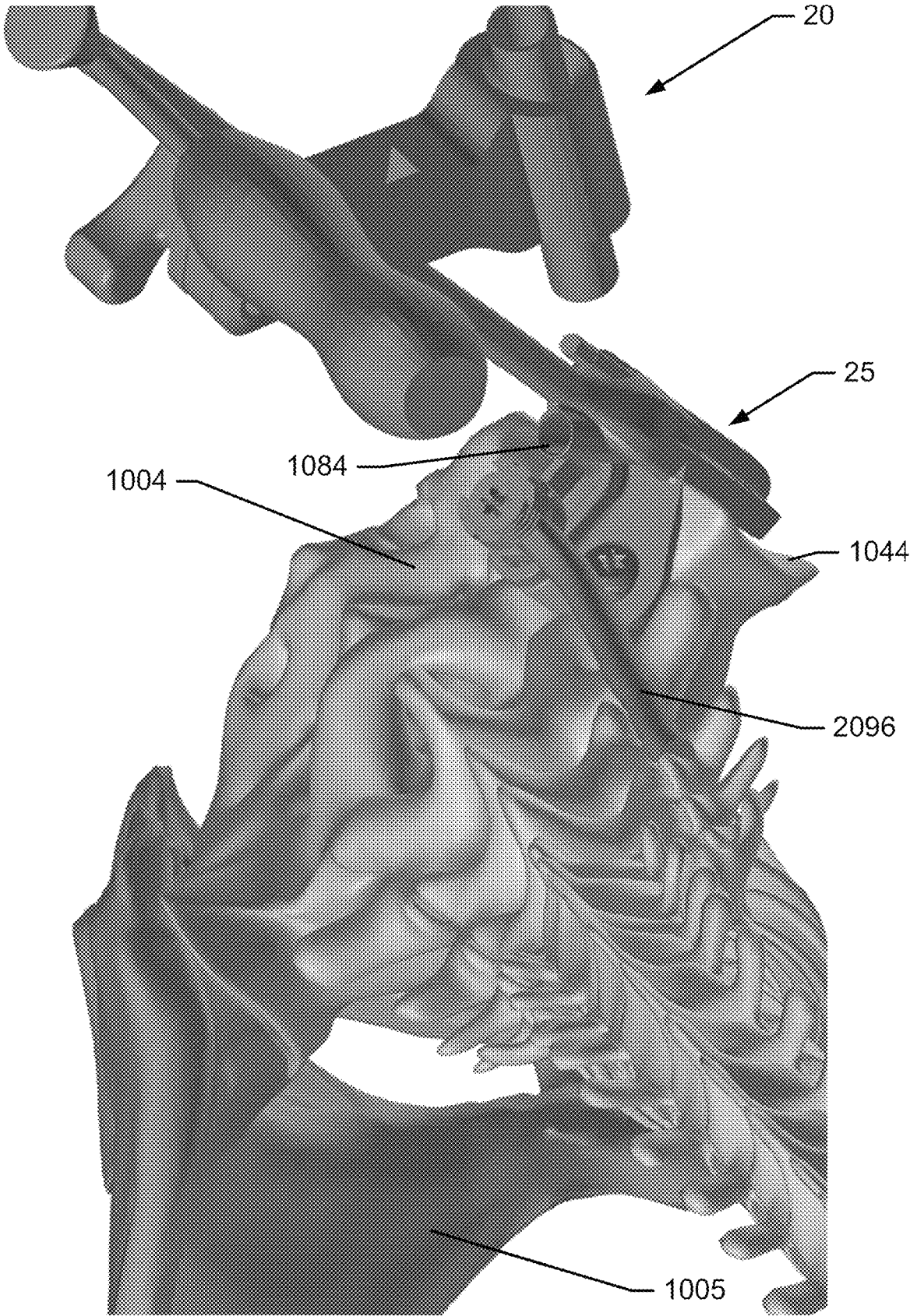


FIG. 84

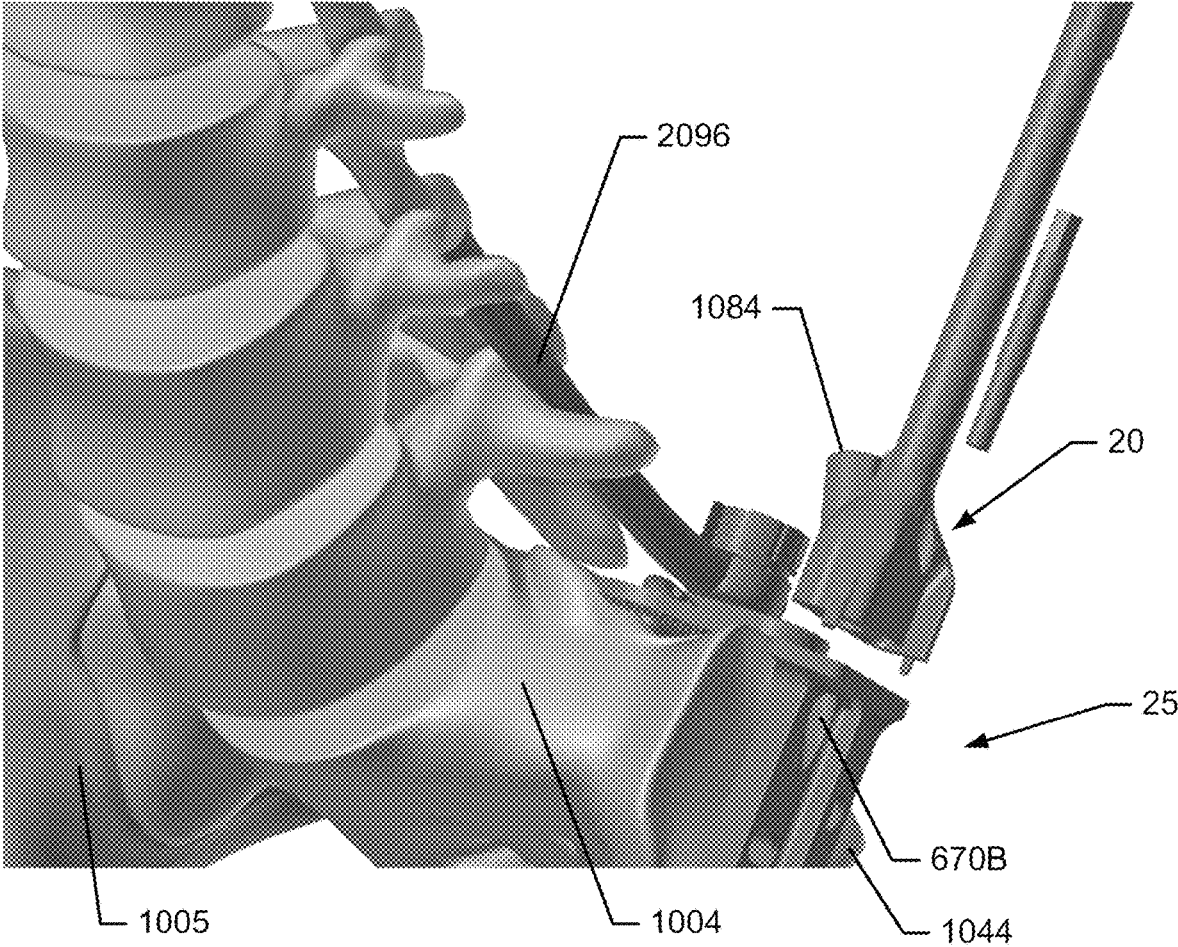


FIG. 85

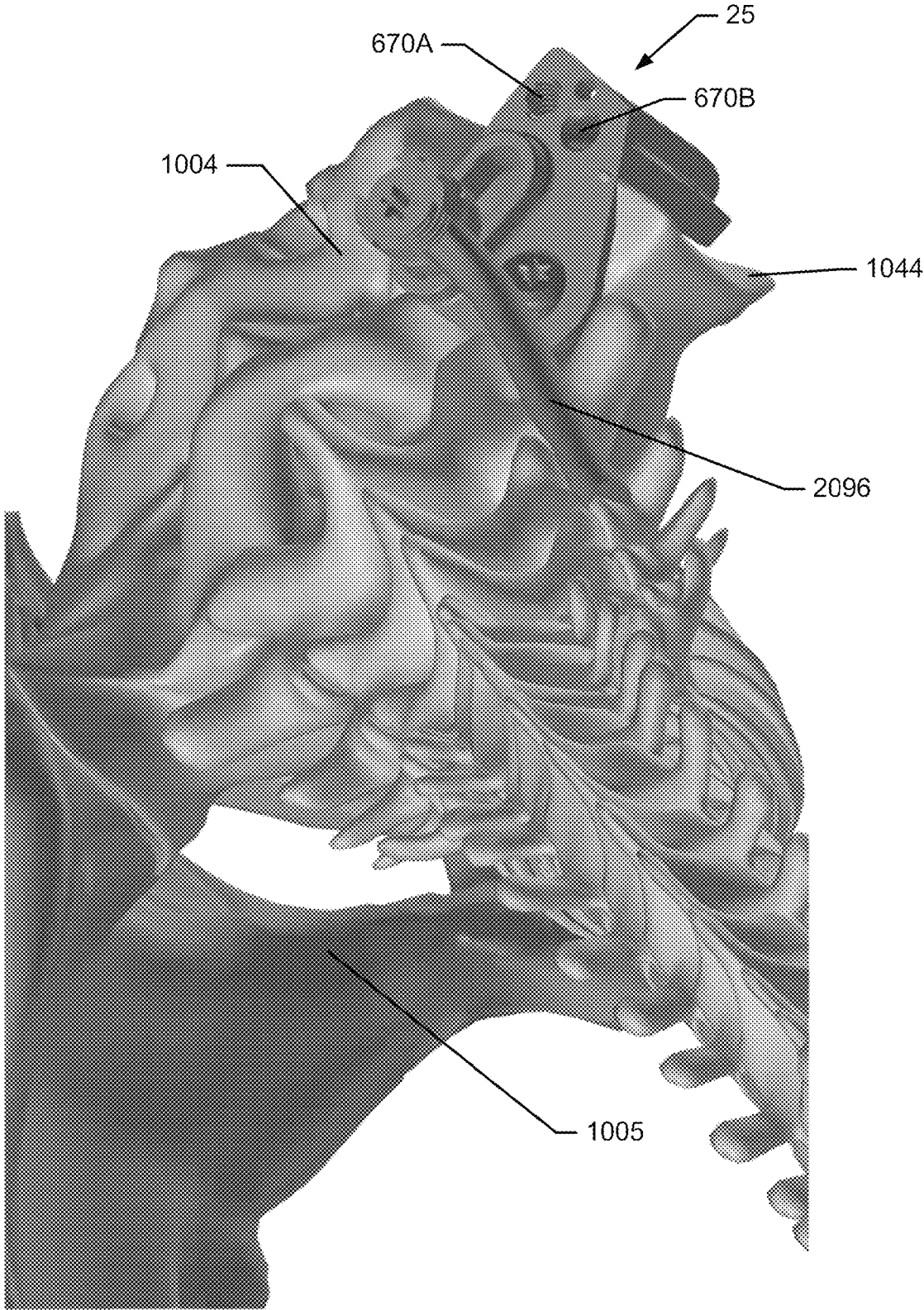


FIG. 86

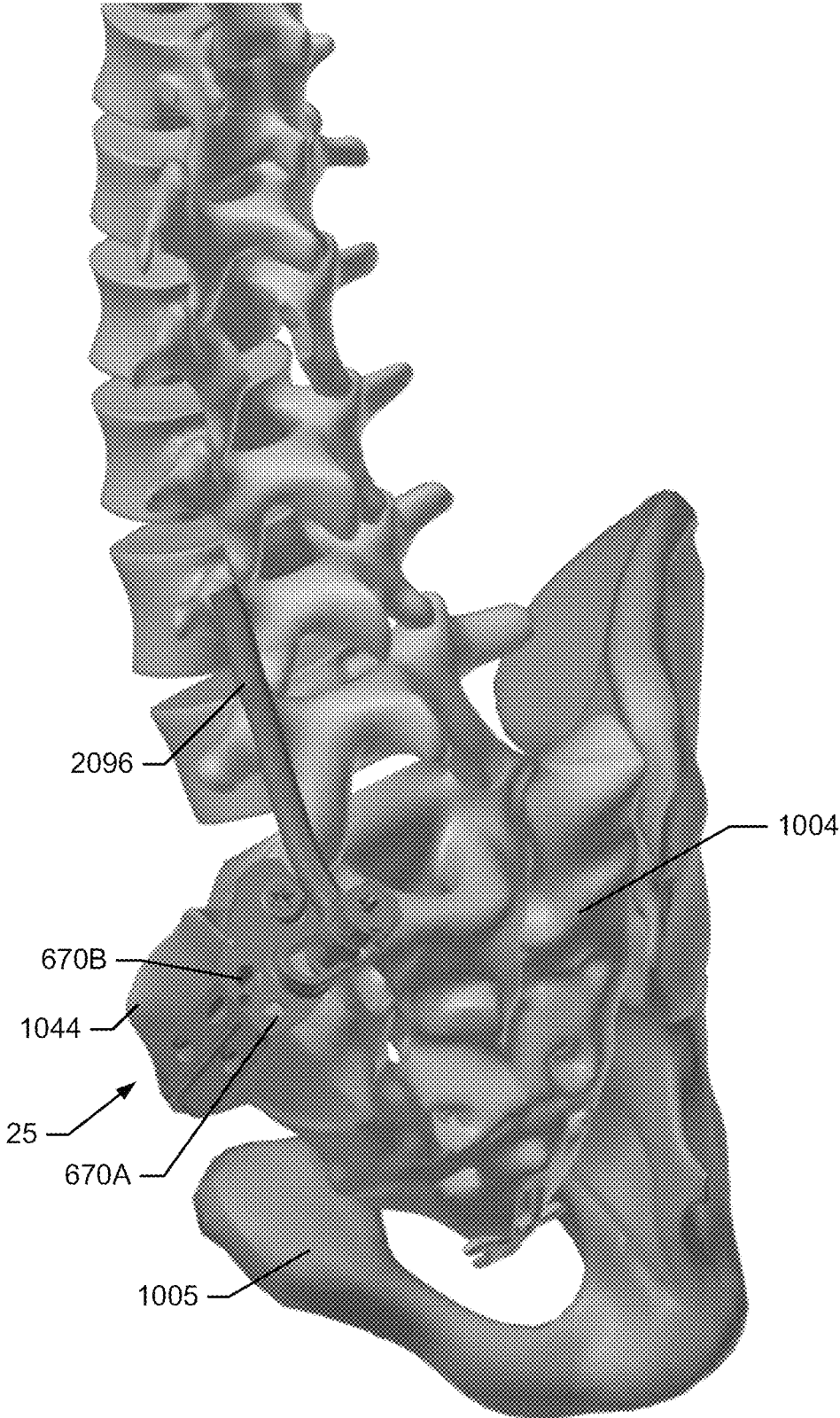


FIG. 87

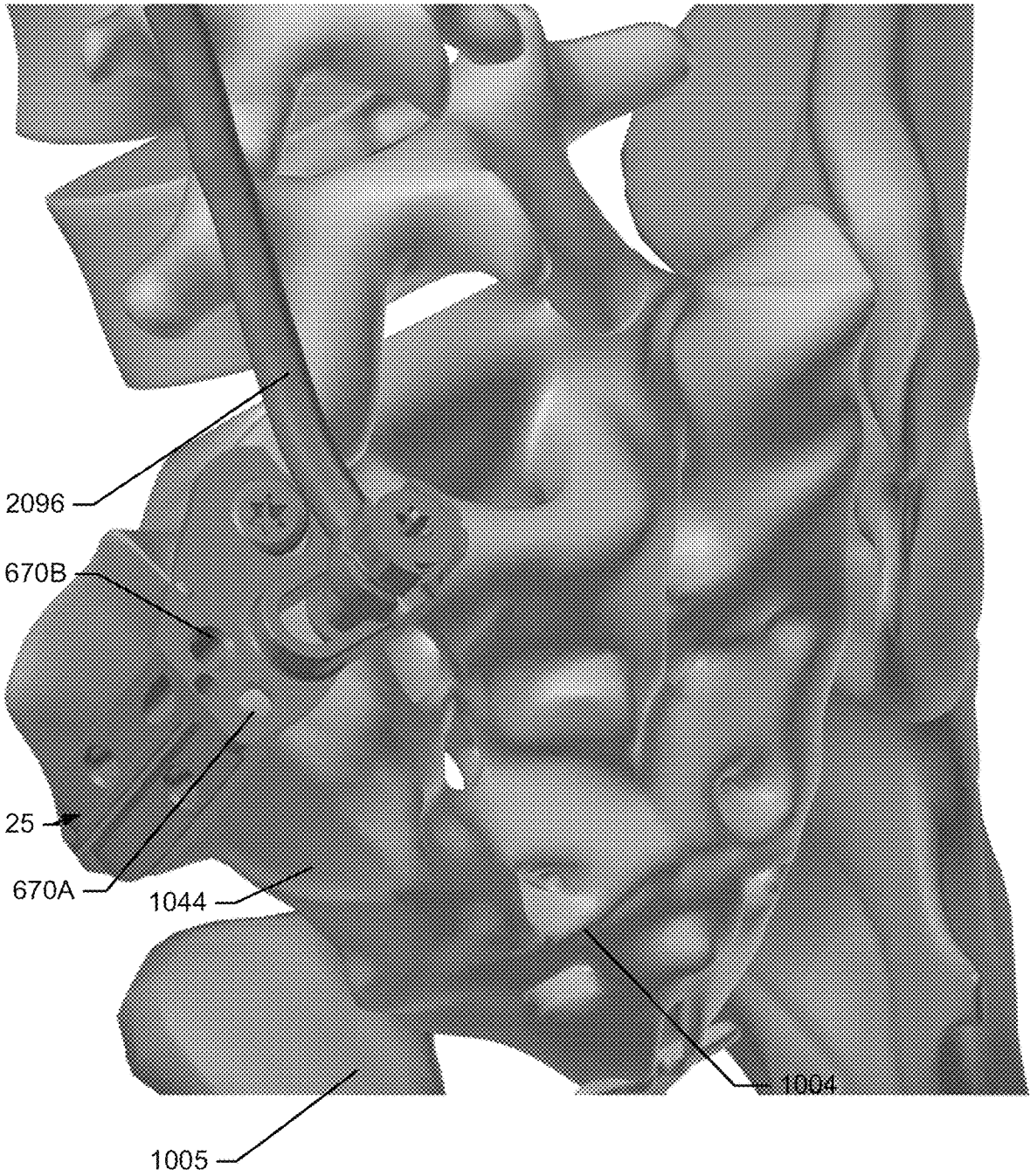


FIG. 88

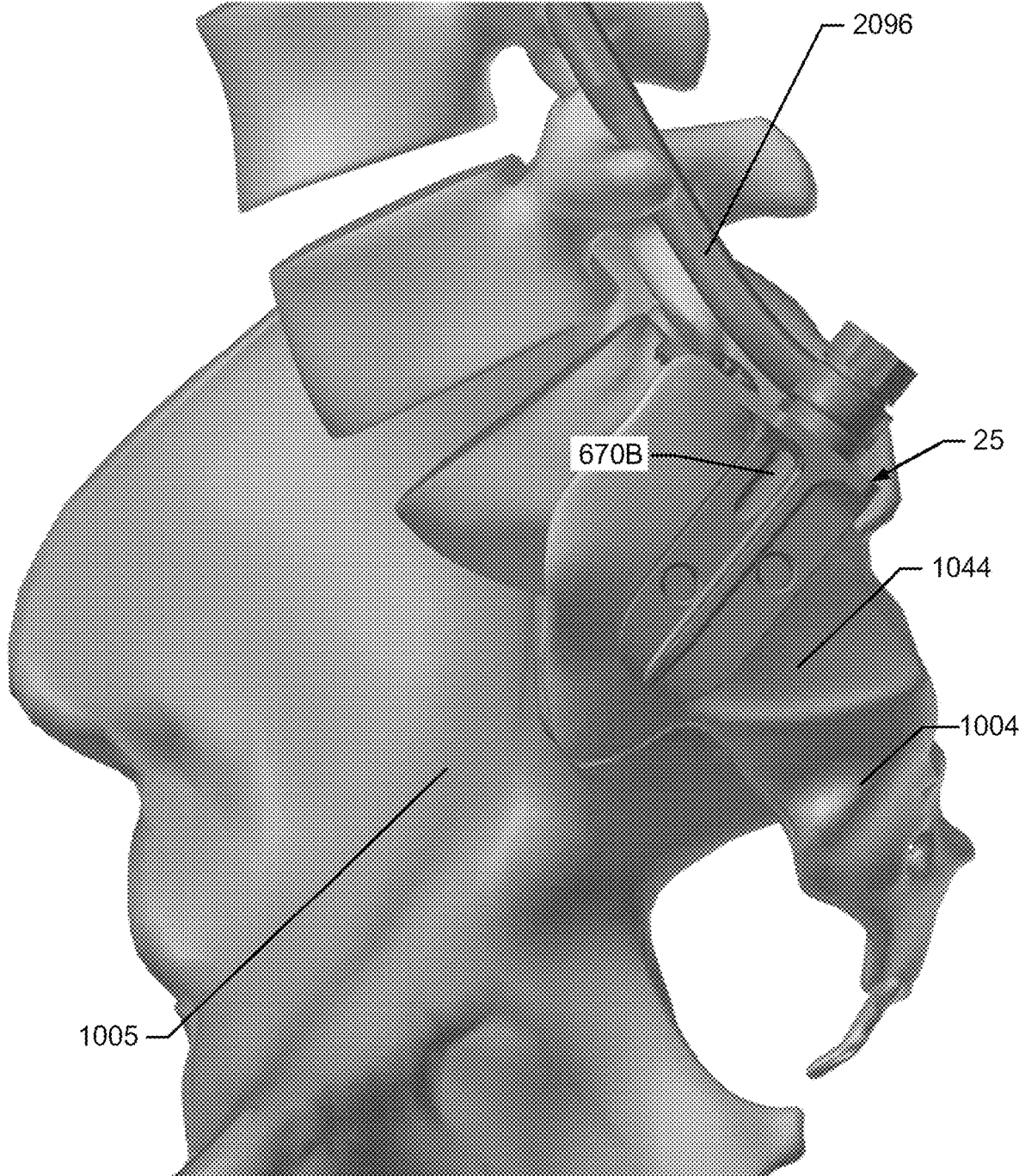


FIG. 89

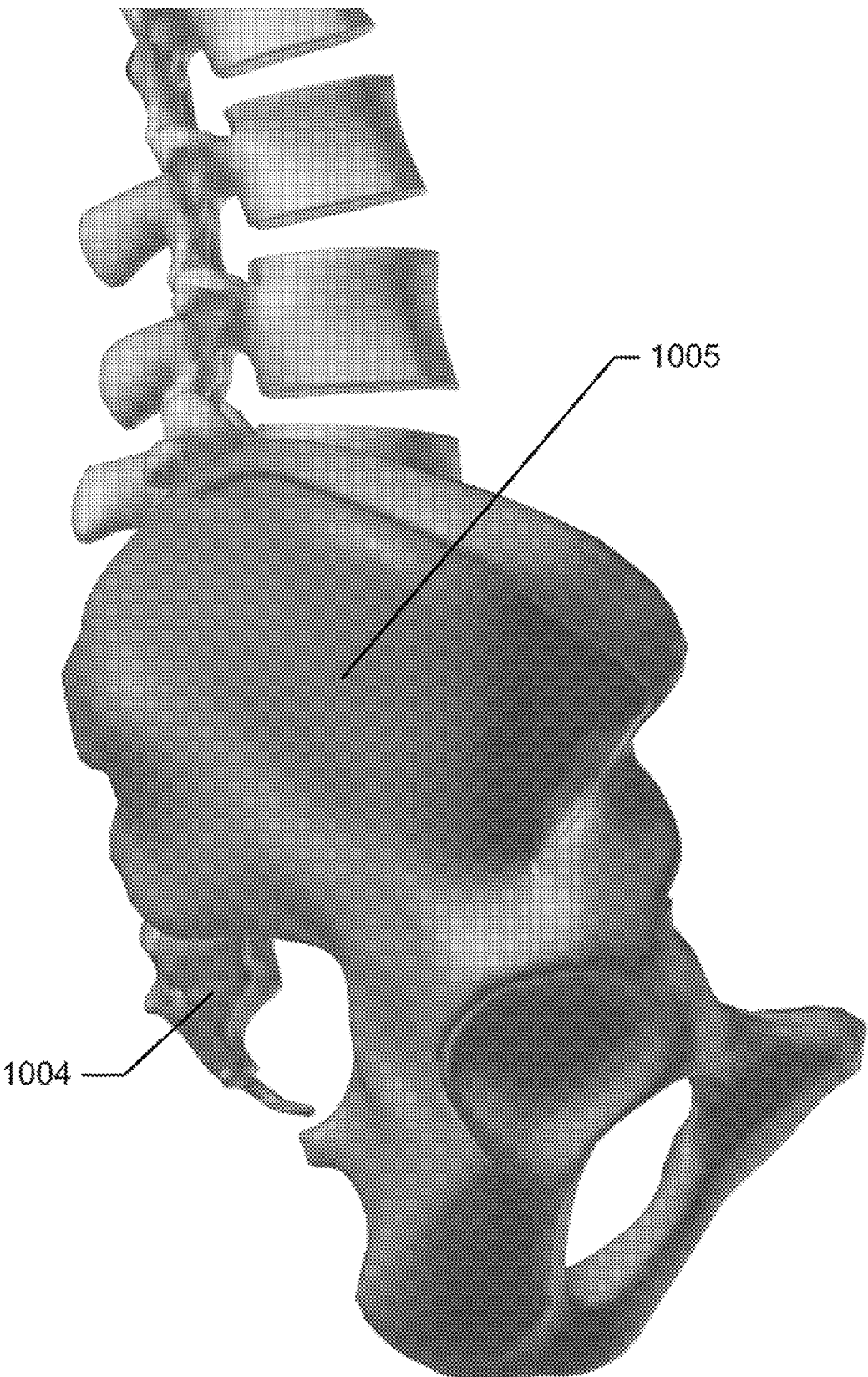


FIG. 90

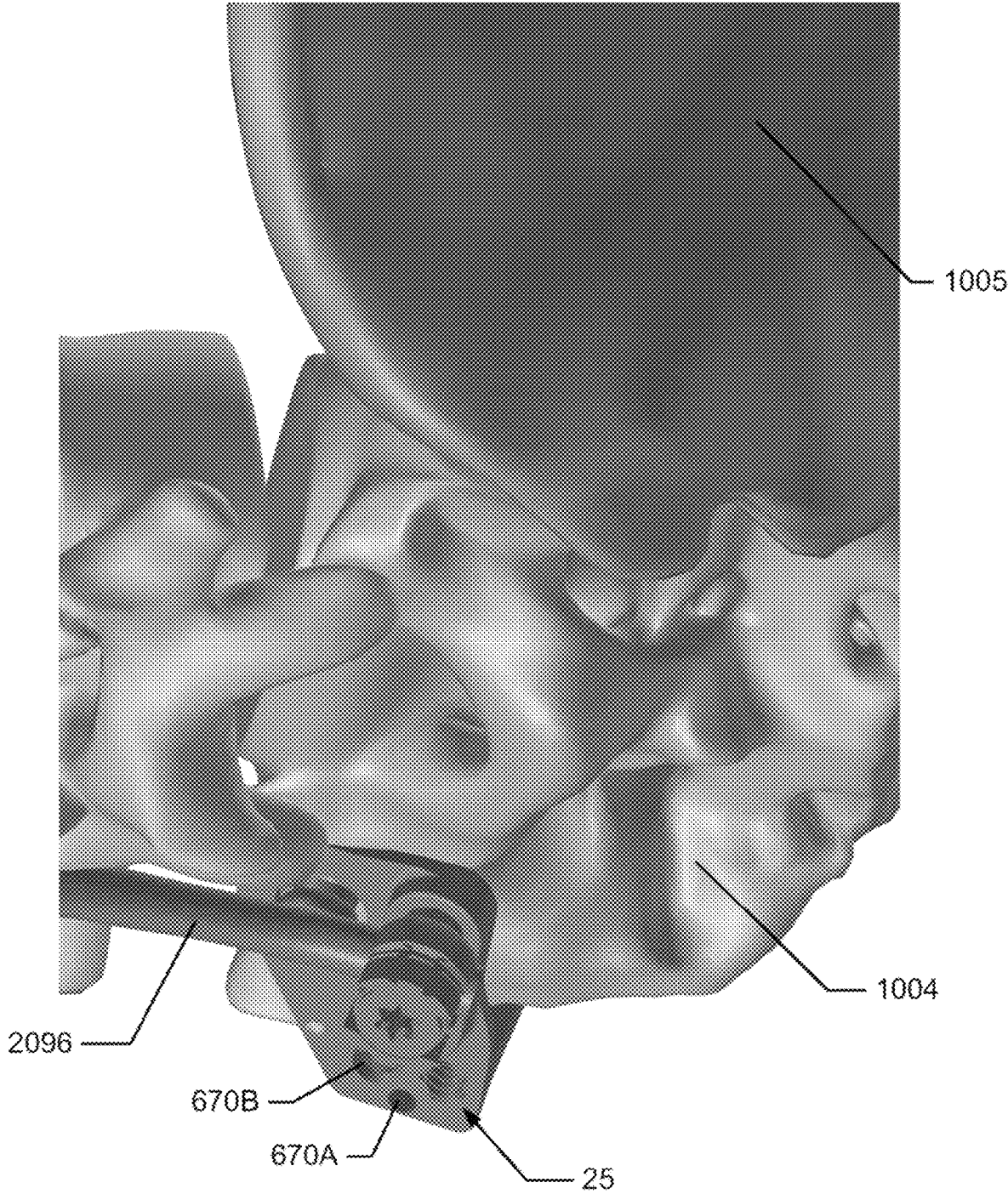


FIG. 91

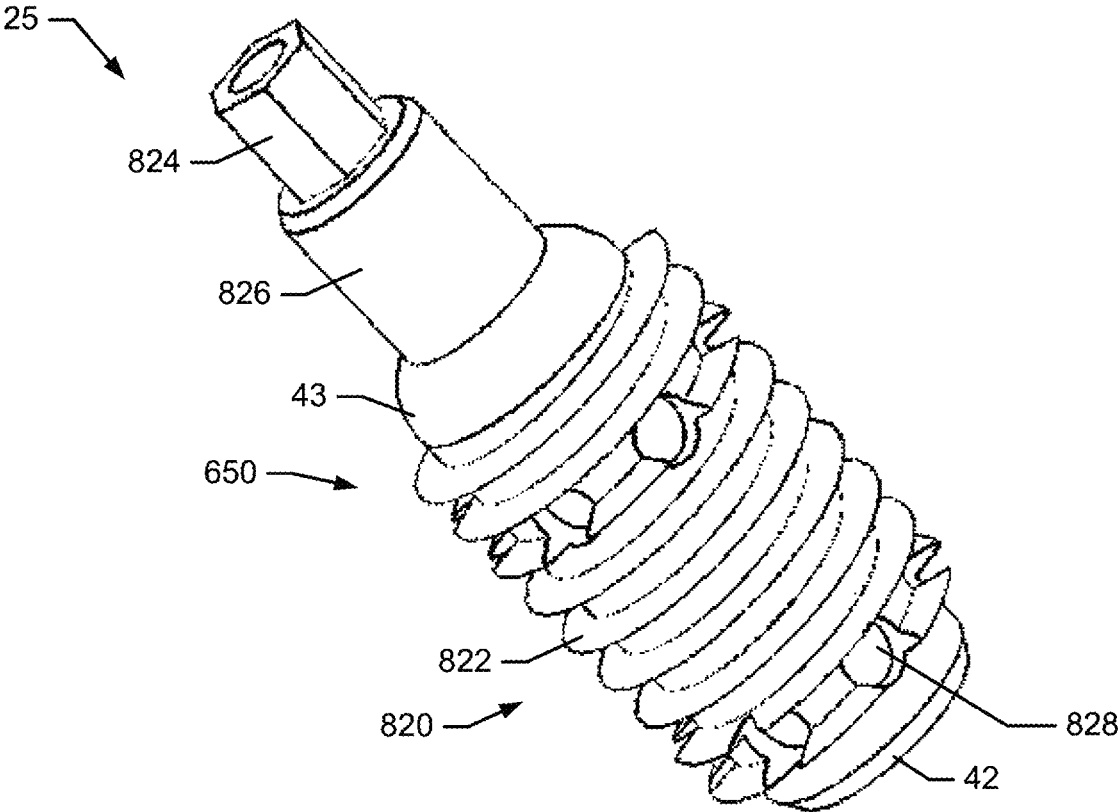


FIG. 92

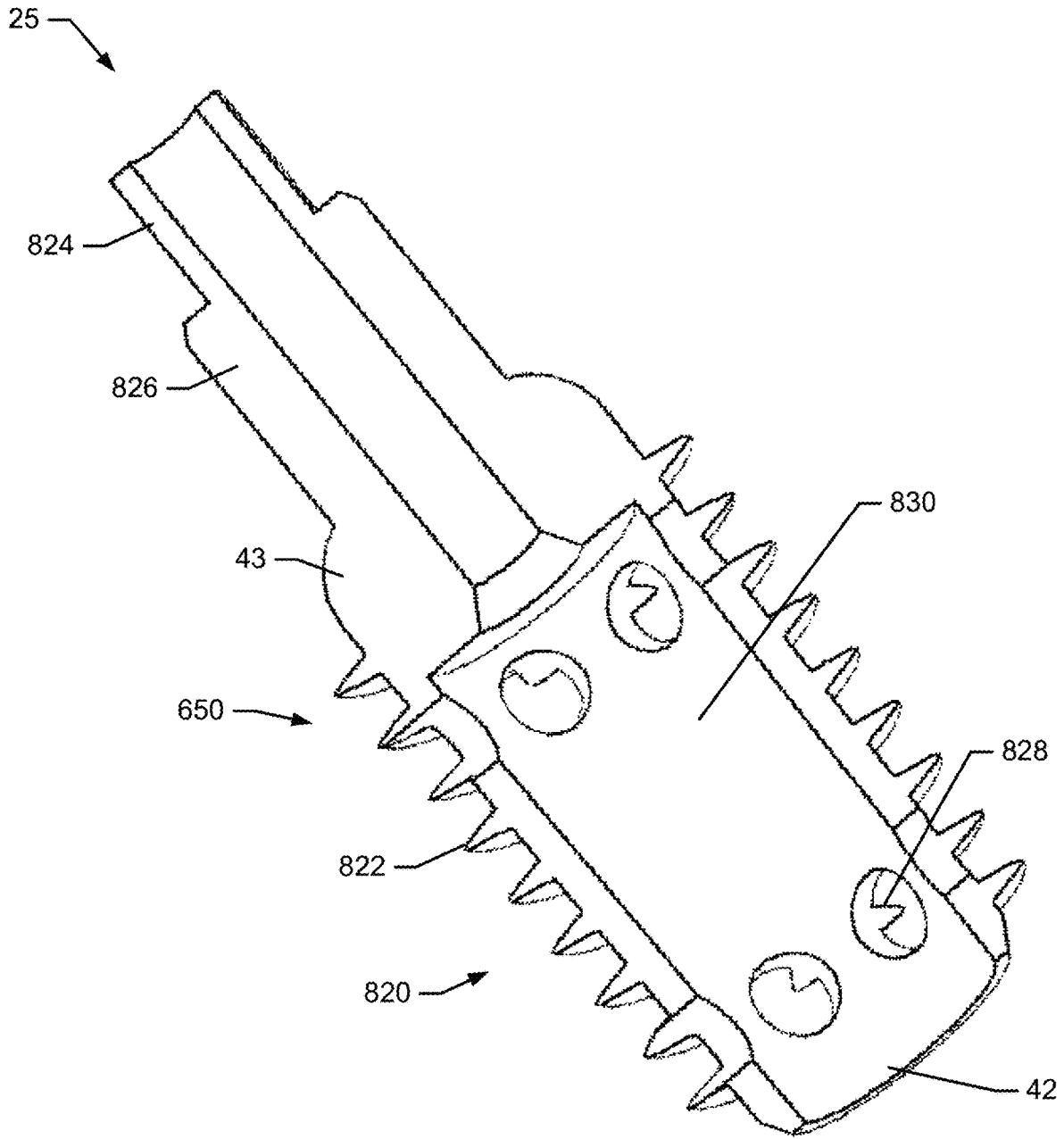


FIG. 93

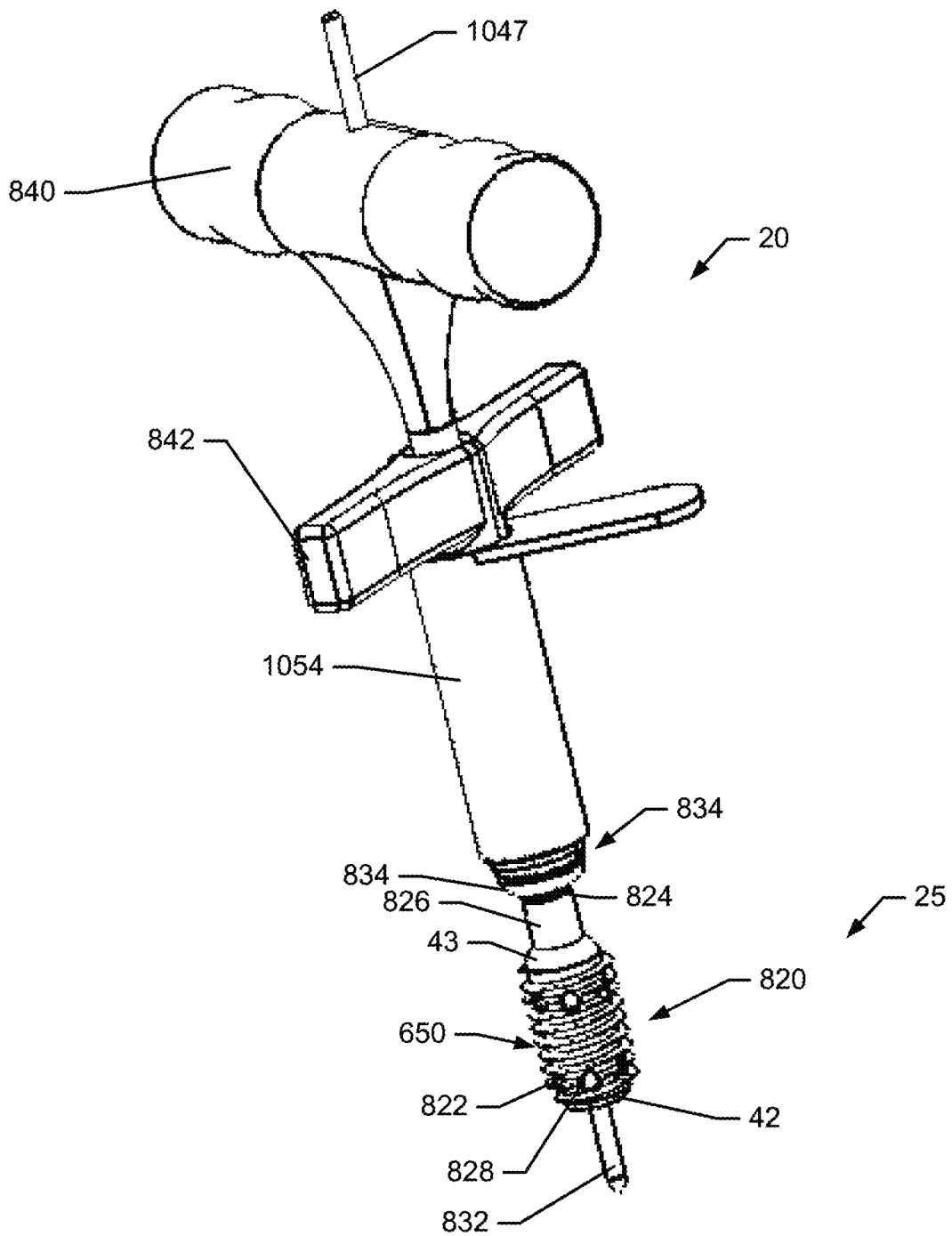


FIG. 94

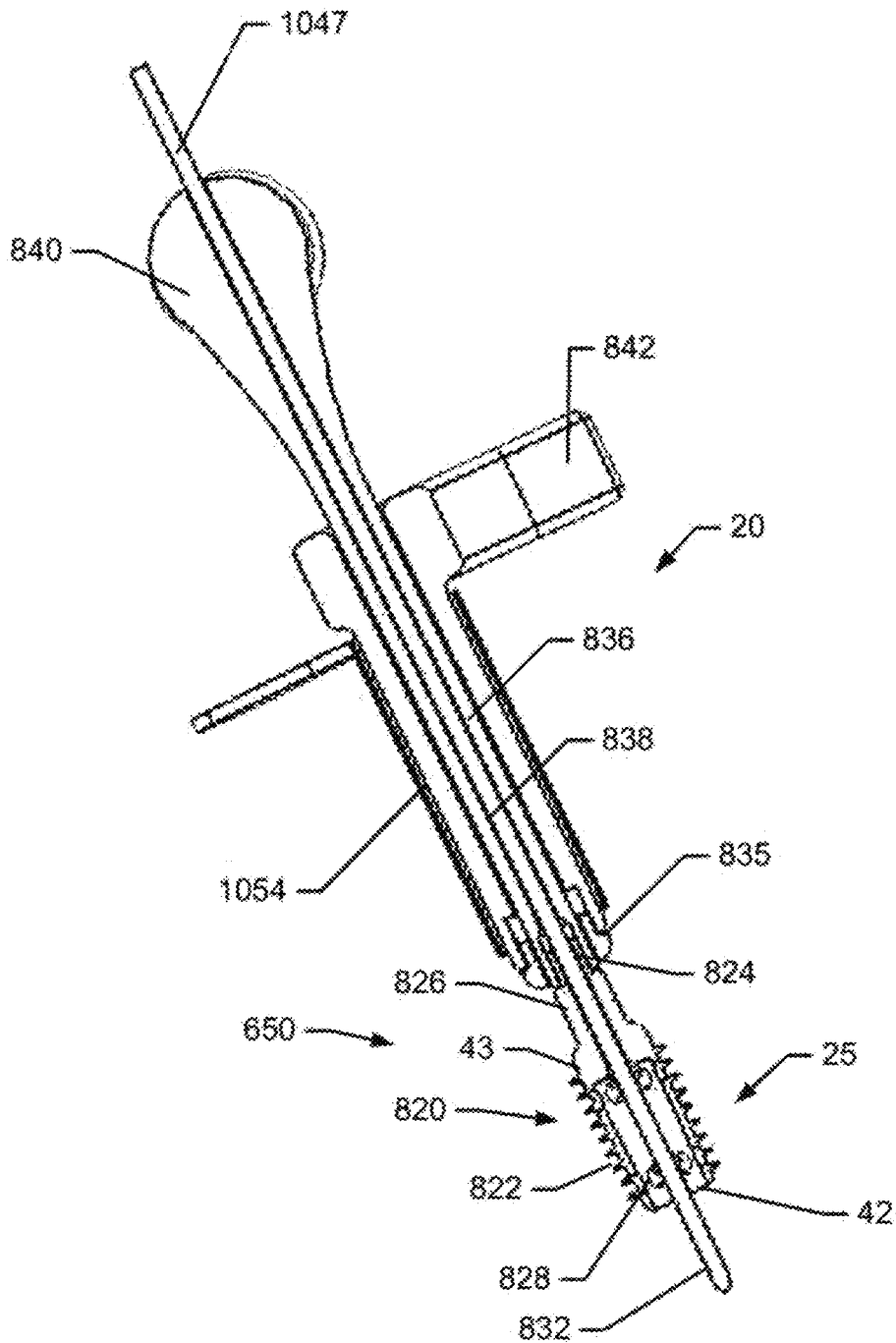


FIG. 95

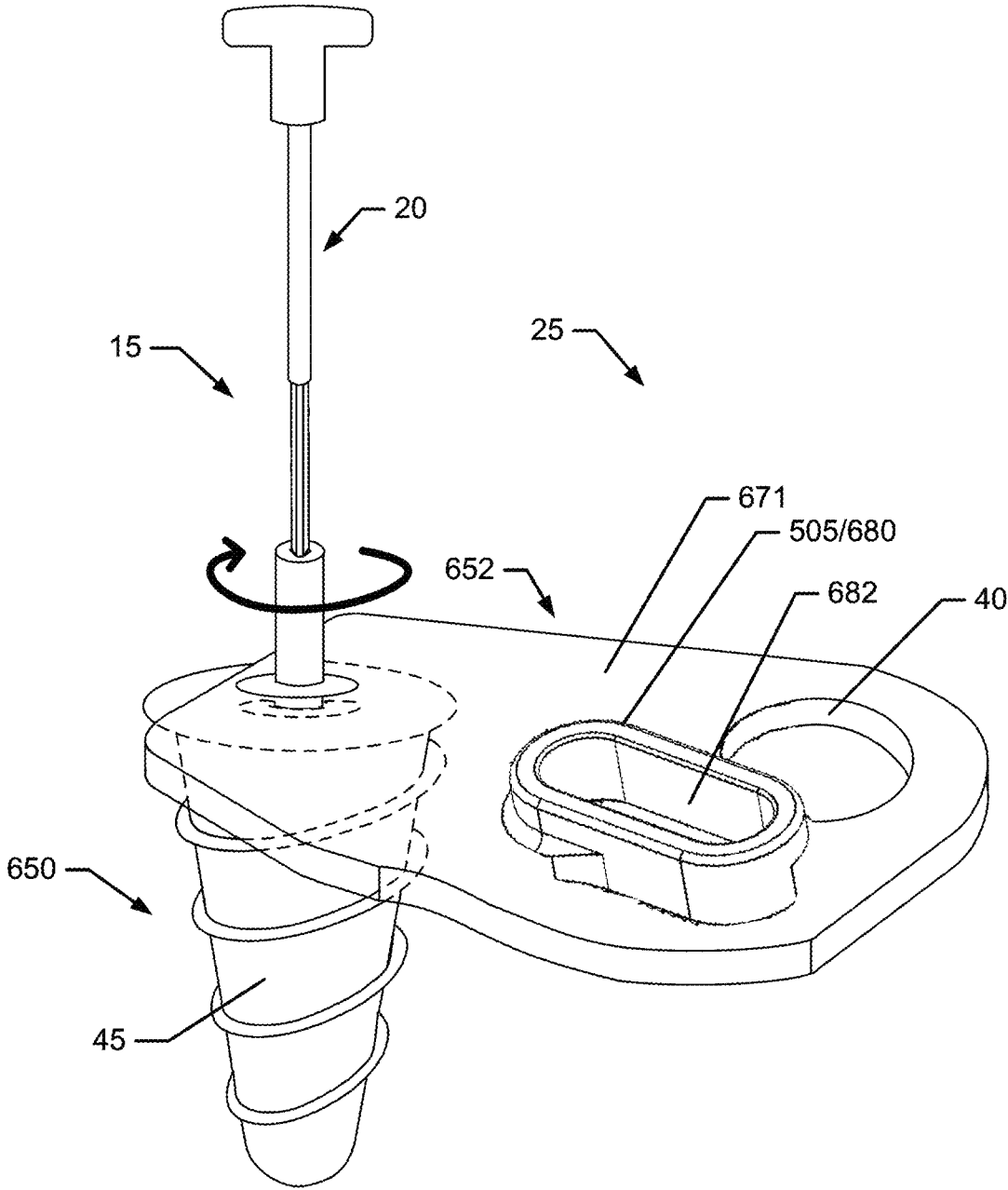


FIG. 96

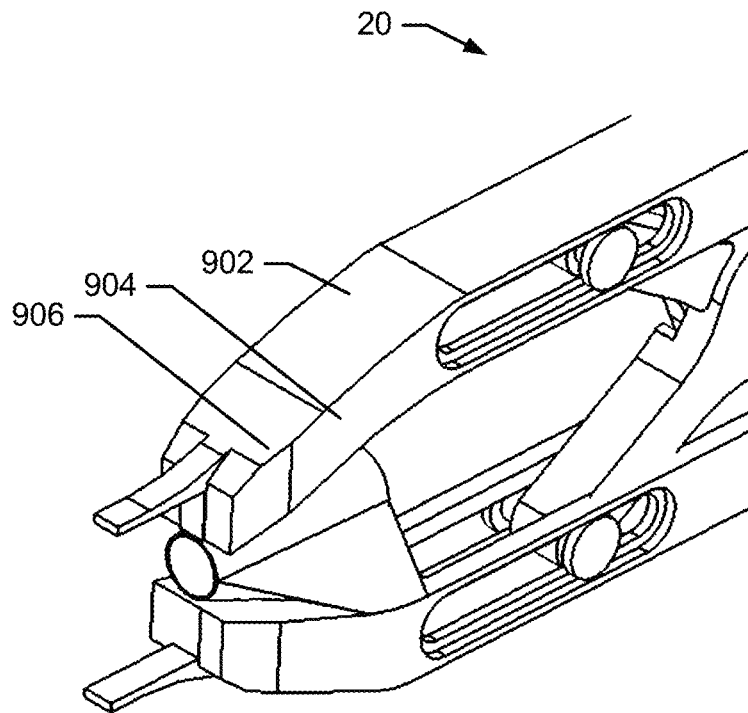
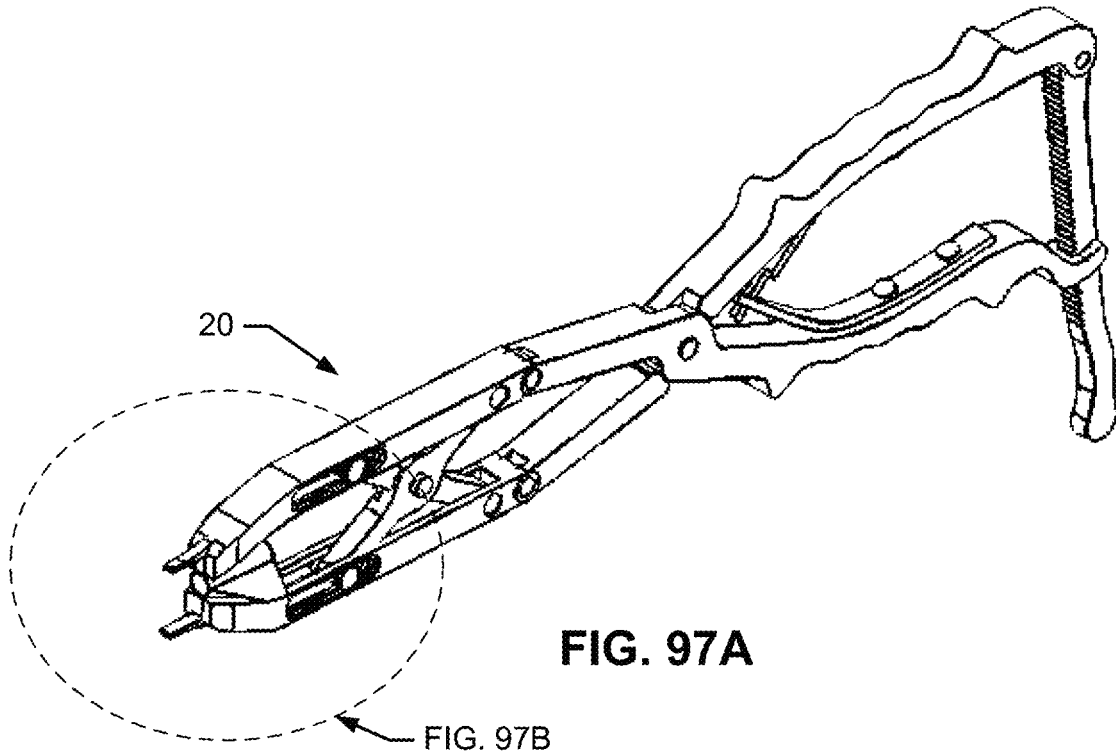


FIG. 97B

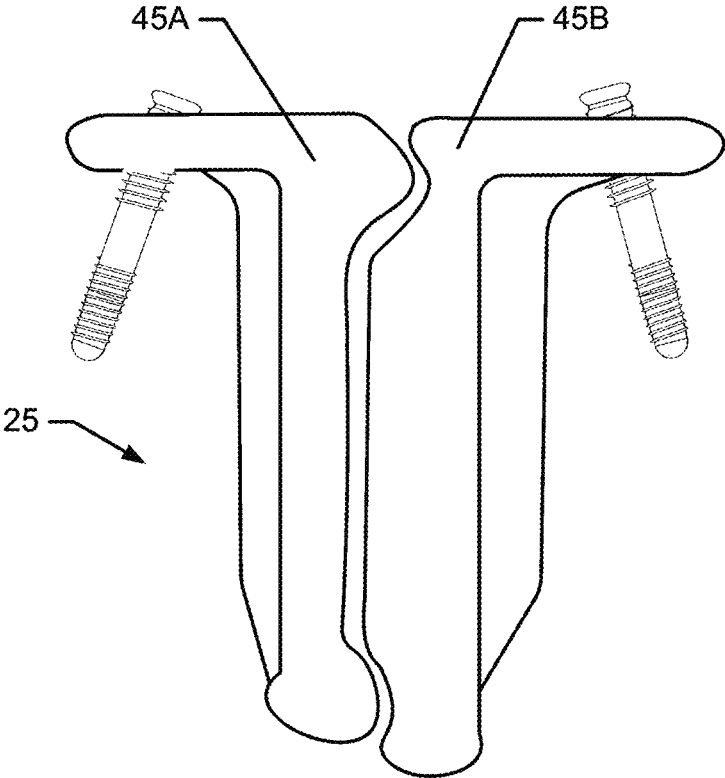


FIG. 98

**IMPLANT ASSEMBLY FOR LOW PROFILE
SPINOPELVIC FIXATION AND SACROILIAC
JOINT FUSION**

CROSS REFERENCE TO RELATED
APPLICATIONS

The present application is a divisional application of U.S. application Ser. No. 14/216,975 filed Mar. 17, 2014, which application is a continuation-in-part application of U.S. patent application Ser. No. 13/475,695, entitled "Systems for and Methods of Fusing a Sacroiliac Joint" filed May 18, 2012, now U.S. Pat. No. 9,381,045, which application is a continuation-in-part application of U.S. patent application Ser. No. 13/236,411, entitled "Systems for and Methods of Fusing a Sacroiliac Joint" filed Sep. 19, 2011, now U.S. Pat. No. 9,017,407. U.S. patent application Ser. No. 13/236,411 is also a continuation-in-part application of U.S. patent application Ser. No. 12/998,712 (the '712 application"), filed on May 23, 2011 and entitled "Sacroiliac Joint Fixation Fusion System", now U.S. Pat. No. 8,979,928. The '712 application is the National Stage of International Patent Cooperation Treaty Patent Application PCT/US2011/000070 (the 'PCT application"), filed on Jan. 13, 2011 and entitled "Sacroiliac Joint Fixation Fusion System". The PCT application claims the benefit under 35 U.S.C § 119(e) of U.S. Provisional Patent Application No. 61/335,947, which was filed Jan. 13, 2010 and entitled "Sacroiliac Joint Fusion System". U.S. patent application Ser. No. 14/216,975 further claims the benefit of and priority to U.S. Provisional Patent Application 61/798,225, entitled "Systems and Methods for Fusing a Sacroiliac Joint and Anchoring an Orthopedic Appliance" and filed on Mar. 15, 2013.

Each application referenced above is hereby incorporated by reference in its entirety as if fully set forth herein.

FIELD OF THE INVENTION

Aspects of the present invention relate to medical apparatuses and methods. More specifically, the present invention relates to devices and methods for providing an anchoring attachment for a spinal stabilization system and for concomitantly stabilizing, immobilizing, fixating or fusing a sacroiliac joint.

BACKGROUND OF THE INVENTION

Reinforcement, stabilization, replacement, reconstruction, or fusion of a joint or vertebrae may be indicated as a treatment of an afflicted region of a patient. Examples of specific treatments include spinal stabilization, spinal fusion, posterolateral spinal fusion, posterior lumbar interbody fusion, transforaminal lumbar interbody fusion, lateral interbody fusion, anterior lumbar interbody fusion, vertebral immobilization or reinforcement, intervertebral joint immobilization or reinforcement, degenerative disk stabilization, repair of traumatic fracture dislocation of the pelvis, treatment of degenerative arthritis, treatment of sacroiliitis (an inflammation or degenerative condition of the sacroiliac joint), osteitis condensans ilii, and treatments of other degenerative conditions of joints or vertebrae or other musculoskeletal injuries, diseases, conditions or disorders.

This reinforcement of intervertebral joints, sacroiliac joints, or other joint stabilizations may be accomplished by one or more existing methods, including inserting stabilizing implants such as support rods into the afflicted regions. Typically these fusion implants span an afflicted joint and

may be anchored to bone tissue on either side of the afflicted joint using existing orthopedic fasteners such as pedicle screws or other orthopedic anchoring devices. These existing fusion implants may completely immobilize the afflicted joint or may allow limited or unconstrained movement to approximate or permit the normal movements of the afflicted joint.

One limitation of many existing fusion procedures involves the challenge of situating a fusion implant in suitably close alignment with the removed tissues of the patient to achieve a stable fixation of the joint or vertebrae. Existing implant structures may have insufficient engagement with the articular surfaces or cortical bone of the joint for adequate fixation or fusion. This failure to sufficiently stabilize and fuse the joint with the conventional implant structures and methods may result in a failure to relieve the condition being treated.

Another limitation of the fusion and fixation implants and associated anchors used in existing fusion procedures is the relatively large profile or prominence of the components. The large footprint of existing fusion implants and associated anchors necessitate the removal of considerable bone and/or soft tissue to prepare the area for the installation of the implant, possibly resulting in considerable post-operative pain. Further, the high profile or prominence of elements of the fusion or fixation implant projecting away from the spine or pelvis may chronically irritate the soft tissues, resulting in chronic pain during long-term use of the fusion implant and may require further surgeries and explantation.

Additional limitations of existing fusion implants are also related to the long-term use of the implants. Over time, the anchoring elements such as pedicle screws may loosen over time due to exposure to repeated loads associated with movements of the patient, thereby reducing the stabilization provided by the implant. Even if more robust anchoring devices or systems are used, the long-term use of these existing fusion implants are associated with an increased chance of injury to one or more joints adjacent to the reinforced joint.

The stabilization of afflicted lumbar intervertebral joints poses a particular challenge with respect to surgical interventions. The lumbar intervertebral joints are particularly vulnerable to injury or degradation because these joints bear the majority of the body's weight but also effectuate about half of the body's overall flexion movements (forward-backward bending). As a result, a sizeable fraction of back pain symptoms are associated with injuries or degradation of the lumbar intervertebral joints, in particular the L3-L4 and L4-L5 joints.

Treatment of spinal pathologies, including scoliosis, using existing lumbosacral fusion or fixation implants may increase the patient's risk of complications including loosening of anchor elements, implant-induced injury of surrounding joints, and/or implant-induced injury or chronic irritation of soft tissues surrounding the implant as described previously. Some existing lumbar fusion implants may provide additional anchoring to the ilium and/or sacrum bones of the pelvic girdle to enhance the robustness of anchoring and/or structural support. However, anchoring a lumbar fusion implant to one or more bones of the pelvic girdle presents additional risks of complications not yet completely addressed by existing implant systems or methods.

Due to the relatively dense concentrations of exposed nerves emerging from the sacrum region, the implantation of a transacrally fixed lumbar fusion implant is associated with an increased risk of nerve injury during implantation and/or chronic use of the implant. In addition, the bone tissue of the

sacrum consists largely of lower density cancellous bone tissue, which is less structurally robust and therefore more vulnerable to anchor loosening relative to other bones. Lastly, the increased loading applied to the sacrum via the attached lumbar fusion implant may induce an accelerated degradation or failure of one or both sacroiliac joints.

Other existing lumbosacral fusion or fixation implants may provide additional anchors fixed to the ilium; the ilium contains a much higher proportion of higher-density cortical bone and therefore provides a more robust anchoring surface than the sacrum. However, additional loads induced by an ilium-fixed lumbar fusion implant may induce an accelerated degradation or failure of one or both sacroiliac joints. Although some existing lumbar fusion implants are anchored to both the ilium and the sacrum, alterations to the chronic loading of the articulating surfaces of the sacroiliac joints may induce accelerated degradation or failure of one or both sacroiliac joints.

In the practice of orthopedic and neurologic surgery, while attempting to correct a pathology of the spine by means of fixation or stabilization, strong forces can be concentrated on certain parts of the spine and pelvis. Specifically, the junction above or below a fixated or stabilized segment of the spine can undergo forces which can affect healthy alignment of the spine, or portions of the pelvis such as the sacroiliac joint. Unhealthy alignment of anatomic structures involved in such procedures can result in severe complications for example chronic severe pain, permanent disability and paralysis. The complexity of the spinal reconstruction, the sagittal balance realignment, the number of vertebrae involved, or other factors may increase the risk of complications. In published literature morbidity rates near fifty percent for such procedures. In order to minimize the forces a fixated or stabilized segment of vertebrae can create, a conventional technique employs the use of metal or plastic rods (or bands, cord, etc.) which can be configured to extend to a sacrum or ilium and screws inserted into either or both bones or across both bones which can then connect to the rods to help stabilize the spinal construct. Substantial problems with conventional techniques exist which can significantly affect a patient's recovery from the surgery.

A significant problem with certain conventional methods for pelvic fixation including the procedure mentioned above is there is a tendency for the screws to pull out, loosen, break or otherwise cause complications due to the strong forces which can be present. Another significant problem with certain conventional methods for pelvic fixation including placement of a (S2 alar iliac (S2AI)) screw into the second sacral body (S2) which then crosses the sacroiliac joint (extra-articularly) and continues into the ilium extending across the cortical bone to better fixate the screw may be that the screw is positioned such that it violates the articular portion of the sacroiliac joint. Literature shows that this can occur up to 60% of the time. Due to the high chances of trauma caused by the screw to the articular portion of the joint severe pain may result.

The inventive anchoring system for one or more elements of a spinal stabilization system described herein addresses the problems associated with conventional methods and apparatuses used to anchor one or more elements of a spinal stabilization system.

BRIEF SUMMARY OF THE INVENTION

One implementation of the present disclosure may take the form of a sacroiliac joint fusion implant assembly including an implant body and an anchor. The implant body

may include an insertion element including an elongate body with a proximal insertion element end and a distal insertion element end, as well as an attachment element mechanically attached to the proximal insertion element end. The attachment element includes an anchor fitting formed within the attachment element or mechanically attached to the attachment element. The anchor fitting may be configured to receive the anchor inserted within a predetermined range of anchor insertion trajectories.

In another implementation, the insertion element may be an insertion plate. The insertion plate may include a medial face and a lateral face opposite to the medial face. The insertion plate may also include one or more elongate fins. Each of the one or more fins may project perpendicularly outward from the medial face or the lateral face and may extend longitudinally between the proximal insertion element end and the distal insertion element end. The fins and the insertion plate may taper toward a narrow insertion plate leading edge. The insertion plate leading edge may be configured for insertion into the joint space of a sacroiliac joint.

The insertion plate may further include one or more additional bores. Each additional bore may include a bore cross-sectional profile and a bore axis situated along the bore centerline. The bore centerline may include a line connecting each additional bore's cross-sectional profile centroids. Each additional bore may be situated on the medial face or lateral face and may be directed inward along the bore centerline, and each additional bore may be configured to receive a distal end of an additional orthopedic fastener. Each additional bore may be a blind bore extending partially through the insertion plate to the lateral face or medial face in one implementation. In another implementation, each additional bore may be an open bore extending through the insertion plate from the lateral face to the medial face. One of the additional bores may be configured to receive a distal end of the anchor projecting from the anchor fitting after insertion of the anchor into the anchor fitting within the predetermined range of anchor insertion trajectories. One of the additional bores may have a cross-sectional profile chosen from: square, rectangular, circular, oval, triangular and any combination thereof.

In another implementation, the attachment element may be permanently attached at a fixed position and angle to the proximal end of the insertion element. The angle formed between the attachment element and the insertion element may range from about 30° to about 120°. The attachment element and insertion element may be formed as a continuous structure. The attachment element and insertion element may be attached in a hinged attachment; the angle formed between the attachment element and insertion element may range from about 30° to about 120°.

In another implementation, the anchor fitting may include a bore formed within the attachment element. The bore may be an open bore passing from a proximal attachment element surface to a distal attachment element surface. The bore may have a cross-sectional profile chosen from: square, rectangular, circular, oval, triangular and any combination thereof. The bore may be configured to allow the insertion of an anchor at any angle of up to about 45° relative to an axis perpendicular to a region of the attachment element in close proximity to the bore.

The anchor fitting may be attached to an anchor support element of the attachment assembly and configured to receive an anchor within a preselected range of anchor insertion trajectories. The anchor support element may include a rectangular cross-sectional profile and the anchor

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fitting may include a channel with a rectangular cross-sectional contour matched to the cross-sectional profile of the anchor support element; the anchor fitting may resist rotation about the axis of the anchor support. The anchor support element may include a circular cross-sectional profile and the anchor fitting may include an anchor fitting attachment bore with a circular cross-sectional contour matched to the cross-sectional profile of the anchor support element. The anchor fitting may permit rotation about the axis of the anchor support.

The anchor may be chosen from: a cortical screw, a cancellous screw, and a Steffee screw. In one implementation the anchor may be a Steffee screw and the anchor support element may be a Steffee plate formed within the attachment element. In another implementation, the anchor may be a dual-threaded bone screw that includes a head and a shaft. The shaft may include a proximal threaded segment with a first threading pattern and a distal threaded segment with a second threading pattern.

In another implementation, the attachment element may also include an attachment fitting attached to a guide formed within the attachment element. The guide may include a guide bore configured to receive an attachment fitting that includes a head of a polyaxial pedicle screw. The distal end of the polyaxial screw may be inserted through the guide bore within a predetermined range of attachment fitting insertion angles. The head of the polyaxial pedicle screw may include at least two sides forming a lower surface of an upward-facing groove configured to receive a rod and further forming a threaded fitting configured to receive a locking nut.

In another implementation, the attachment fitting may include a sliding attachment fitting configured to translate within a guide slot formed within the attachment element. The guide slot may include an elongate hole passing through the attachment element and directed along a slot pathway. The slot pathway may be selected from any one or more of: a straight line, a curve, an arc, and any combination thereof. The guide slot may also include a raised edge projecting proximally from the proximal surface of the attachment element around a perimeter of the guide slot.

In an implementation, the sliding attachment fitting may include a proximal head including at least two sides forming a lower surface of an upward-facing groove configured to receive a rod and further forming a threaded fitting configured to receive a locking nut. The sliding attachment fitting may also include a shaft configured to slide within the guide slot; a first end of the shaft may be attached to the proximal head opposite to the upward-facing groove. The sliding attachment fitting may further include a distal contact surface attached at a second end of the shaft opposite to the first end. The distal contact surface and proximal head may be situated on opposite sides of the attachment element and connected by the shaft situated within the guide groove.

The distal contact surface of the attachment fitting may include an essentially flat planar surface that restricts the rotation of the attachment fitting to essentially rotations about a shaft axis. The distal contact surface of the attachment fitting may include a curved surface that permits the rotation of the attachment fitting about axes perpendicular to the shaft axis.

In another implementation, the guide may include a guide rail and the attachment fitting may include a sliding attachment fitting configured to translate along the guide rail. The sliding attachment fitting may include a proximal head including at least two sides forming a lower surface of an upward-facing groove configured to receive a rod and fur-

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ther forming a threaded fitting configured to receive a locking nut. The sliding attachment fitting may also include a transverse channel configured to receive the guide rail situated at a distal end of the attachment fitting opposite to the upward-facing groove. The guide rail and the transverse channel may also include a rectangular cross-section; the guide rail may resist rotation of the attachment fitting in any direction.

In another implementation, the sliding attachment fitting may also include: a proximal element forming the lower surface of the upward-facing groove at one end and forming an annular channel at an opposite end; and a distal element forming the transverse rectangular channel at a first end and forming an annular flange at a second end opposite to the first end. The annular channel and the annular flange may engage in a sliding rotational engagement to permit the rotation of the attachment fitting about an axis of rotation coincident with the central axis of the sliding attachment fitting. The guide rail and the transverse channel may have circular cross-sectional profiles, permitting the attachment fitting to rotate about the axis of the guide rail.

Another implementation may take the form of a sacroiliac joint fusion implant assembly including an implant body and one or more anchors. The implant body may include an insertion element having an elongate cylindrical body with a proximal insertion element end, a distal insertion element end, and a threaded outer surface configured for insertion into a joint space of a sacroiliac joint by twisting the insertion element into a cylindrical receiving bore formed within the joint space. Each of the one or more anchors may be configured for insertion through one or more transverse bores formed within the implant body.

In an implementation, the insertion element may further include an attachment fitting attached to the proximal insertion element end. The insertion element may also include an attachment element fastener attached to the proximal insertion element end. The implant assembly may also include an attachment element fastened to the proximal insertion element end at the attachment element fastener.

Another implementation may take the form of a sacroiliac joint fusion and anchoring system that includes an implant assembly and a delivery tool. The implant assembly may include an implant body including an insertion element with an elongate body with a proximal insertion element end and a distal insertion element end, as well as an attachment element mechanically attached to the proximal insertion element end. The attachment element may include an anchor fitting formed within the attachment element or mechanically attached to the attachment element. The implant assembly may also include an anchor.

In this implementation, the delivery tool may include an implant arm with a distal implant arm end configured to releasably couple to the proximal insertion element end as well as an anchor arm including a proximal anchor arm end coupled to the implant arm and a distal anchor arm end opposite to the proximal anchor arm end. The distal anchor arm end distally ends in a sleeve configured to guide the anchor within a predetermined range of anchor insertion trajectories. The sleeve is configured to guide the anchor through the anchor fitting within the predetermined range of anchor insertion trajectories when the distal implant arm end is releasably coupled to the proximal insertion element end.

The insertion element may also include an attachment fitting formed within the proximal insertion element end. The attachment fitting is configured to receive a corresponding attachment fastener situated within the distal end of the delivery tool. The attachment fitting may be a threaded bore

and the attachment fastener may be a screw. The attachment fitting may also include one or more alignment features chosen from: one or more additional threaded bores formed within the proximal insertion element end and separated by a lateral distance from the attachment fitting; and one or more alignment peg receptacles configured to receive one or more corresponding alignment pegs projecting distally from an extreme distal face of the delivery tool.

The alignment peg receptacles may be situated within a proximal surface of the attachment element within the lateral edge of the attachment element. The alignment peg receptacles may be inset within the lateral edge of the attachment element. The alignment pegs may be arranged in a pattern corresponding to an edge contour of the lateral edge of the attachment element.

In one implementation, the sleeve of the anchor arm may include a tubular guide with a proximal opening and a distal opening. The proximal opening is configured to receive a distal tip of the anchor or other orthopedic fastener and the distal opening is configured to guide the distal tip of the anchor or other orthopedic fastener within a predetermined range of insertion trajectories. The sleeve of the anchor arm may be narrow relative to the diameter of a head and shaft of an anchor or other orthopedic fastener; the sleeve in this implementation may be configured to guide the distal tip of the anchor or other orthopedic fastener within a narrow predetermined range of insertion trajectories. The sleeve of the anchor arm may be wide relative to the diameter of a head and shaft of an anchor or other orthopedic fastener; the sleeve in this implementation may be configured to guide the distal tip of the anchor or other orthopedic fastener within a wide predetermined range of insertion trajectories. The sleeve of the anchor arm may be relatively wide relative to the diameter of a head and shaft of an anchor or other orthopedic fastener; in this implementation, the sleeve may be configured to guide the distal tip of the anchor or other orthopedic fastener within a wide predetermined range of insertion trajectories. The sleeve may be a conical sleeve with a proximal opening that is large relative to the distal opening; in this implementation, the conical sleeve may be configured to guide the distal tip of the anchor or other orthopedic fastener within a wide predetermined range of insertion trajectories.

Another implementation may be in the form of a method of fusing a sacroiliac joint and providing an anchor for a spinal support system. The method may include providing a sacroiliac joint fusion and anchoring system that may include an implant assembly and delivery tool. The implant assembly may include an implant body and an anchor. The implant body may include: an insertion element that includes an elongate body with a proximal insertion element end and a distal insertion element end; and an attachment element mechanically attached to the proximal insertion element end. The attachment element may include an anchor fitting formed within the attachment element or mechanically attached to the attachment element. The delivery tool may include: an implant arm that includes a distal implant arm end releasably coupled to the proximal insertion element end of the implant body; and an anchor arm that includes a proximal anchor arm end coupled to the implant arm and a distal anchor arm end opposite to the proximal anchor arm end. The distal anchor arm end may distally end in a sleeve configured to guide the anchor within a predetermined range of anchor insertion trajectories.

The method may further include preparing an implant receiving space via an extra-articular recess access region of the sacroiliac joint. The implant receiving space may extend

from a posterior portion of the sacroiliac joint toward an anterior portion of the sacroiliac joint by removing an amount of articular cartilage and other tissues from between an ilium articular surface and a sacrum articular surface defining the joint space. The method may also include situating the insertion element of the implant body non-transversely within the implant receiving space such that the attachment fitting projects in a medial direction from a joint line of the sacroiliac joint and the anchor fitting is situated over a region of the sacrum just lateral to the lateral edge of the S1 foramen and just superior to the superior edge of the S1 foramen. The method may also include inserting a driving tool through a lumen of the sleeve of the anchor arm such that a distal end of the driving tool is engaged with a proximal end of the anchor. The method may further include operating the driving tool to insert the anchor on a S2AI trajectory. In the S2AI trajectory the distal end of the anchor may pass through the anchor fitting, enters the sacrum near a first sacral foramen in a medial to lateral direction and further enters the ilium. The method may additionally include detaching the distal end of the delivery tool from the implant body.

The method in this implementation may also include inserting one or more additional fasteners through additional bores formed within the attachment member or insertion member. The one or more additional fasteners may be chosen from one or more of: a) a first additional fastener inserted through the ilium in a lateral to medial direction such that a distal tip of the first additional fastener is situated within a blind bore formed within a lateral face of the insertion element; b) a second additional fastener inserted through the ilium in a lateral to medial direction such that a distal tip of the second additional fastener is driven through an open bore formed transversely through the insertion element and into the sacrum adjacent to a medial face of the insertion element; c) a third additional fastener inserted through the sacrum in a medial to lateral direction such that a distal tip of the third additional fastener is situated within a blind bore formed within a medial face of the insertion element; d) a fourth additional fastener inserted through the sacrum in a medial to lateral direction such that a distal tip of the fourth additional fastener is situated within an open bore formed transversely through the insertion element and into the ilium adjacent to a medial face of the insertion element; and e) a fifth additional fastener inserted through an additional open bore formed through the attachment element in a fifth fastener direction chosen from any one of: a lateral to medial direction into the sacrum, a medial to lateral direction into the sacrum, a medial to lateral direction into the sacrum and ilium, a cranial direction into the sacrum, and a caudal direction into the sacrum.

The implant assembly used in this implementation of the method may further include an attachment fitting attached to the attachment element. In this implementation, the method may further include attaching a support element of a spinal support system to the attachment fitting.

The anchor used in this implementation of the method may be a S2 alar iliac bone screw.

While multiple embodiments are disclosed, still other embodiments of the present disclosure will become apparent to those skilled in the art from the following detailed description, which shows and describes illustrative embodiments of the disclosure. As will be realized, the invention is capable of modifications in various aspects, all without departing from the spirit and scope of the present disclosure. Accordingly, the drawings and detailed description are to be regarded as illustrative in nature and not restrictive.

BRIEF DESCRIPTION OF THE DRAWINGS

The following figures illustrate various aspects of the invention.

FIG. 1 is an isometric view of a first embodiment of a system for anchoring one or more elements of a spinal stabilization system.

FIG. 2 is an isometric view of the first embodiment of the system with the implant assembly separated from the delivery tool.

FIG. 3 is a posterior view of a first embodiment of an implant assembly implanted within a sacroiliac joint; a rod element of a spinal stabilization system is attached to an attachment element of the implant assembly.

FIG. 4 is a side isometric view of the implant assembly of the first embodiment attached to the rod element from the spinal stabilization system.

FIG. 5 is a side isometric of an implant body of the implant assembly in the first embodiment.

FIG. 6A is a normal cross-sectional view of an insertion body of the first embodiment taken at section A-A of FIG. 5. FIGS. 6B and 6C are normal cross-sectional views of alternative embodiments that include insertion elements with curved contours.

FIG. 7A is a medial side view of the implant body of the first embodiment. FIGS. 7B and 7C are medial side views of implant bodies in alternative embodiments with proximally projecting extensions of the attachment elements. FIG. 7D and FIG. 7E are medial side views of additional alternative

embodiments that include proximally bent sections of the attachment elements.

FIG. 8A is a caudal side view of the implant body of the first embodiment. FIG. 8B is a caudal side view of an implant body with a proximally projecting extension of the insertion element similar to the alternative embodiments illustrated in FIGS. 7B-7C. FIG. 8C is a caudal side view of an implant body with a proximal/lateral projecting extension of the insertion element. FIG. 8D is a caudal side view of an implant body with a surface feature projecting distally from an attachment element. FIGS. 8E-8H are alternative embodiments that include chamfering, filleting, and ribbing along the interior corner of the implant body; the interior corner is an enlargement of region B within FIG. 8A.

FIG. 9 is an isometric view of a second embodiment of the implant body; and, further includes a tool engagement peg situated on an edge of the attachment element in an embodiment.

FIG. 10A is a top view of the first embodiment of the implant body. FIG. 10B is a top view of the first embodiment of the implant body attached to a delivery device. FIG. 10C is a top view of an alternative embodiment that includes additional locations of the bore. FIG. 10D is a top view of an additional alternative embodiment that includes a projection projecting from a proximal end of the insertion element coupled to a rod element of a spinal stabilization system. FIGS. 10E-10H are cross-sectional views of the projection taken at section C-C of FIG. 10D. FIGS. 10I-10J are top views of attachment elements of implant bodies in other embodiments that include alternative planform profiles of the attachment elements.

FIG. 11A is a lateral side view of the implant body of the first embodiment. FIG. 11B is a side view of the implant body with a distally projecting extension of the attachment element and an anchor inserted in a lateral-medial trajectory: i) through the ilium (not shown), ii) through a bore in the distally projecting extension and across the sacroiliac joint

(not shown), iii) into sacrum (not shown), and iv) toward the sacral promontory (not shown).

FIG. 12A is a top isometric of a third embodiment of the implant body. FIGS. 12B and 12C are normal cross-sectional view of an anchor support element of the implant body taken at section D-D of FIG. 12A. FIGS. 12D-12F are various views of a portion of a pivoting anchor support element in an additional embodiment. FIGS. 12G-12H are isometric views of a portion of anchor support elements that include energy-absorbing elements in alternative embodiments.

FIG. 13A is a cranial side view of a fourth embodiment of the implant body. FIG. 13B and FIG. 13C are cranial side and top views, respectively, of an implant system that includes an anchor, a rotatable insertion element, and an indicator indicating an alignment of a bore of the rotatable insertion element with a bore of the attachment element.

FIG. 14 is a general side view of a section of the attachment element according to certain embodiments showing the anchor inserted through the anchor fitting at various anchor insertion angles.

FIG. 15A is a top view of the implant body in the third embodiment with the anchor inserted in a distal direction. FIG. 15B is a top view of the implant body in the third embodiment with the anchor inserted in a medial direction. FIG. 15C is a top view of the implant body in the third embodiment with the anchor inserted in a lateral direction.

FIG. 16A is a cross-sectional view of a vertical bore with a constant cross-sectional diameter. FIG. 16B is a cross-sectional view of an angled bore with a constant cross-sectional diameter. FIG. 16C is a cross-sectional view of a vertical bore with a hemispherical cross-sectional segment. FIG. 16D is a cross-sectional view of a vertical bore with a conical cross-sectional segment. FIG. 16E is a cross-sectional view of a vertical bore with a "compression plate" cross-sectional contour. FIGS. 16F-16G are cross-sectional views of additional bore cross-sectional contours.

FIG. 17 is front view of an anchor fitting with an anchor retention feature in one embodiment.

FIG. 18 is a side view of a polyaxial screw in one embodiment.

FIG. 19 is a side view of an attachment fitting in one embodiment.

FIG. 20 is a side view of the attachment fitting attached to the rod of a spinal stabilization system and fixed in place on the implant body.

FIG. 21 is an isometric view of a slideable socket in one embodiment.

FIG. 22 is a cross-sectional isometric view of the slideable socket in the one embodiment.

FIG. 23 is a side cross-sectional isometric view of the slideable socket in the one embodiment attached to the rod of a spinal stabilization system and fixed in place on the implant body.

FIG. 24 is a top view of the implant body in a fourth embodiment with a slideable attachment socket situated on a pivoting guide rail.

FIG. 25 is a top view of the implant body in a fifth embodiment with a first and second slideable attachment sockets situated on an elongated pivoting guide rail.

FIG. 26 is a bottom isometric view of an insertion plate of an implant body with a first embodiment of anti-migration surface features included on the exposed surfaces.

FIG. 27 is a front isometric view of an insertion plate of an implant body with a second embodiment of anti-migration surface features included on the exposed surfaces of the insertion plate.

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FIG. 28A is a front isometric view of an insertion plate of an implant body with a third embodiment of anti-migration surface features included in the form of notches distributed along longitudinally extending free edges or ends of the fins. FIG. 28B is a rotated side view of the insertion plate illustrated in FIG. 28A.

FIG. 29A is a front isometric view of an insertion plate of an implant body with a fourth embodiment of anti-migration surface features included in the form of are flared longitudinally extending free edges or ends of the fins. FIG. 29B is a transverse cross-sectional view of the insertion plate illustrated in FIG. 29A.

FIG. 30 is a side view of an anchor in a first embodiment.

FIG. 31 is a side view of an anchor in a second embodiment.

FIG. 32 is a top view of the anchor in the first embodiment.

FIG. 33A is a side view of a Steffee-type anchor in one embodiment. FIG. 33B is a side view of a Steffee-type anchor in a second embodiment including a nut and a driver segment configured with rounded/curved opposing faces to allow different angles between an anchor and plate.

FIG. 34A is a medial side view of the implant body of the first embodiment secured using the Steffee-type anchor illustrated in FIG. 33A. FIG. 34B is a medial side view of the implant body of the first embodiment secured using the Steffee-type anchor illustrated in FIG. 33B in which the longitudinal axis of the anchor is secured in a non-perpendicular alignment relative to the surface of the attachment element. FIG. 34C is a medial side view of the implant body of the first embodiment secured using a polyaxial screw similar to the one illustrated in FIG. 18.

FIG. 35 is an exploded view of the delivery tool in the first embodiment.

FIG. 36 is a close-up perspective view of the distal end of the delivery tool in the first embodiment.

FIG. 37 is a close-up perspective view of the distal end of the delivery tool in the first embodiment with an attached implant body.

FIG. 38 is a top view of an anchor arm attached to an implant arm of the delivery tool in the first embodiment.

FIG. 39 is a perspective view of a delivery tool in a second embodiment attached to an implant body.

FIG. 40 is a perspective view of the implant arm of the delivery tool in the second embodiment.

FIG. 41 is a longitudinal cross-sectional view of the implant arm of the delivery tool in the second embodiment.

FIG. 42 is a side view of an implant retaining arm.

FIG. 43A is a side cross-sectional/cutaway view of the delivery tool in a second embodiment attached to an implant body with an anchor and polyaxial screw installed. FIG. 43B is an isometric view of another embodiment of an implant assembly including an implant body with a polyaxial or monoaxial attachment fitting situated on the attachment element wherein the attachment fitting is located between a first and second attachment element bore.

FIG. 44A is a right lateral side view of a hip region of a patient lying prone, wherein the soft tissue surrounding the skeletal structure of the patient is shown in dashed lines.

FIG. 44B is an enlarged view of the hip region of FIG. 44A.

FIG. 45A is a lateral-posterior view of the hip region of the patient of FIG. 44A, wherein the patient is lying prone and the soft tissue surrounding the skeletal structure of the patient is shown in dashed lines.

FIG. 45B is an enlarged view of the hip region of FIG. 45A.

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FIG. 46A is a posterior view of the hip region of the patient of FIG. 45A, wherein the patient is lying prone and the soft tissue surrounding the skeletal structure of the patient is shown in dashed lines.

FIG. 46B is an enlarged view of the hip region of FIG. 46A.

FIGS. 47A-47Q are each illustrations of a step in the methodology in one embodiment and are each illustrated as a transverse cross section taken along a plane extending medial-lateral and anterior posterior along section 99-99 in FIG. 46B.

FIG. 48A is a posterior-lateral view of the hip region of the patient, illustrating the placement of a cannula alignment jig. FIGS. 48B-48C are additional isometric views of the cannula alignment jig.

FIG. 49A is a posterior-lateral view of the hip region of the patient, illustrating the placement of a drill jig. FIG. 49B is an isometric view of the drill jig illustrated in FIG. 49A. FIGS. 49C-49E are side, top, and front views, respectively, of a cannula in an embodiment. FIG. 49F is a posterior-lateral view of the hip region of the patient, illustrating the placement of the cannula illustrated in FIGS. 49C-49E for use during a sacroiliac joint procedure via a posterior inferior access region. FIG. 49G is a posterior-lateral view of the hip region of the patient illustrating the placement of the cannula of FIGS. 49C-49E. FIG. 49H is a posterior-lateral view of the hip region of the patient, illustrating the placement of the cannula of FIGS. 49C-49E, in which a posterior inferior access region of a sacroiliac joint articular region on a sacroiliac joint line is visible. FIG. 49I is a generally posterior-inferior view of the hip region of the patient, illustrating the placement of the cannula of FIGS. 49C-49E. FIG. 49J is a generally posterior-inferior view of the hip region of the patient, illustrating the placement of the cannula of FIGS. 49C-49E. FIG. 49K is a posterior-lateral view of the hip region of the patient, illustrating the placement of the cannula of FIGS. 49C-49E, wherein a posterior inferior access region of a sacroiliac joint articular region on a sacroiliac joint line is visible.

FIG. 50A is a lateral view of the hip region of the patient, illustrating the implant implanted in the caudal region of the sacroiliac joint space.

FIG. 50B is an anterior view of the hip region of the patient, illustrating the implant implanted in the caudal region of the sacroiliac joint space.

FIG. 50C is an enlarged view of the implant taken along the plane of the sacroiliac joint.

FIG. 50D is a transverse cross section of the implant and joint plane taken along section line 102D-102D of FIG. 50C.

FIG. 51A is a lateral-posterior view of the hip region of the patient illustrating the position and alignment of a delivery tool being used to deliver the implant to the sacroiliac joint space.

FIG. 51B is an enlarged view of the delivery tool and implant assembly within the hip region illustrated in FIG. 51A.

FIG. 52 is a lateral view of the hip region of the patient illustrating the position and alignment of a delivery tool being used to deliver the implant assembly to the sacroiliac joint space.

FIG. 53 is the lateral view of FIG. 52, with the implant assembly fully inserted into the prepared space in the sacroiliac joint.

FIG. 54 is the lateral view of FIG. 53 with the ilium removed to expose the sacroiliac joint space boundary defined along the sacrum and the implant positioned for implantation within the joint space.

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FIG. 55 is a posterior-inferior view of the hip region of the patient illustrating the position and alignment of a delivery tool being used to deliver the implant to the sacroiliac joint space; the soft tissues surrounding the skeletal hip bones are represented as dashed lines.

FIG. 56 is a posterior view of the implantation area and fully-inserted implant assembly.

FIG. 57 is a lateral-inferior-posterior view of the implant assembly and delivery tool positioned within a patient's hip skeletal structure.

FIG. 58 is an inferior-posterior view of the implant assembly and delivery tool positioned within a patient's hip skeletal structure.

FIG. 59 is a lateral side view of a hip region of a patient lying prone with the ilium removed showing the implant body positioned for implantation within the extra-articular space.

FIGS. 60A-60P illustrate successive steps in a second methodology embodiment; each step is illustrated within the transverse cross section taken along a plane extending medial-lateral and anterior posterior along section line 101-101 in FIG. 46B.

FIG. 61 is a posterior view of the implant assembly fully inserted within the implantation area.

FIGS. 62-91 are various views of the sacroiliac joint and associated skeletal structures of a patient illustrating the position and orientation of the delivery tool and/or implant assembly in various embodiments during implantation of the implant assembly within the extra-articular space of the sacroiliac joint using various embodiments of a method.

FIG. 92 is a side isometric view of a threaded cylinder insertion element in an embodiment.

FIG. 93 is a cross-sectional view of the threaded cylinder insertion element in the embodiment.

FIG. 94 is a side isometric view of the threaded cylinder insertion element reversibly coupled to a delivery tool in an embodiment.

FIG. 95 is a cross-sectional view of the threaded cylinder insertion element reversibly coupled to the delivery tool.

FIG. 96 is an isometric view of an implant assembly that includes a threaded cylinder insertion element reversibly coupled to a driver tool in an embodiment, wherein the insertion element is helically threaded and driven with rotation forces.

FIG. 97A is an exploded isometric view of an implant assembly mounted to a hemostat-type delivery tool in an embodiment. FIG. 97B is a close-up exploded isometric view of the implant assembly mounted to the hemostat-type delivery tool.

FIG. 98 is a side view of an implant system in which the implant body consists of multiple implant bodies or pieces (e.g., 2 or 3 or more pieces) in one embodiment thereby permitting motion at a sacroiliac joint.

Corresponding reference characters and labels indicate corresponding elements among the views of the drawings. The headings used in the figures should not be interpreted to limit the scope of the claims.

DETAILED DESCRIPTION

Implementations of the present disclosure involve an anchoring system for attaching one or more elements of a spinal stabilization system and concomitantly fusing, fixating, replacing, reconstructing, stabilizing or otherwise treating a sacroiliac joint. FIG. 1 is an isometric view of an anchoring system 10 in one embodiment. The system 10 includes a delivery tool 20 and an implant assembly 15 for

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delivery to a sacroiliac joint via the delivery tool 20. The implant assembly 15, which includes an implant body 25 and anchor 30, is configured to fuse or stabilize a sacroiliac joint once implanted at the joint. The implant assembly 15 further includes an attachment fitting 500 configured to attach to an element of a spinal stabilization system such as a rod 2096.

The delivery tool 20 is configured such that the anchor 30 can be quickly, accurately and reliably delivered to the implant body 25 supported off of the tool distal end 35 in a sacroiliac joint. Once the implant assembly 15 is delivered to the sacroiliac joint and secured in place using the anchor 30, the implant assembly 15 may be detached from the distal end 35 of the delivery tool 20, as illustrated in FIG. 2.

FIG. 3 is a posterior view of an ilium 1005 and sacrum 1004 forming a sacroiliac joint 1000. The implant assembly 15 is installed in the sacroiliac joint 1000 and secured in place by the anchor 30, which extends from the sacrum 1004 to the ilium 1005 in this embodiment. A rod 2096 from a spinal stabilization system may be attached to an attachment fitting 500 of the implant system 15 and locked into place, thereby providing a robust anchor for the spinal stabilization system. In addition to providing the robust anchor for the rod 2096, the implant assembly 15 also fuses or stabilizes the sacroiliac joint 1000 by virtue of the anchor 30, which may extend distally and laterally from the sacrum into the ilium to form the fused or stabilized joint as illustrated in FIG. 3. In some embodiments, the implant assembly 15 may also fuse or stabilize the sacroiliac joint 1000 by virtue of the insertion element 650 which may be configured to fixate the prepared joint surfaces thereby permitting bony fusion to occur through, around, near, up to or onto the implant body 25.

The embodiments of the anchoring system 15 overcome many of the limitations of previous anchoring methods used in conjunction with previous spinal stabilization systems. The implant body 25 is configured to fuse or stabilize the sacroiliac joint, thereby reducing the risk of degradation or failure of the sacroiliac joint to which the anchoring system 15 is attached. In addition to the anchor 30, which bridges the sacroiliac joint and secures the ilium to the sacrum, the implant body 25 of the implant assembly 15 includes an insertion element (no shown) that is situated within the sacroiliac joint in a distal orientation between the articular surfaces of the ilium and sacrum. The insertion element 650 may incorporate features such as surface textures, fittings, and/or receptacles for additional fasteners that enhance the grip of the insertion element within the sacroiliac joint. In addition, one or more of these features may facilitate the integration of surrounding bone tissue into the peripheral margins of the implant assembly 15 during chronic residence of the implant body 25 to further strengthen the fusion of the sacroiliac joint. This integration of bone tissue may further function as a redundant fusion fixation mechanism to compensate for any loosening of the anchor 30 or other fasteners anchoring the implant assembly 15 in place, thereby maintaining the integrity of the implant assembly 15 as an attachment for the spinal stabilization system.

Further, as discussed in further detail herein below, the implant assembly 15 has a relatively low profile, enabling the implantation procedure to install the implant assembly 15 using a smaller incision surgical procedure that entails removal of less bone and/or soft tissues to prepare the surgical area, resulting in a lower risk of post-operative pain and/or other adverse events. In addition, the low profile of the implant assembly 15 may reduce the risk of chronic soft

tissue irritation relative to existing devices and methods during long-term use of the implant assembly **15**.

Referring again to FIG. **3**, the attachment fitting **500** may be designed to permit the translation and/or rotation of the attached end of the rod **2096** through a wide range of motion and variety of directions, thereby facilitating the alignment of the rod **2096** within its associated spinal stabilization system without need for excessive bending of the rod **2096**. This adjustability may reduce reactive forces applied to the underlying implant body **25** and anchor **30** during any required bending of the rod **2096** during the installation of the spinal stabilization system. In addition, the enhanced adjustability afforded by the design of the attachment fitting **500** may result in the reduction of small misalignments of the rod **2096** within the spinal stabilization system, thereby reducing the occurrence of internal forces within the spinal stabilization system; this reduction in internal forces may reduce the risk of developing pain in regions surrounding the spinal stabilization system and/or degradation of joints adjacent to the afflicted joint. Furthermore, the various embodiments described herein may simplify the surgery and reduce operating time, fluoroscopy time (ionizing radiation from imaging technology) and anesthesia time thereby making the surgical procedure safer and more efficacious than conventional methods and systems. Further, the various embodiments described herein may further allow the treatment of patients who might otherwise not be able to undergo conventional surgery to treat a musculo skeletal pathology.

The implant assembly may be further configured to dissipate forces arising from an attached spinal construct over a greater surface area of the pelvis while acting as a shock absorber by a semi constrained communication between the components of a spinal construct and implant assembly **15**.

Detailed descriptions of various embodiments of the anchoring system **10** including the implant assembly **15**, delivery tool **20**, as well as methods of using the system **10** to provide an attachment for a spinal stabilization system are provided herein below.

I. Implant Assembly

To begin a detailed discussion of components of various embodiments of the implant assembly **15**, reference is made to FIG. **4**, which is a side isometric view of the implant assembly **15** with attached rod **2096** in one aspect. As shown in FIG. **4**, the implant assembly **15** includes an implant body **25**, an anchor **30**, and an attachment fitting **500**. The anchor **30** is configured to be received in a bore **40** defined through the implant body **25**. The bore **40** extends through the implant body **25** and is sized such that the anchor element **30** can extend through the implant body **25** as illustrated in FIG. **4** and into the underlying bone tissue (not shown).

The attachment fitting **500** in this embodiment is configured to be received within a guide **505** formed within the implant body **25**. In general, the guide **505** accommodates limited translations and/or rotations of the attachment fitting **500**, and further provides the ability to lock the attachment fitting **500** in a fixed position relative to the implant body **25** when the rod **2096** is locked into place within the attachment fitting **500**. The guide **505** may be a slot as illustrated in FIG. **4**, or any of a variety of other embodiments discussed in detail herein below.

a. Implant Body

To begin a detailed discussion of the implant body **25**, reference is made to FIG. **5**, which is a side isometric view of an implant body **25** in one embodiment. In general, the implant body **25** includes an insertion element **650** and an attachment element **652**. The insertion element **650** is configured to be inserted into the joint space of a sacroiliac joint

in a direction that is essentially parallel to, or sufficiently engaged with, the articulating surfaces of the sacrum and ilium to implement the robust anchoring of the implant body **25**.

Additional features of the insertion element **650** such as open and/or blind bores may interact mechanically with the anchor **30** (not shown) and optional additional fasteners to enhance the anchoring of the implant body **25**. Other additional features of the insertion element such as fins **50** or other projections such as surface textures (not shown) may enhance the grip of the insertion element **650** within the joint space of the sacroiliac joint; these other additional features may further enhance the integration of bone tissue within the joint space into the surface of the insertion element **650**, thereby strengthening the mechanical fusion and immobilization of the sacroiliac joint.

The implant body **25** also typically includes an attachment element **652** configured to mechanically interact with the anchor **30** to secure the implant body **25** to the sacroiliac joint. In addition, the attachment element **652** typically includes a guide **505**, such as the slot **505** illustrated in FIG. **4**. In general, the guide **505** is configured to receive the attachment fitting **500** (not shown) and allow limited translation and rotation of the attachment fitting **500** to allow for minor adjustments of the position and/or orientation of the rod **2096** (not shown) within the spinal stabilization system prior to locking the attachment fitting **500** to the guide **505** of the implant body **25**.

In various embodiments described herein below, the implant body **25** may have a variety of external shapes and cross-sectional profiles depending upon the desired properties and uses of the implant body **25**. For example, different shapes, sizes, and/or cross-sectional profiles of the implant body **25** may be selected to accommodate various patient morphologies, shapes and types of anchors and orthopedic fasteners, and/or any other relevant criteria.

In various embodiments, the implant body **25** may be machined, molded, formed, or otherwise manufactured from stainless steel, titanium, ceramic, polymer, composite, bone or other biocompatible materials.

Other features and aspects of the implant body **25** are discussed in detail herein below.

i. Insertion Element

Referring again to FIG. **5**, the implant body **25** includes an insertion element **650** that includes a flattened elongate insertion plate **45**. The insertion plate **45** has a medial face **654** and an opposite lateral face **656** (not shown) extending the width of the insertion plate **45** as well as opposed edges **658** extending the thickness of the insertion plate **45**. In entering the sacroiliac joint space, the implant body **25** is oriented such that its wide medial face **654** and lateral face **656** are oriented generally parallel to, and aligned with, the sacroiliac joint line and within the joint plane. Within the sacroiliac joint space, the medial face **654** is generally adjacent to the articulating surface of the sacrum and the lateral face **656** is generally adjacent with the articulating surface of the ilium.

Referring to FIG. **7A**, the insertion plate **45** may have a generally rectangular side profile (as viewed from a lateral or medial side). According to other embodiments, e.g., FIG. **9**, FIG. **39** and FIG. **43A**, the insertion plate **45** may have a generally triangular side profile. The side profile shape of an insertion plate **45** may be configured to match a portion of the articular surfaces of a sacroiliac joint. For example, a generally triangle shaped side profile of an insertion plate **45** may be best suited to match the area footprint of the articular surfaces of the sacroiliac joint, e.g., within an extra-articular

space or region, or to substantially fill the area footprint of a substantial majority of the entire articular surfaces of a sacroiliac joint. In another aspect, a generally rectangular side profile may be best suited to match a portion of the articular surfaces within an interarticular region of a sacroiliac joint, e.g., a caudal or cranial arm of the interarticular region. In another aspect, a generally C-shaped or L-shaped side profile may be selected to be configured to substantially cover an area of the articular surfaces of the sacroiliac joint within an interarticular region.

Although the insertion plate **45** illustrated in FIG. **5** has a generally flat planar profile, in general the insertion plate **45** may have any contour including, but not limited to curved, corrugated, and any other suitable contour. In one aspect, the contour of the insertion plate **45** may be selected to match the contour of the joint space in the sacroiliac joint within which the insertion plate **45** is to be inserted. In another aspect, a variety of insertion plates **45** may be formed with varying contours and the contour which best matches the contour of the sacroiliac joint of the patient to be treated is selected for use. In another additional aspect, the insertion plate **45** may be formed to be deformable by the surgeon; in this additional aspect the surgeon may bend or otherwise deform the insertion plate **45** to form an appropriate contour to match the contour of a patient's sacroiliac joint space, sacral surfaces, and/or iliac surfaces.

FIG. **92** is a side perspective view of an insertion element **650** in another embodiment. As illustrated in FIG. **92**, the insertion element **650** may be provided in the form of a threaded cylinder **820**. The insertion element **650** may include threads **822** that extend from the proximal end **43** to the distal end **42**, thereby allowing the insertion element **650** to be implanted by twisting the insertion element **650** into a preformed bore within a joint space. The proximal end **43** of the threaded cylinder may further include a driver tool fitting **824** including, but not limited to, a hexagonal driver head as illustrated in FIG. **92**. In another embodiment, the proximal end **43** may further include a projecting fastener fitting **826** that may function as an anchor for an element of a spinal support system, or alternatively to fasten an attachment element **652** to the insertion element **650**. For example, the fastener fitting **826** may be threaded (not shown) and may function in a manner similar to a Steffee bolt.

In this embodiment, the threaded cylinder **820** may further include one or more transverse bores **828** configured to receive one or more additional fasteners inserted transversely through the surrounding ilium bone in a lateral to medial direction, or through the surrounding sacrum bone in a medial to lateral direction in various embodiments. FIG. **93** is a cross-sectional view of the threaded cylinder **820**. As illustrated in FIG. **93**, in one embodiment the cylinder **820** may be hollow, and the transverse bores **828** may direct a fastener along a diameter of the lumen to corresponding opposite bores aligned along a diagonal path opposite to the first transverse bores **828**.

FIG. **94** is a side isometric view of the threaded cylinder **820** reversibly coupled to a delivery tool **20**. FIG. **95** is a longitudinal cross-section of the threaded cylinder **820** reversibly coupled to the delivery tool **20**. Referring to FIG. **94** and FIG. **95**, the delivery tool **20** may include a cannula **1054** to guide the insertion of the various other elements of the delivery tool **20**. The threaded cylinder **820** may be inserted over the guide pin (not shown) or tubular member **1047** in which the distal end **832** may be inserted within a joint space (not shown) within which the threaded cylinder **820** is to be inserted. The driver tool **838** and associated distal hexagonal socket **834** may be inserted such

that the distal hexagonal socket **834** is situated over the driver tool fitting **824**. A first proximal handle **840** provides torque to drive the threaded cylinder **820** into the joint space (not shown). As illustrated in FIG. **95**, a guide ring **835** and associated guide tool **836** may be inserted over the driver tool fitting **824** projecting proximally from the proximal end **43** of the threaded cylinder **820**. The guide tool **836** terminates proximally in a second proximal handle **842**.

In particular embodiments, the lateral and medial surface contours of the insertion plate **45** may be selected to match the contour of the joint space in the sacroiliac joint within which the insertion plate **45** is to be inserted. For example, the medial or sacral face **654** of insertion plate **45** may be configured to be generally convex to match the contour of a sacral auricular bony surface or to match the contour of an extra-articular region of a sacrum (e.g., a sacral fossa). In one aspect, the sacral or medial bone interface surface **654** of the insertion plate **45** may be generally a surface negative of the articular surfaces **1016** of the extra-articular space **3007** and/or interarticular region **1044** of the sacrum **1004**. As another example, the lateral or iliac face **656** of the insertion plate **45** may be configured to be generally concave to match the contour of an iliac auricular bony surface or to match the contour of an extra-articular region of an ilium (e.g., an iliac tuberosity). In one aspect, the iliac or lateral bone interface surface **656** of the insertion plate **45** may be generally a surface negative of the articular surfaces **1016** of the extra-articular space **3007** and/or interarticular region **1044** of the ilium **1005**.

1. Fins

In one embodiment, the insertion plate **45** includes a distal or leading end **42**, a proximal end **43**, and one or more keels, fins or planar members **50** that extend perpendicularly away from the medial face **654** and/or lateral face **656** of the insertion plate **45**. The fins **50** typically extend in length from the proximal end **43** to the distal end **42** of the insertion plate **45**. In some embodiments, the fins **50** may extend along any one or more portions of the full distance between the proximal end **43** and the distal end **42** of the insertion plate **45**.

FIG. **6** is a normal cross-sectional view of the insertion plate **45** in FIG. **5** taken at section A-A. Referring to FIG. **6**, the fin **50** extends perpendicularly away from the medial face **654** and a second fin **50A** extends perpendicularly away from the lateral face **656** of the insertion plate **45** in this embodiment. In one embodiment, the fins **50** and **50A** may be grouped into pairs that are generally coplanar with each other, as illustrated in FIG. **6**; fins **50** and **50A** in this embodiment generally exist in the same plane. In various other embodiments, the fins **50** and **50A** may extend in directions that are generally parallel to one another, but not necessarily coplanar as illustrated in FIG. **6**. For example, the fin **50** may extend along a plane that is parallel but offset from the extension plane of the second fin **50A**.

In various embodiments, the number of fins **50** extending from the medial face **654** and/or lateral face **656** of the insertion plate **45** may vary without limitation. The number of fins **50** extending from the medial face **654** need not be equal to the number of fins **50** extending from the lateral face **656**. In one aspect, all fins **50** may be identical in cross-sectional size and shape. In other aspects, one or more fins **50** may differ in cross-sectional size and shape.

Referring again to FIG. **6**, the width W_1 of the insertion plate **45** extending between the opposed edges **658** may range from approximately 5 mm to approximately 30 mm in one embodiment. In another embodiment, the thickness T_1 of the insertion plate **45** between the medial face **654** and the

opposite lateral face 656 may range from approximately 2.5 mm to approximately 15 mm. The overall length of the insertion plate 45 extending from the proximal end 43 (not shown) and the distal end 42 (not shown) may range between approximately 5 mm and approximately 70 mm. In other embodiments, W_1 may vary at or between ends 42 and 43.

In an additional embodiment, the perpendicular extension distance D_1 of the fins 50 measured relative to a plane 660 situated midway between the medial face 654 and lateral face 656 and parallel to both faces 654/656 may range between approximately 2.5 mm and approximately 18 mm. The thickness T_2 of the one or more fins 50 width may range from approximately 1 mm to approximately 10 mm.

In these various aspects, the dimensions of the insertion plate 45 and associated one or more fins 50 can and will vary based on various aspects. The thickness T_1 of the insertion plate 45 may be selected to exert firm pressure against the articulating surfaces of the sacrum and ilium within the joint space without undue stretching or distortion of the sacroiliac joint and surrounding soft tissues. The width W_1 of the insertion plate 45 may be selected to fit within the sacroiliac joint along the joint line, and to provide sufficient structural integrity to the insertion plate 45 while minimizing the extent of bone and soft tissue removal needed to prepare the sacroiliac joint to receive the insertion plate 45.

The perpendicular extension distance D_1 of the one or more fins 50 may be selected to result in the incursion of the one or more fins 50 into the articulating bone surfaces within the sacroiliac joint in order to facilitate the integration of bone tissue into the surface of the insertion plate 45. In addition, the perpendicular extension distance D_1 , fin thickness T_2 , and/or length of the one or more fins 50 may be configured to provide structural reinforcement to the insertion plate 45 to resist deflection in any direction. In one embodiment, the one or more fins 50 may provide structural reinforcement against bending deflections in the medial and/or lateral directions.

2. Tapered Distal End

Referring back to FIG. 5, the distal end 42 of the insertion plate 45 may taper in a pointed end, a bullet nose, or any other otherwise rounded configuration, wherein the rounded configuration extends outward away from the distal extremity of the insertion plate 45 and along the distal or leading edge 662 of the insertion plate 45 as well as the distal or leading edge 57 of the one or more fins 50. FIG. 7 is a side view of the implant body 25 looking toward the medial face 654 of the insertion plate 45. FIG. 8 is a second side view of the insertion body 25 looking toward one of the edges 658 of the insertion plate 45. Thus, as can be understood from FIGS. 5 and 7, 9-13, the leading or distal edge 42 of the insertion plate 45 and the leading edge 57 of the fins 50 may be rounded in the radially extending length of the lead or distal edges and/or in a direction transverse to the radially extending length of the lead or distal edges. In one embodiment, the leading edges 57 of the fins 50 may each have a radius R_2 ranging from approximately 1 mm to approximately 15 mm and the leading edge 42 of the insertion plate 45 may have a radius R_1 ranging from approximately 1 mm to approximately 15 mm. In another embodiment, the leading edge 42 of the insertion plate 45 and the leading edges 57 of the fins 50 may have a generally conical pointed configuration, a polygonal configuration, or an elliptical dome configuration.

3. Delivery Tool Fittings

As indicated in FIGS. 5, 7, and 8 the proximal end 43 of the insertion plate 45 may have a generally planar face that

is generally perpendicular to a proximal-distal center axis CA of the insertion plate 45 in one embodiment. Referring back to FIG. 5, the generally planar face of the insertion plate 45 may facilitate the secure attachment of the implant assembly 15 to the distal end 35 of the delivery tool 20, which may have a generally planar distal face (not shown). In other embodiments, the proximal end 43 of the insertion plate 45 may be contoured to match a corresponding contour of the distal face of the delivery tool 20. For example, the proximal end 43 of the insertion plate may have a domed contour that matches a corresponding cupped contour of the distal face of the delivery tool 20, or vice-versa.

In various embodiments, the proximal end 43 of the insertion plate 45 may define or contain one or more additional features to effectuate a reversibly locked engagement with the distal end 35 of the delivery tool 20. Referring back to FIG. 5, a center attachment bore 70 may be defined in the proximal end 43 of the insertion plate 45 in one embodiment; this center attachment bore 70 may be centered about the longitudinal center axis CA. In one embodiment, the center attachment bore 70 may be a blind hole in that it only has a single opening. Alternatively, the center attachment bore 70 may be configured as a hole that communicates between the proximal end 43 and distal end 42 of the insertion plate 45. Bore 70 may alternatively or additionally communicate with the lateral or medial surfaces of an insertion element 650 in order to permit the introduction by injection, or by any other known means of introduction, of stem cells or other biocompatible material up to or near the joint surfaces via the bore 70. The center attachment bore 70 may further incorporate additional features to receive an element of the delivery tool 20 in a reversibly locked engagement. For example, the center attachment bore 70 may contain threads matched to the threads of a set screw used to secure the distal end 35 of the delivery tool 20 to the implant assembly 25.

In other embodiments, the proximal end 43 of the insertion plate 45 may include additional features to further enhance the reversibly locked engagement with the delivery tool 20. In one embodiment, the proximal end 43 may contain one or more additional lateral attachment bores 75 (not shown) offset from the center bore 70. These lateral attachment bores 75 may be threaded to receive one or more additional set screws in an embodiment. In another embodiment, these lateral attachment bores may be shaped to match corresponding alignment pegs protruding from the distal end 35 of the delivery tool 20.

In other additional embodiments, protruding or recessed elements situated on or within the implant assembly 15 may be configured to interface with pliers, hemostats or other delivery tool configurations. FIG. 97A is an isometric view of a hemostat-type of delivery device 20. FIG. 97B is a close isometric view of the jaws 902 of the delivery device 20. As illustrated in FIG. 97B, each of the jaws 902 terminate distally in a projecting alignment peg 904 that fits within a recessed element or other tool attachment fittings formed in or on the implant body 25. The locked engagement of the alignment pegs 904 within the recessed elements or other tool attachment fittings resists any tendency for the implant body 25 to rotate during insertion into a joint space using the delivery tool 20. FIG. 12 illustrates an implant body 25 that includes a recessed element 154 suitable for use with the hemostat-type of delivery device 20 illustrated in FIG. 97A-B.

FIG. 9 is an isometric view of a second embodiment of an implant body 25. In this embodiment, an additional lateral attachment bore 75 is provided in the form of an alignment

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peg receptacle. This alignment peg receptacle **75** may be a blind hole configured to receive an alignment peg protruding from the distal end **35** of the delivery tool **20** (not shown).

In one embodiment, the center bore **70** may have a diameter ranging from approximately 2 mm to approximately 10 mm. In another embodiment, the one or more lateral attachment bores may each have a diameter ranging from approximately 0.5 mm to approximately 3 mm.

FIG. **10A** is a top view of the first embodiment of the implant body **25** illustrated in FIG. **5**. In an embodiment, the outer contour **664** of the proximal end **43** of the insertion plate **45** may be contoured to fit within two or more additional alignment pins **150** protruding in a distal direction from the distal end **35** of the delivery tool (not shown). FIG. **10B** is the top view of the implant body **25** illustrated in FIG. **10A** with the distal end of the delivery tool **20** mounted in place. In this embodiment, the additional alignment pins **150** project in a distal direction to entrap the lateral margin of the proximal end **43**. In this configuration, the additional alignment pins **150**, in cooperation with a set screw **95** advanced into the central bore **70** of the implant body **25**, secure the delivery tool **20** to the implant body **25** and prevent the delivery tool **20** from translating or rotating relative to the implant body **25**.

In an embodiment, the implant body **25** is fixed in place within the joint space of the sacroiliac joint by means of an anchor **30** directed through a bore **40**. In another embodiment, the insertion plate **45** may further include one or more additional bores **670**. The additional bores **670** may be directed through the corner formed by the attachment element **652** and the insertion element **650** as illustrated previously in FIG. **5**. Referring to FIG. **10A** and FIG. **10B**, the additional bores **670A** and **670B** may be accessed via anchor guides **1082** and **1084**, respectively. In this embodiment, the anchor guides **1082** and **1084** may direct the anchors **30** along a direction consistent with the central axes of the additional bores **670A** and **670B**. FIG. **11A** is a lateral side view of the implant body **25** viewing the lateral face **656** of the insertion plate **45** in one embodiment. In this embodiment, one or more bores **670** may be formed in the insertion plate. The one or more additional bores **670** may be open bores passing through the insertion plate **45** in one aspect. In another aspect, the one or more additional bores **670** may be blind bores opening to the medial face **654** and/or opening to the lateral face **656**. For example, the one or more additional bores **670** may be blind bores opening to the lateral face **656** of the insertion plate **45** as illustrated in FIG. **11A**.

The one or more additional bores **670** may be provided with any cross-sectional profile and dimension without limitation. In one embodiment, each of the one or more additional bores **670** may have a cross-sectional profile that is square, rectangular, circular, oval, triangular and any combination thereof. For example an additional bore **670** may have a round cross-sectional profile within a first bore segment and transition to a round cross-sectional profile in a second bore segment. In another embodiment, one or more additional bores **670** may be further configured to permit an anchor **30** directed through a bore **40** to be further advanced through a bore **670**, which is substantially greater than the diameter of the anchor **30**, within a predetermined range of trajectories. In this other embodiment, the anchor **30** may be inserted as selected by a surgeon within a predetermined range of trajectories at the time of implantation while still passing through a bore **40** and further through an additional bore **670**. For example, as illustrated in FIG. **43** and described herein below, a second anchor arm **115B** may

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include a conical sleeve **165B** that effectuates the insertion of an anchor **30** within a predetermined range of anchor insertion angles; this predetermined range of insertion angles may be constrained by the contour of the conical sleeve **165B**, as well as by the location and cross-sectional profile of the bore **40** and/or the location and cross-sectional profile of any additional bores **670**. The conical sleeve **165B** may be included in the delivery device **20** to facilitate the placement and insertion of fasteners in which some latitude in placement may be desired. Furthermore, the one or more additional bore **670** may provide an open channel, pathway, other connection to permit bone growth between a sacrum **1004** and ilium **1005** through one of more elements of the implant body **25**, including, but not limited to, the insertion element **650**. In various embodiments, the conical sleeve **165B** may be configured to guide the trajectory of any suitable fastener including, but not limited to, polyaxial bone fasteners and pedicle screws.

4. Additional Fastener Bores

Each of the one or more additional bores **670** may be configured to receive an orthopedic fastener including, but not limited to a screw, a pin, or any other known orthopedic fastener. In one aspect, if the one or more additional bores **670** may be blind bores, each additional bore **670** may be configured to receive the distal end or tip of the orthopedic fastener; in this aspect, each additional bore may be provided with a locking mechanism to mechanically retain the shaft, distal end, and/or tip of the orthopedic fastener. In another aspect, if the one or more additional bores **670** may be open bores, each of the additional bores **670** may be configured to receive a center portion of the shaft of the orthopedic fastener. In this other aspect, the diameter of each additional bore **670** may be sized to allow the passage of the shaft of the orthopedic fastener with little mechanical play to restrict the orientation the orthopedic fastener relative to the insertion plate **45**. Alternatively, the diameter of each additional bore **670** may permit some degree of mechanical play in order to permit a limited variation in the orientation of the orthopedic fastener relative to the insertion plate **45**.

In one embodiment, the orientation of the bore axis of each additional bore **670** may be aligned perpendicular to the medial face **654** and/or lateral face **656** of the insertion plate **45**, as illustrated in FIG. **11A**. In other embodiments, the bore axis of each additional bore may have any orientation without limitation. In general, the orientation of the one or more additional bores **670** may be selected in order to facilitate the incorporation of additional orthopedic fasteners directed medially toward the implant body **25** from the ilium and/or directed laterally toward the implant body **25** from the sacrum. For example, an orthopedic fastener may be directed from the ilium, through an additional open bore **670**, and into the sacrum; the fastener may enhance the anchoring of the implant body **25** within the joint space of the sacroiliac joint as well as strengthening the fusion and fixation of the sacroiliac joint and subsequent spinal construct from the lumbar spine.

In an additional embodiment, an additional bore **670** may be an open bore configured to guide the anchor **30** in cooperation with the bore **40** within the attachment element **652** of the implant body **25**. FIG. **13A** is a side view of an implant body **25** with an anchor **30** inserted through the bore **40** in the attachment element **652** and additionally through the additional bore **670** in the insertion plate **45**. As illustrated in FIG. **13A**, the aligned bore axes of the bore **40** and the additional bore **670** are configured to guide the anchor **30** into the underlying bone tissue at a laterally-directed downward angle. In general, the bore axes of the bore **40** and the

additional bore 670 may be aligned at any angle without limitation, constrained only by dimensions of the insertion element 650 and the attachment element 652 of the implant body 45.

In another embodiment, illustrated in FIG. 5, additional bores 670A and 670B may be at least partially directed through the corner formed by the attachment element 652 and the insertion element 650. The additional bores 670A and 670B are configured to guide the anchor 30 into the underlying bone tissue at a laterally-directed downward angle. The additional bores 670 in this embodiment may be threaded as illustrated as additional bore 670A or unthreaded as illustrated as additional bore 670B in FIG. 5.

In other additional alignments, the additional bores 670 may be open bores formed within additional attachment plates of various sizes projecting in various orientations relative to the attachment element 652 of the implant body 45. In one aspect, illustrated in FIG. 7B, the attachment element 652 may include an additional attachment plate 794 containing one or more additional bores 796; an anchor 30 may be inserted through each additional bore 796 to secure the implant assembly 25 in place. The additional attachment plate 796 may vary in length and may be relatively short as illustrated in the additional attachment plate 796 shown in solid lines in FIG. 7B or may extend up to the full extent of the edge of the implant assembly 25 from which the additional attachment plate 794 projects.

In these other additional aspects, the additional attachment plate 794 may contain one or more additional bores 796. By way of non-limiting example, the additional attachment plate 794 may include a single additional bore 796 as illustrated in FIG. 7B. By way of another non-limiting example, the additional attachment plate 794 may include multiple additional bore 796A-796B as illustrated in FIG. 7C.

Also in these additional other aspects, the additional attachment plate 794 may project at a variety of orientations relative to the attachment element 652 of the implant body 45. In one aspect, the additional attachment plate 794 may project in a proximal direction as illustrated in FIG. 7B and FIG. 7C, as well as in side view in FIG. 8B. In this one aspect, the additional bore axis 798 is essentially perpendicular to the proximal-distal center axis CA. In a second aspect, illustrated in FIG. 8C the additional attachment plate 794 may project at an angle such that the additional bore axis 798 is shifted an angle 800 away from perpendicular to the proximal-distal center axis CA. In a third aspect, the additional attachment plate 794 may project in a cranial or caudal direction as illustrated in FIG. 7D and the additional bore axis 798 may be deflected at an angle 802 relative to the proximal-distal center axis CA.

The angle at which the additional attachment plate 794 projects may be preformed in the implant assembly 25, or the angle may be set and or adjusted by deforming the additional attachment plate 794 along the edge at which the additional attachment plate 794 joins the attachment element 652. By way of non-limiting example, a surgeon may select an implant assembly 25 with a preformed additional attachment plate 794 in order to achieve a closer fit of the regions of the implant assembly 25 with the local topology of the underlying bone tissue. In another non-limiting example, a surgeon may iteratively deform an additional attachment plate 794 during a surgical procedure in order to fine-tune the closeness of fit of the implant assembly 25 within the surgical region.

In various other aspects, the additional attachment plate 794 may be non-planar and may contain accessory bores

configured to contain accessory fasteners used for purposes other than securing the implant assembly 25 in place. In one aspect, the additional attachment plate 794 may project in a curved profile as illustrated in FIG. 7E. In this example, the curved additional attachment plate 794A may contain an accessory bore 804 configured to receive a set screw or pin 806. As illustrated in FIG. 7E, the curved additional attachment plate 794A may form a fitting within which a rod 2096 or other element of a spinal stabilization system may be secured using the set screw or pin 806.

In yet other additional embodiments, the additional bore 670 may be provided within certain elements of the implant assembly 15 that may require alignment in addition to the alignment inherently provided by the delivery tool. In one embodiment, illustrated as cranial and side views in FIG. 13B and FIG. 13C, the implant assembly 15 may include an anchor 30 inserted through a bore 1302 formed through a rotatable insertion element 1300. The rotatable insertion element 1300 may be helically threaded as illustrated in FIG. 13B and may be driven into the joint space of the sacroiliac joint using torques delivered by an insertion tool (not shown). In this embodiment, an indicator 1304 may be provided to indicate an alignment of the bore 1302 of the rotatable insertion element 1300 with a bore 40 of the attachment element 652.

ii. Attachment Element

Referring back to FIG. 5, the implant body 25 may further include an attachment element 652 configured to provide a guide 505 for the attachment fitting 500 that provides robust mechanical anchoring throughout a predetermined range of positions and orientations. In addition, the attachment element 652 is configured to receive the anchor 30 through a bore 40 formed in the attachment element 652. The bore 40 permits the insertion of the anchor 30 through the implant body 25 and into the underlying bone tissue at a predetermined range of positions and orientations.

In one embodiment, the attachment element 652 may include a lateral edge 672 that is mechanically attached to the proximal end 43 of the insertion element 650. In another embodiment, the attachment element 652 may include a medial edge 671 that is mechanically attached to the proximal end 43 of the insertion element 650. In an additional embodiment, the lateral edge 672 of the attachment element 652 may be welded, glued, joined using fasteners such as screws, or otherwise permanently attached at a fixed position and angle to the proximal end 43 of the insertion element 650 as illustrated in FIG. 5. In another embodiment, the attachment element 652 and the insertion element 650 may be formed as a single integrated structural element. In yet other embodiments, the lateral and/or medial edges of the attachment element 652 may be attached to the proximal end 43 of the insertion element 650 in a hinged attachment such that the angle formed between the insertion element 650 and the attachment element 652 may be varied within a predetermined range prior to fixing within the sacroiliac joint space to accommodate variations in patient morphologies.

FIG. 8 illustrates the angle θ formed between the insertion element 650 and the attachment element 652. In various embodiments, this angle θ may range between approximately 30° and approximately 120° to accommodate a range of patient morphologies. In one embodiment, the angle θ may be approximately a right angle, or may be approximately 90°, as illustrated in FIG. 8. Any intersection between attached edges of various elements of the implant body including, but not limited to, the insertion element 650

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and the attachment element **652** may include filleting, chamfering and/or ribbing along the interior and/or exterior corners.

In one embodiment, a variety of implant bodies **25** with a range of angles θ may be provided, and an implant body **25** with a particular angle θ that most closely matches the morphology of the patient to be treated may be selected for use. In another embodiment, a single implant body **25** in which the lateral or medial edge of the attachment element **652** and the proximal end **43** of the insertion element **650** are attached in a hinged attachment may provide a variable angle θ that may be customized to best accommodate the patient's morphology during the insertion of the implant body **25** into the sacroiliac joint space of the patient. In yet another embodiment, an implant body **25** with an initial angle θ in which the implant body **25** may be elastically and/or plastically deformed to alter the angle θ within a predetermined range (e.g., by a medical person) may be provided to the surgeon. In this other embodiment, a practitioner including, but not limited to a surgeon or other medical person, an apparatus, a surgical robot or a computer controlled device may deform the implant body **25** to accommodate the patient's morphological variation prior to inserting the implant body **25** into the sacroiliac joint space of the patient.

1. Anchor Fitting

In various embodiments, the attachment element **652** may include an anchor fitting **40** configured to receive an anchor **30**. The anchor fitting **40** mechanically interacts with the anchor **30** to mechanically fix the insertion plate **45** within the sacroiliac joint space of the patient. Referring back to FIG. **5**, the anchor fitting **40** may be provided in the form of an open bore **40**. In one embodiment, the open bore **40** may be provided with a bore diameter sufficiently large to permit limited mechanical play such that the anchor **30** may be inserted through the bore **40** throughout a range of insertion angles. In another embodiment, one or more portions of the attachment element **652** situated near an anchor fitting **40** may be further configured like a Steffee plate. In various other embodiments, the bore **40** may have any cross-sectional profile without limitation. Non-limiting examples of cross-sectional profiles suitable for the bore **40** include: circular, oval, slotted, square, rectangular and/or any combination and permutation of any cross-sectional profile.

FIG. **14** is a side view of a section of the attachment element **652** showing the anchor **30** inserted through the anchor fitting **40** in one embodiment. As illustrated in FIG. **14**, the anchor may be inserted at any of a variety of insertion angles Φ . The insertion angle Φ , as defined herein refers to an angle relative to a perpendicular axis PA aligned perpendicular to the attachment element **652**. In one embodiment, the attachment element **652** may be provided with a non-planar or contoured profile; in this embodiment, the perpendicular axis PA may be aligned perpendicular to a region of the attachment element **652** in close proximity to the bore **40**. In another embodiment, the insertion angle Φ may range between approximately 0° (i.e. perpendicular to the attachment element **652**) and approximately 45° . In another embodiment, the insertion angle Φ may be directed in any direction without limitation including, but not limited to anterior, lateral, medial, cranial, caudal, anterior, posterior, ventral, dorsal, and any intermediate direction without limitation. Other desired trajectories and starting locations are discussed throughout herein.

In various embodiments, the anchor insertion angle may be constrained to varying degrees by variations in the cross-sectional profile of the bore **40**. FIGS. **16A-16D** are a

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series of cross-sectional views of the cross-sectional anchor bores **40** in various embodiments. In one embodiment, the bore **40** may be a vertical bore with a constant diameter cross-sectional profile as illustrated in FIG. **16A**; an anchor **30** is shown inserted in the bore **40** to provide the orientation of the view. FIG. **16B** illustrates an angled bore **40** with a constant diameter cross-sectional profile. The embodiment illustrated in FIG. **16C** is a bore **40** that includes a hemispherical cross-sectional profile configured to permit a wider range of anchor insertion angles. FIG. **16D** illustrates a bore **40** that includes a conical cross-sectional profile configured to permit a wider range of anchor insertion angles.

Referring to FIGS. **9** and **13**, the anchor fitting **40** may act in cooperation with an additional bore **670** formed in the insertion element **652** as described previously herein. In this embodiment, the insertion path of the anchor **30** through the bore **40** and additional bore **670** may permit relatively limited mechanical play, thereby constraining the anchor insertion angle to a relatively narrow range. In another embodiment, the additional bore **670** may be provided in the form of a slot to provide for a wider range of mechanical play and permitted anchor insertion angles.

In various embodiments including, but not limited to the implant bodies **25** illustrated in FIG. **5** and FIG. **9**, the anchor fitting **40** may be provided as a bore, a slot, or any other suitable fastener guide formed in an essentially planar material. In various other embodiments, the anchor fitting **40** may be a discrete structure mechanically attached to an anchor support element of the attachment element **652**. Referring back to FIG. **12**, the anchor fitting **40** may be provided in the form of an anchor socket **40** mechanically attached to an anchor support element **674**. In this embodiment, the anchor socket **40** may be configured to permit anchor insertion angles through a relatively wide range of angles and directions. FIGS. **15A-15C** are top views of the implant assembly illustrated in FIG. **12**, illustrating anchors **30** inserted into anchor sockets **40** at a variety of anchor insertion angles and directions. The anchor **30** may be inserted at a relatively vertical insertion angle as illustrated in FIG. **15A**, in a more medial direction as illustrated in FIG. **15B**, or in a more lateral direction as illustrated in FIG. **15C**.

The anchor support element **674** is configured to mechanically hold the anchor fitting **40** in a fixed position and orientation in various embodiments. In one embodiment, the anchor fitting **40** may be attached in a fixed position to the anchor support element **674**. Referring back to FIG. **12**, the anchor support element **674** may have a rectangular cross-sectional profile to provide a fixed support for the anchor fitting **40** that is resistant to rotation. In general, the anchor support element **674** may have any cross-sectional shape without limitation. In another embodiment, the anchor support element **674** may have a circular cross section to permit the rotation of the anchor fitting **40** about the anchor support element **674** to permit a wider range of anchor insertion angles and directions.

In one embodiment, the anchor fitting **40** may be provided with additional anchor retention features to retain the anchor **30** in place during long-term use of the implant assembly **15**. As illustrated in FIG. **17**, which is an enlarged view of the anchor fitting **40**, the anchor fitting **40** has a plurality of arcuate members **320** distributed along an inner circumferential boundary **325** of a rim **330** of the anchor fitting **40**. There may be five or more or less arcuate members **320** distributed generally evenly about the inner circumferential surface **325** of the rim **330**.

In one embodiment, each arcuate member **320** has ends **332** that intersect the inner circumferential surface **325** of

the rim **330**, with a center point **335** of the arcuate member **320** that is offset or spaced apart from inner circumferential surface **325** of the rim **330**. Thus, in one embodiment, the arcuate members **320** may be deflectable so as to allow the head of the anchor member **30** (not shown) to pass between the center points **335** of the members **330** as the head of the anchor member **30** is seated in the anchor fitting **40**. As a result, the arcuate members **320** can act against the head of the anchor member **30** to prevent the anchor member **30** from working its way out of the anchor fitting **40** and opening **315** of the implant body **25**, thereby serving as an anchor member locking mechanism.

In another embodiment, the anchor fitting **40** may be provided with additional anchor retention features, such as a set screw, to retain the anchor **30** in place during long-term use of the implant assembly **15**.

2. Anchor

Referring again to FIG. **4** and FIG. **5**, an anchor **30** may be used to mechanically fix the insertion blade **45** of the insertion element **650** within the joint space of the sacroiliac joint in various embodiments. The anchor **30** may be in the form of an elongated body such as, for example, a nail, rod, pin, threaded screw, expanding body, a cable (e.g., configured with a ball end), etc. The anchor element **30** is configured to be received in a bore **40** defined through the implant body **25**. According to particular embodiments, the anchor **30** includes a flange located proximal to a threaded portion and protruding beyond the main anchor shaft diameter and sized larger than the attachment element bore in order to resist pullout and may further include a proximal end configured to allow the attachment of an attachment fitting including, but not limited to a poly-head attachment fitting.

In one embodiment, the anchor **30** may be a bone screw. Any suitable orthopedic-grade bone screw may be used as the anchor **30** including, but not limited to a cortical screw, a cancellous screw, a Steffee screw, and any other suitable orthopedic bone screw. FIG. **30** is a side view of an anchor **30** in one embodiment. The anchor **30** may include a head **302** and a shaft **304**. In various embodiments, the shaft **304** may be threaded along the full length of the shaft. The threads may be configured for insertion into cortical bone and/or cancellous bone in various other embodiments. The threads and/or shaft may be tapered. In various other embodiments the anchor **30** may be cannulated along the longitudinal axis of the anchor **30**. Additionally, the anchor **30** may be provided with bone windows communicating with the lumen of the cannulated anchor **30**.

In one embodiment, the shaft **304** may contain one or more threaded segments including, but not limited to a proximal threaded segment **306** and a distal threaded segment **308** as illustrated in FIG. **30**. The shaft **304** may further include one or more non-threaded segment **310**. In one embodiment, the non-threaded segment may be situated between the proximal threaded segment **306** and the distal threaded segment **308**, as illustrated in FIG. **30**. FIG. **31** is a side view of another embodiment of the anchor **30**, in which the non-threaded segment **310** is situated between the head **302** and the distal threaded segment **308**; this embodiment may function as a lag screw.

Referring back to FIG. **30**, the proximal threaded segment **306** and the distal threaded segment **308** may include similar thread patterns or dissimilar thread patterns according to the intended use of the anchor **30**. The anchor **30** may be inserted within the sacrum **1004**, which contains largely cancellous bone and may be additionally be inserted within the ilium, which contains cortical bone. In addition, the

anchor **30** may receive additional threaded fasteners including but not limited to threaded nuts, threaded sleeves, and other threaded fittings associated with elements of the spinal stabilization system. In various embodiments, one or more washers including, but not limited to curved washers and/or locking washers may be used in conjunction with the anchor **30** and/or any additional threaded fasteners. In various embodiments, the one or more threaded segments may be provided with any one or more thread patterns including, but not limited to a cortical thread pattern, a cancellous thread pattern, a metal screw thread pattern, and any other appropriate thread pattern known in the art.

In one embodiment, the proximal threaded segment **306**, which may be situated within the sacrum, may be provided with a cancellous thread pattern, as illustrated in FIG. **30**. In this same embodiment, the distal threaded segment **308**, which may be situated within the ilium, may be provided with a cortical thread pattern.

The anchor **30** may further include a tip **312** situated on a distal end of the shaft **304** opposite to the head **302**. In one embodiment, the tip **312** may be a rounded tip as illustrated in FIG. **30**. In other embodiments, the tip **312** may be self-tapping tip or any other suitable tip for an orthopedic bone screw known in the art.

The head **302** of the anchor **30** may be provided with any known screw head shape including, but not limited to: round, flat, hexagonal, square, and any other known screw head shape. Referring back to FIG. **30**, the head **302** may be a round head in one embodiment. A top view of the head **302** is illustrated in FIG. **32**. The head **302** may include a screwdriver fitting **314** configured to receive a screwdriver blade or fitting. The screwdriver fitting shape may be any known fitting shape including, but not limited to: a single slot, a cross insert (Phillips head fitting), a hexagonal inset, a star-shaped inset (TORX fitting), and any other known fitting shape.

In an additional embodiment, the anchor **30** may be a Steffee-type screw, as illustrated in side view in FIG. **33**. The Steffee-type anchor **30** may include the shaft **304**, the distal threaded portion **308**, and the distal tip **312**, as in previous anchor **30** embodiments. In addition, the Steffee-type anchor may include a driver segment **316** configured to be compatible with a known screwdriving or bolt insertion tool including, but not limited to, a wrench. For example, the driver segment **316** may have a hexagonal cross-section, thereby rendering the driver segment **316** compatible with a hexagonal wrench. In addition, the Steffee-type anchor **30** may include a threaded attachment segment **318** ending in a headless proximal end **324**. The headless proximal end provides the ability for additional fastener elements to be attached to the threaded attachment segment **318** including, but not limited to a first nut **320** and/or a second nut **322**.

FIG. **34** is a side view of the Steffee-type anchor **30** installed through the bore **40** of an implant body **25** to fix the implant body to the underlying bone tissue. In use, the distal threaded portion **308** may be inserted into the underlying bone tissue using a tool such as wrench attached to the driver segment **316**. Once the anchor **30** is situated in place, the implant body **25** may be situated over the protruding distal threaded portion **308** of the anchor such that the bore **40** is centered over the distal threaded portion **308**. The implant body **25** may then be situated such that the insertion element **650** is situated within the joint space of the sacroiliac joint. One or more fasteners, such as the second nut **322** may be installed on the distal threaded portion **308** such that the

attachment element **652** is sandwiched between the driver segment **316** and the second nut **322**, as illustrated in FIG. **34**.

In one aspect, the anchor **30** and associated fasteners such as the first and second nuts **320** and **322** may be machined, molded, formed, or otherwise manufactured from stainless steel, titanium, ceramic, polymer, composite, bone or other biocompatible materials. The material of the anchor **30** may be compatible for continuous contact with the implant body **25** and associated fasteners.

3. Attachment Fitting

In addition to the anchor fitting **40**, the attachment element **652** further includes an attachment fitting **500** in various embodiments. Referring back to FIG. **3**, the attachment fitting **500** is configured to attach to an element of a spinal stabilization system including, but not limited to, a rod **2096** in a locked mechanical position, thereby providing robust anchoring to the spinal stabilization system. In various embodiments, the attachment fitting **500** may be provided with one or more features to facilitate the positioning and orientation of the rod **2096** or other element of the spinal stabilization system; typically these one or more features may provide the ability to translate and rotate the attachment fitting in a variety of different directions. In various other embodiments, the attachment fitting **500** is configured to be located on and/or supported off attachment element **652**. For example, the attachment fitting **500** may be provided as a monoaxial or polyaxial attachment fitting **500** and the associated attachment element **652** may be configured substantially as a monolithic structural element.

In various embodiments, the attachment fitting **500** is configured to be received by a guide **505** formed within attachment element **652**. The guide **505** is configured to effectuate limited translational and rotational movements of the attachment fitting **500** prior to engagement of the attachment fitting **500** with the element of the spinal stabilization system. In addition, the guide **505** is configured to lock the attachment fitting **500** in a fixed position and orientation when the element of the spinal stabilization system is locked into place within the attachment fitting **500**.

Referring to FIG. **9**, the attachment fitting **500** may be a head **676** of a polyaxial orthopedic fastener **678** including, but not limited to a pedicle screw. In this embodiment, the polyaxial screw **678** may be inserted through a guide **505** in the form of a bore **680**. In this embodiment, the bore **680** is similar to the anchor bore **40** illustrated previously in FIG. **5** and discussed herein above. The cross-section profile of the bore **680** may be a slanted profile, as illustrated in FIG. **9**, or any other cross-sectional profile discussed herein above for the anchoring bore **40** and illustrated in FIGS. **16A-16D**. The cross-sectional profile of the bore **680** may be configured to permit the insertion of the polyaxial orthopedic fastener **678** within a predefined range of fastener angles and directions. In addition to providing an attachment point for an element of the spinal stabilization system, the polyaxial screw may further supplement the implant holding force provided by the anchor **30**.

FIG. **18** is a side view of a polyaxial screw **678** in one embodiment. The head **676** may be provided in the form of a tulip-like head **676** in one embodiment. In this embodiment, the head **676** may include at least two support elements **2812** and **2814** forming the sides of at least one upward-opening groove **2816**. The head **676** may further include a compression element **2818** forming the bottom surface of the groove **2816**. The inner surfaces of the at least two support elements **2812** and **2814** may further form a

threaded fitting **2820** into which a threaded compression nut **2822** may be inserted during use.

In this embodiment, the head **676** may be attached to the top end **2806** of the shaft **2804** such that the head **676** may rotate freely about a longitudinal axis of the shaft **2804** and/or in additional directions offset from the longitudinal axis of the shaft **2804**. In use, a rod **2096** (not shown) may be situated within the groove **2816**. The compression nut **2822** may be situated within the threaded fitting **2820** and advanced until the reinforcing element is held fixed between the compression nut **2822** and the compression element **2818**. In another aspect, the introduction of a compressive force onto the compression element **2818** by the compression nut **2822** via the reinforcement element may further introduce a holding force within the attachment of the head **676** to the top end **2806** of the shaft **2804** such that the head **676** may no longer rotate freely.

In one aspect, the polyaxial screw **678** may be machined, molded, formed, or otherwise manufactured from stainless steel, titanium, ceramic, polymer, composite, bone or other biocompatible materials. The material of the polyaxial screw **678** may be compatible for continuous contact material with the implant body **25**.

Referring back to FIG. **4**, the attachment fitting **500** may be provided in the form of a dedicated attachment fitting **500** in another embodiment. The attachment fitting **500** includes a tulip-head fitting similar to the head **676** of the polyaxial screw **678** described herein previously. In this other embodiment, the attachment fitting **500** is configured to translate within a guide **505** in the form of a slot **680**. Referring back to FIG. **5**, the slot **680** includes an opening **682** passing through the attachment element **652**. The slot **680** further includes a raised rim **684** protruding in a proximal direction from the attachment element **652** and forming the perimeter of the slot **680**.

The slot **680** may define any shape of pathway without limitation including, but not limited to: a straight line; a curve or arc; and any combination thereof. Referring again to FIG. **5** the slot dimensions may include a slot width SW, a slot height SH, and any other relevant slot dimension (not shown) including, but not limited to: slot length, slot curvature, slot orientation, and any other relevant slot dimension. In one aspect, the slot dimensions may be selected to be compatible with elements of the attachment fitting **500**.

FIG. **19** is an isometric view of the attachment fitting **500** in one embodiment. FIG. **20** is a close-up side view of the attachment fitting **500** in this embodiment. Referring to FIGS. **19** and **20**, the attachment fitting **500** may include at least two support elements **686** and **688** forming the sides of at least one upward-opening groove **690**. In addition to at least two support elements **686** and **688** may be configured to receive a locking nut **696** in a threaded engagement.

In this embodiment, the attachment fitting **500** further includes a shaft **692** configured to pass through the opening **682** of the slot **680** and an expanded distal portion **694**. In one non-limiting example, the shaft **692** may be a cylindrical element with a cylinder diameter that is slightly less than the slot width SW. The attachment fitting **500** is retained within the slot **680** due to the mechanical interference of the distal contact surface **700** of the expanded distal portion **694**, which protrudes distally from the slot **680**. In addition, the diameter of the proximal contact surface **698** of the attachment fitting **500** is larger than the slot width SW to prevent the attachment fitting **500** from passing through the slot in a proximal direction.

In use, a rod **2096** or other element of a spinal stabilization system may be inserted within the groove **690** and held in a

fixed attachment within the groove 690 by tightening down the locking nut 696, thereby pressing the rod 2096 against the lower surface 704 of the locking nut 696, the walls of the groove 690, and the raised rim 684 of the slot 680. In addition, the tightening of the locking nut 696 presses the contact surface 700 of the attachment fitting 500 against the distal surface 702 of the slot 680, effectuating a locked mechanic engagement between the attachment fitting 500 and the attachment element 652.

In one embodiment, a spinal rod reducer tool may be used to place a rod 2096 extending from a lumbar spine into or near the attachment fitting 500. In another embodiment, a spinal rod (parallel) distractor may be used to distract a lumbar vertebra situated a distance from one or more elements of the implant assembly 15. In this other embodiment, the lumbar vertebra may be distracted to restore a lost disc height between the lumbar vertebra and an adjacent vertebra including, but not limited to the L5-S1 disc height during a procedure to treat a medical condition. In an additional embodiment, a spinal rod (parallel) compressor may be used to compress and/or draw together certain components of the implant assembly 15 and/or associated tissues. For example, the spinal rod compressor may be used to draw adjacent surfaces of an ilium and a sacrum toward one another during a procedure to treat a medical condition.

In one embodiment, the contact surface 700 of the attachment fitting 500, the distal surface 702 of the slot 680, and the proximal contact surface 698 of the attachment fitting 500 may be essentially planar surfaces. In other embodiments (not shown), these contact surfaces may be curved in order to permit limited rotation about one or more axes to facilitate the placement and alignment of the rod 2096 or other element within the spinal support system.

Referring again to FIG. 12, the attachment fitting 500 may be provided in the form of a slideable socket 706 configured to attach in a reversibly locked mechanical engagement with a guide 505 in the form of a guide rail 708. FIG. 21 is an isometric view of the slideable socket 706 in one embodiment. Referring to FIG. 21, the slideable socket 706 may include at least two support elements 710 and 712 forming the sides of at least one upward-opening groove 714. In this embodiment, the slideable socket 706 may further include a channel 716 configured to receive the guide rail 708 in a sliding engagement. The proximal surface of the channel 716 may be formed by a slideable insert 718 configured to press on the proximal surface of the guide rail 708 to lock the slideable socket 706 onto the guide rail 708 in use.

FIG. 22 is a cross-sectional isometric view of the slideable socket 706 in another embodiment. In this other embodiment, the slideable socket 706 includes a distal element 720 and a proximal element 722. The distal element 720 forms the lower channel surface 724 and side channel surfaces 726. In addition, the distal element 720 includes a circular flange 728 that slideably engages a corresponding annular channel 730; this slideable engagement allows the proximal segment to rotate about a central axis 790 of the proximal segment 722. This rotation permits the rod 2096 or other element of a spinal stabilization system to be aligned along a wide range of angles, as illustrated in FIGS. 15A-15C.

Referring again to FIG. 22, the proximal portion 722 of the slideable socket 706 includes the at least two support elements 710 and 712 that include a threaded inner surface 732 configured to receive a locking nut 734 in a threaded engagement. Alternatively, the outer surface 795 may be threaded and configured to receive a locking nut (not shown). The proximal portion 722 further includes a slideable insert 736 configured to slide proximally and distally

within the essentially cylindrical lumen formed by the at least two support elements 710 and 712. The proximal surface 738 of the slideable insert 736 forms the bottom surface of the groove 714 and the distal surface 740 of the slideable insert 736 forms the proximal surface 718 of the channel 716 illustrated in FIG. 21.

FIG. 23 is a cross-sectional view of the slideable socket 706 mounted on the guide rail 708 and engaging a rod 2096 of a spinal stabilization system in a mechanically locked engagement. In use, the rod 2096 or other element of a spinal stabilization system may be inserted within the groove 714 formed by the proximal surface 738 of the slideable insert 736 and held in a fixed attachment within the groove 714 by tightening down the locking nut 734, thereby pressing the rod 2096 between the lower surface 744 of the locking nut 734 and the proximal surface 738 of the slideable insert 736. As the locking nut 734 is advanced into the slideable socket 706, the slideable insert 736 is shifted in a distal direction until the distal surface 740 of the slideable insert 736 contacts that proximal surface 746 of the guide rail 708. As the locking nut is further tightened, the guide rail 708 is pressed between the distal surface 740 of the slideable insert 736 and the lower surface 724 of the channel 716, thereby mechanically locking the slideable socket 706 in a fixed engagement on the guide rail 708.

In one embodiment, the guide rail 708 may include an end stop 742 with a cross-sectional area that is larger than the cross-sectional area of the channel 716 to prevent the slideable socket 706 from slipping off of the end of the guide rail 708 as illustrated in FIG. 23. In this embodiment, the guide rail 708 has a rectangular cross-sectional shape to prevent the slideable socket 706 from rotating about the longitudinal axis of the guide rail 708 as illustrated in FIG. 21. In general the guide rail may have any cross-sectional shape without limitation so long as the cross-sectional shape and dimensions of the channel 716 permit the insertion of the guide rail 708 in a sliding engagement.

In another embodiment (not shown) the guide rail 708 may have a circular cross-sectional shape to permit the slideable socket 706 to rotate about the longitudinal axis of the guide rail 708, thereby enhancing the ability of the slideable socket 706 to position the rod 2096 of the spinal stabilization system into a desired position and orientation. In this other embodiment, as before, the slideable socket may be locked into place by tightening the locking nut 734 into the slideable socket 706 as described herein previously.

In an additional embodiment, illustrated in FIG. 10D, the attachment element 652 may be provided in the form of a projection 708A projecting from the proximal end 45 of the insertion element 650. In this embodiment, a rod 2096 of a spinal support system may be attached to the projection 708A using a connector 706A. The projection 708A may have any cross-sectional profile without limitation. FIGS. 10E-10H illustrate non-limiting examples of suitable cross-sectional profiles of the projection 708A taken at section C-C of FIG. 10D in various embodiments.

FIG. 24 is a top view of an implant body 25 in an additional embodiment. In this additional embodiment, the guide rail 708 is divided into a fixed segment 748 and a pivotable segment 750 mechanically attached in a pivoting engagement including, but not limited to, a pin joint 752. The pin joint 752 permits the free end 754 of the pivotable segment 750 to rotate a pivot angle β within a predetermined range, thereby enhancing the ability of the slideable socket 706 to position the rod 2096 (not shown) of the spinal stabilization system into a desired position and orientation. In this additional embodiment, the pin joint 752 may be

locked to fix the pivot angle β at a desired position; non-limiting examples of suitable locking mechanisms include a locking pin, a set screw, and any other suitable hinge joint locking mechanism. In another additional embodiment, the guide rail **708** of the implant body **25** may include two or more pivotable segments **750**.

In yet other embodiments, the implant body **25** may include two or more slideable sockets **706** situated on the guide rail **708** of the attachment element **652**. FIG. **25** is a top view of an implant body **25** in one other embodiment. As illustrated in FIG. **25**, the guide rail **708** may be relatively elongated to accommodate a first slideable socket **706A** and a second slideable socket **706B**. In this other embodiment, the second slideable socket **706B** may be used to anchor a second element **2096B** of a spinal stabilization system. In additional embodiments, these elements may be configured to connect at least two implants in a fixed or stabilized relation.

In various other embodiments, the attachment fitting **500** may be attached in a fixed position to the attachment element **652** of the implant body **25**. In one aspect, illustrated in FIG. **43B**, the attachment fitting may be provided in the form of a tulip-like head **676** similar to the head of the polyaxial screw **678** described previously herein and illustrated in FIG. **18**. In this embodiment, the head **676** is attached to a post **4302** protruding proximally from the attachment element **652**. In various embodiments, the post **4302** may be fixed in position on the attachment element **652**. In one aspect, the post **4302** may be situated between one or more bores **40** and **40A** through which one or more anchors **30** and **30A** may be inserted into the underlying bone tissue as described previously herein. The shape of the post **4302** may be spherical to accommodate a polyaxial head **676** as illustrated in FIG. **43B**. In other embodiments, the post **4302** may be configured to attach to other forms of attachment fittings, such as monoaxial heads (not shown).

iii. Anti-Migration Features on Bone Contact Surfaces

In various embodiments, the implant body **25** may further include surface features and/or textures on any exposed surface making contact with underlying bone tissue. These surface features may interact with the bone tissue within the sacroiliac joint space mechanically and/or biologically and may include anti-migration surface features. These anti-migration surface features may assist in preventing the insertion plate **45** from loosening, moving, and/or migrating within the afflicted area during prolonged use by the patient. Non-limiting examples of exposed surfaces of the implant body **25** making contact with underlying bone tissue include: the insertion plate **45** including the medial face **654**, the lateral face **656**, the edges **658**, and/or the one or more fins **50**; the attachment element **652** including the distal surface. Non-limiting examples of anti-migration surface features include a plurality of projections, a plurality of serrated teeth or ridges, a plurality of perforations, or any other surface feature which may reduce the migration of insertion plate **45** and/or implant body **25**.

The surface features may be unidirectional in one embodiment. FIG. **26** is a bottom isometric view of an insertion plate **45** of an implant body **25** with anti-migration surface features **355** included on the exposed surfaces of the insertion plate **45** of the implant body **25**. As shown in FIG. **26**, the anti-migration features **355** are generally evenly distributed along the medial face **654**, the lateral face **656** (not shown), and each of the fins **50** in a rows and columns arrangement. The anti-migration features **355** are generally similarly distributed along the planar surfaces of the edges of the fins **50**. The anti-migration features **355** may be in the

form of trapezoids, squares, rectangles, etc. The anti-migration features **355** may have a rectangular cross sectional elevation with a thickness ranging from approximately 0.2 mm to approximately 5 mm. In another aspect, illustrated in FIG. **7A**, the anti-migration surface features **355** may be generally evenly distributed along a distal face **357** of the attachment element **652**. In this other aspect, the distal face **357** contacts the underlying bone tissue once the implant assembly **25** is inserted within the joint space of the sacroiliac joint.

As another example, as shown in FIG. **27** which is a front isometric view of an insertion plate **45** of an implant body **25** with another type of anti-migration surface features **355** included on the exposed surfaces of the insertion plate **45**. As shown in FIG. **27**, the anti-migration features **355** are in the form of unidirectional serrated teeth or ridges **355**, wherein the ridges **355** have a triangular cross sectional elevation wherein the rearward or trailing end of the features **355** are the truncated or vertical end of the triangle cross sectional elevation, and the front or leading end of the features **355** are the point end of the triangle cross sectional elevation. The anti-migration features **355** with the triangular cross sectional elevations have a thickness ranging from approximately 0.2 mm and approximately 5 mm, with one embodiment having a thickness FT of approximately 1 mm to approximately 15 mm. The triangular ridges **355** may be generally evenly distributed along the fins **50** in ridges that run transverse to the length of the insertion plate **45**. The anti-migration features **355** are generally similarly distributed along the planar surfaces of the edges of the fins **50**.

Although the anti-migration features **355** are depicted in the form of unidirectional serrated teeth or ridges **355** on each of the textured surfaces of the insertion plate **45** in this embodiment, the invention is not so limited and, as to particular embodiments, can be configured to have said features **355** arranged in multiple directions, unidirectional, or a combination of multiple direction on some surfaces of the insertion plate **45** and unidirectional on other surfaces of the insertion plate **45**. Accordingly, the features **355** can be so arranged on the various surfaces of the insertion plate **45** so as to prevent undesired migration in particular directions due to the forces present at the sacroiliac joint **1000**.

In another embodiment, illustrated in FIG. **8D**, the anti-migration features **355** may include one or more discrete projections **358**. As illustrated in FIG. **8D**, the discrete projections **358** may project in a direction toward the underlying bone and may further enhance the anti-migration features **355** of the implant assembly **25**. In one aspect, the discrete projections **358** may be in the form of a tapered perpendicular projection from a contact surface including, but not limited to, the tapered discrete projection **358** projecting distally from the distal face **357** of the attachment element **652** as illustrated in FIG. **8D**.

Depending on the embodiment, the insertion plate **45** may have an edge configuration of the fins **50** designed to prevent migration of the implant body **25** once implanted in the sacroiliac joint space. For example, as shown in FIG. **28A** which is a front isometric of an insertion plate **45** of an implant body **25**, the anti-migration edges **360** of the fins **50** are in the form of notches **365** generally evenly distributed along longitudinally extending free edges or ends of the fins **50**. As indicated in FIG. **28B**, a rotated side view of the insertion plate **45** illustrated in FIG. **28A**, the notches **365** may have parallel sides **370** inwardly terminating as an arcuate end **375**. The orientation of each notch **365** may be such that the center line NL of the notch **365** forms an angle NA with the center axis CA of the insertion plate **45** that

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ranges between approximately 90 degrees and approximately 15 degrees. As indicated in FIG. 28, each notch 365 may have a length LN between the extreme point on the arcuate end 375 and the outer edge boundary of the notch of between approximately 0.2 mm and approximately 10 mm. Each notch 365 may have a width WN of between approximately 0.5 mm and approximately 20 mm.

As another example, as shown in FIG. 29 which is a front isometric of an insertion plate 45 of an implant body 25, the anti-migration edges 360 are flared longitudinally extending free edges or ends of the fins 50. The edges 360 include a series of ridges 370 that are generally evenly distributed along the length of the edges 360 and oriented transverse to the length of the edges 360.

As indicated in FIG. 29, the ridges 370 have triangular cross sectional elevations with an overall height of between approximately 0.2 mm and approximately 8 mm. As illustrated in FIG. 29, the flared longitudinally extending free edges or ends of the fins 50 have rim edges 380 defining the edges of the anti-migration edges 360 of the fins 50, wherein the rim edges 380 have slopes 385 transitioning between the planar surfaces 65 of the fins 50 and the rim edges 380.

The edges 360 have a height EH between the edges 380 of between approximately 0.5 mm and approximately 15 mm, with one embodiment having a height EH of approximately 4 mm. The width EW of the flared edge 360 from the beginning of the sloped transition 385 to the face of the edge 360 is between approximately 0.2 mm and approximately 9 mm, with one embodiment having a width EW of approximately 1 mm.

In particular embodiments, the insertion plates 45 of the implant bodies 25 with features as described above with respect to FIGS. 26-29 can alternatively be configured to function as a broach or other surgical site preparation tool that can assist in the removal of certain tissues, for example, cartilage or bone, during certain steps of a procedure. In certain aspects, the implant body 25 may be configured as a trial to allow a surgeon presented with a number of different embodiments of implant bodies 25 to evaluate the different embodiments to assess the suitability of any particular embodiment for the treatment of a particular patient, an idiopathic anatomy, a particular implant receiving space and/or other application.

In one additional aspect, the exposed surfaces of the implant body 25 making contact with underlying bone tissue may be treated with a bone growth factor or other compounds to encourage bone tissue growth around the implant assembly 200. Non-limiting examples of exposed surfaces of the implant body 25 making contact with underlying bone tissue include: the insertion element 650 including the medial face 654, the lateral face 656, the edges 658, and/or the one or more fins 50; the attachment element 652 including the distal surface.

II. Delivery Tool

To begin a detailed discussion of components of an embodiment of the delivery tool 20, reference is again made to FIGS. 1 and 2. As shown in FIG. 2, the delivery tool 20 includes a distal end 35 and a proximal end 80. The distal end 35 supports the implant assembly 15 components including, but not limited to, the implant body 25. The proximal end 80 is configured to be grasped and manipulated to facilitate the implantation of the implant assembly 15 in the sacroiliac joint.

The delivery tool 20 further includes an arm assembly 85 made up of an implant arm 110 configured to retain the implant body 25 and an anchor arm 115 supported off of the

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implant arm 110 at a predetermined angle by an anchor arm fitting 112. In this embodiment, the delivery tool 20 may further include a handle 90.

a. Implant Arm and Locking Screw

FIG. 35 is an exploded isometric view of the delivery tool 20 illustrated previously in FIGS. 1 and 2. As illustrated in FIG. 35, the delivery tool 20 further includes an arm assembly 85, a handle 90, a locking screw 95, a sleeve 100 and a trocar or guidewire 105. The implant body 25 may be reversibly attached to the distal end 35 of the delivery tool 20 by inserting the locking screw 95 into the attachment bore 70 within the implant body 25 in one embodiment. FIG. 36 is a bottom isometric view of the distal end 35 of the delivery tool 20 in one embodiment. The locking screw 95 may be inserted through a bore 97 formed through the distal end 35 such that a distal tip 96 of the locking screw 95 may protrude from a planar extreme distal face 152 of the delivery tool 20. The locking screw 95 and attachment bore 70 may be provided with meshing threads to enable a reversibly locked engagement when the distal tip 96 of the locking screw 95 is advanced into the attachment bore 70.

In various embodiments, the attachment bore 70 and locking screw 95 are essentially aligned with the implant arm 110 as well as the direction of insertion of the insertion element 650 of the implant body 25, as illustrated in FIG. 36 and FIG. 37. In addition, the attachment bore 70 and locking screw 95 may be situated well away from the bore 40 within the attachment element 652. Without being limited to any particular theory, the arrangement reduces the potential for mechanical interference of the locking screw 95 with the other fasteners such as an anchor 30, associated implant assembly tools, and/or any other surgical instruments involved in implanting the implant body 25 within the joint space of a sacroiliac joint.

FIG. 39 is a bottom isometric view of a delivery tool 20 in a second embodiment. In this second embodiment, the arm assembly 85 includes a cannulated implant arm 110. In this embodiment, a first anchor arm 115A may be supported off of the implant arm 110 at first and second predetermined angles by a first anchor arm fitting 112A and second anchor arm fitting 112B, respectively.

FIG. 40 is a distal isometric view of the arm assembly 85 in one embodiment in which the anchor arms 115A/115B and anchor arm fittings 112A/112B have been removed for better visualization. In one or his embodiment, the distal end 120 includes a cylindrical opening 137 of a cylindrical bore 132, one or more fins 140/145, pins 150, and a planar extreme distal face 152. As depicted in FIG. 41, which is a longitudinal cross section of the implant arm 110 as taken along section line 20-20 in FIG. 40, the cylindrical bore 132 extends the full length of the implant arm 110 between the proximal opening 135 and the distal opening 137.

As illustrated in FIG. 42, which is a full isometric view of an implant retainer 95, the implant retainer 95 includes a longitudinal cylindrical member 210, a handle 215 on a proximal end 216 of the longitudinal cylindrical member 210, and a threaded implant retaining screw 220 on a distal end 218 of the longitudinal cylindrical member 210. As can be understood from FIGS. 9 and 39-42, when the system 10 is assembled for the delivery of the implant assembly 15 to the sacroiliac joint, the longitudinal cylindrical member 210 extending from the handle 215 (see FIG. 42) and implant arm bore 132 (see FIG. 41) such that a distal side of the handle 215 abuts or nearly abuts with the implant arm proximal end 125 (see FIG. 41) and the threaded implant retaining screw 220 is received in the implant attachment bore 70 (see FIG. 9). In one embodiment, the implant

retaining screw 220 is in the form of a threaded shaft for engaging complementary threads in the attachment bore 70 of the implant body 25, thereby securing the implant proximal face against the implant arm distal face. In other embodiments, the implant retaining screw 220 and the attachment bore 70 are configured so as to form an interference fit between the two such that an intentional separating force is required to remove the implant engagement feature from within the attachment bore 70 and allow the release of the implant body 25 from the distal end 120 of the implant arm 110.

b. Alignment Pegs

Referring again to FIG. 36, the extreme distal face 152 has an essentially planar surface contour in order to match the essentially planar surface contour of the implant body 25, particularly in the region surrounding the attachment bore 70 in various aspects. In addition, the distal face 152 may include additional alignment features including, but not limited to, one or more alignment pegs 150. These alignment pegs 150 may mechanically interlock with corresponding features on the implant body including, but not limited to, peg receptacles, and notches.

In one embodiment, the alignment pegs 150 may be arranged in a pattern matched to an edge contour of the proximal end 43 of the insertion element 650 of the implant body 25. FIG. 37 is a bottom isometric view illustrating the implant body 25 mounted to the distal end 35 of the delivery tool 20 illustrated in FIG. 36. In one embodiment, the locking screw 95 has been advanced and tightened into the attachment bore 70, thereby securing the proximal end 43 of the insertion element 650 against the distal face 152 of the delivery tool 20. The one or more alignment pegs 150 closely fit the edge contour of the proximal end 43, thereby providing alignment mechanisms and resistance against twisting of the implant body 25 relative to the delivery tool 20.

In another embodiment, the proximal end 43 of the implant body 25 may include one or more recesses 154 formed in the exterior surface of the implant body 25 to receive one or more alignment pegs 150 protruding distally from the distal face 152 of the delivery tool 20. Referring back to FIG. 12, one or more recesses 154 may be provided to receive the one or more alignment pegs 150 (not shown). In one aspect, the one or more recesses 154 may extend distally from the surface of the attachment element 652 for a distance DE ranging between about 0.2 mm and about 20 mm. According to particular embodiments, the recess 154 can extend from said exterior surfaces in the general direction of the attachment bore 70 a distance DA ranging between about 0.25 mm to about 5 mm. In a non-limiting example of a particular embodiment, the distal face 152 of the implant arm distal end 35 can be further configured to wrap completely or only a portion of the periphery of the proximal end 43 of the implant body 25.

In an additional embodiment, the surface of the implant body 25 contacting the distal face 152 of the delivery tool 20 may further contain one or more lateral bores 75 configured to receive one or more alignment pegs 150 protruding distally from the distal face 152 of the delivery tool 20. Referring back to FIG. 9, the pegs 150 (not shown) being received in the lateral bores 75 prevent the implant body 25 from pivoting relative to the distal face 152 of the delivery tool 20. The pegs 150 can be configured to have a rectangular, circular or any other cross section and the corresponding lateral bores 75 can also be configured to have corresponding shapes in cross section.

c. Anchor Arms

Referring again to FIGS. 1, 2, and 35, the arm assembly 85 includes an implant arm 110 and an anchor arm 115 supported off of the implant arm 110 at a predetermined angle by an anchor arm fitting 112. The anchor arm fitting 112 may be mechanically attached to the implant arm 110 and may include a bore 113. The anchor arm 115 may be mounted by situating the tines 116 projecting from the anchor arm on either side of the anchor arm fitting such that the fastener holes 117 formed within the tines 116 are aligned with the bore 113. The shaft 118 of the handscrew 119 may be inserted through the aligned fastener holes 117 and bore 113 to lock the anchor arm 115 in place. FIG. 38 is a top view of the anchor arm 115 mounted to the anchor arm fitting 112 on the implant arm 110 and secured in place by the handscrew 119. In one embodiment, the shaft 118 of the handscrew 119 may be threaded, and one or more of the fastener holes 117 and/or bore 113 may be provided with corresponding matching threads. In other embodiments, the shaft 118 of the handscrew 119 may be provided in the form of a retaining pin or any other reversibly locking alignment device.

As shown in FIGS. 1, 2, and 35, the anchor arm 115 is supported off of the implant arm 110 at an angle and includes a proximal end 155 and a distal end 160 distally terminating in a sleeve or collar 165 having a longitudinal center axis LCA_1 that is generally transverse to the longitudinal axis of the anchor arm 115. The collar 165 has a length of between approximately 10 mm and approximately 60 mm (e.g., 20 mm) disposed between collar ends 166 and 167 configured to permit and maintain accurate alignment of the first sleeve 100 along LCA_1 during the course of the procedure. The targeting proximal end 155 intersects the implant arm 110 at a location between the proximal and distal ends of the implant arm 110. In one embodiment, the proximal end 155 of the anchor arm 115 intersects proximal end 80 of implant arm 110. In another embodiment, the proximal end 155 of the anchor arm 115 is coupled to and/or supported off of the handle 90. Referring back to FIG. 39, the arm assembly 85 of the delivery tool 20 may include a first anchor arm 115A and second anchor arm 115B in another embodiment.

In various embodiments, each of the one or more anchor arms 115 are configured to guide one or more fasteners including, but not limited to the anchor 30 (see FIGS. 2 and 15) and the polyaxial screw 678 (see FIG. 9). In an embodiment, the anchor arm 115 may align the fastener along the direction LCA_1 (see FIG. 35) during insertion of the fastener. FIG. 43A is a side cross-sectional view of the implant body 25 attached to the delivery tool 20 in the embodiment illustrated previously in FIG. 39. As shown in FIG. 39, the anchor 30 may be guided through the first anchor arm 115A and the polyaxial screw 678 may be guided through the second anchor arm 115B.

In this embodiment, the first anchor arm 115A may have a sleeve 165A that is relatively narrow and of constant cross-sectional profile. As a result, the direction of insertion of the anchor 30 from the first anchor arm falls within a relatively narrow range. The second anchor arm 115B may have a conical sleeve 165B that permits the insertion of the polyaxial screw 678 along a range of insertion angles constrained by the contour of the conical sleeve 165B. The conical sleeve may be included in the delivery device 20 to facilitate the placement and insertion of fasteners in which some latitude in placement may be desired.

For example, the incorporation of a second anchor arm 115B with a conical sleeve 165B may permit a surgeon to select a desired insertion trajectory for the anchor 30 while

still passing the anchor **30** through, for example, a bore **40** and/or additional bore **670**. Non-limiting characteristics of a desired trajectory of the anchor may include one or more of: 1) entering at or near a S1 pedicle and further advanced in an anteromedial direction, and further toward or into sacral promontory and/or parallel to an S1 endplate; 2) entering the bone structure near or immediately adjacent a S1 or S2 foramen, and in a generally mediolateral direction further advanced to cross a sacroiliac joint, and further advanced to terminate in or through an ilium (e.g., along a midline between an inner and outer iliac wing table); or 3) be advanced down the plane of a sacroiliac joint.

Referring back to FIG. **35**, the longitudinal center axis LCA_1 of the targeting collar **165** forms an angle $A_{LCA1-LCA2}$ with the longitudinal center axis LCA_2 of the implant arm **110**. For example, the angle $A_{LCA1-LCA2}$ may be range between approximately 15 degrees and approximately 135 degrees. As can be understood from FIG. **39**, in one embodiment, the above-described coaxial and angular relationships between the anchor arm **115** and the implant arm **110** are rigidly maintained due to the anchor arm **115** and its anchor arm fitting **112** being in a fixed, non-adjustable configuration, and the interconnection between the proximal end of the targeting **115** and the implant arm **110** being a fixed, non-adjustable configuration at least with respect to the angle $A_{LCA1-LCA2}$ between the longitudinal center axis LCA_1 of the targeting collar **165** and the longitudinal center axis LCA_2 of the implant arm **110**. Thus, in one embodiment, the delivery tool **20** comes from the manufacture to the physician in a fixed, non-adjustable configuration having the coaxial and angular relationships articulated above with respect to FIG. **21A**.

Referring to FIG. **35**, the anchor arm **115** coaxial and angular relationships between the anchor arm **115** and the implant arm **110** may be adjustable in another embodiment. In this other embodiment, the anchor arm fitting **112** may be translated in a proximal or distal direction along the implant arm **110**. In addition, the angle of the axis LCA_1 may be adjusted by rotating the anchor arm **115** about the shaft **118** of the handscrew **119**. The angle of the axis LCA_1 may be maintained by locking the anchor arm **115** in place by tightening the handscrew **119**.

III. Method of Use

In various embodiments, a method of implanting the implant system **15** non-transversely into the joint space of the sacroiliac joint is provided. The method includes preparing an implant insertion space within the joint space, inserting the insertion plate **45** of the implant body **25** into the implant insertion space using the delivery tool **20**, and inserting an anchor **30** through a bore **40** within the implant body **25** to fix the implant body **25** in place using the delivery tool **20**. A detailed description of the anatomical landmarks associated with the method, as well as a description of the various stages of the method, including insertion space preparation, insertion of the insertion plate into the joint space, and anchoring of the implant is provided in detail herein below. The implant body **25** may be inserted via the extra-articular recess of the sacroiliac joint in an extra-articular approach in one embodiment. In another embodiment, the implant body **25** may be inserted via interarticular region **1044** in an interarticular approach.

a. Anatomical Landmarks

To begin a discussion regarding the methodology associated with employing any of the above-described delivery tools **20** in implanting any of the above-described implant bodies **25** in the sacroiliac joint **1000** of a patient **1001**, reference is first made to FIGS. **44A-46B** to identify the

bone landmarks adjacent, and defining, the sacroiliac joint **1000**. FIG. **44A** is a right lateral side view of a hip region **1002** of a patient **1001** lying prone, wherein the soft tissue **1003** surrounding the skeletal structure **1006** of the patient **1001** is shown in dashed lines. FIG. **44B** is an enlarged view of the hip region **1002** of FIG. **44A**. As illustrated in FIGS. **44A** and **44B**, a lateral view of the patient's hip region **1002** reveals certain features of the ilium **1005**, including the anterior superior iliac spine **2000**, the iliac crest **2002**, the posterior superior iliac spine (PSIS) **2004**, the posterior inferior iliac spine (PIIS) **2006**, the greater sciatic notch **2008** extending from the posterior inferior iliac spine **2006** to the ischial spine **2010**, and the tubercle of iliac crest **2012**. The sacroiliac joint articular region **1044** is shown in dashed lines. A posterior inferior access region **2016** of the sacroiliac joint articular region **1044** has a superior end **2018** on the sacroiliac joint line **2019** that is between approximately 0 mm and approximately 40 mm inferior the posterior inferior overhang **2020** of the posterior superior iliac spine **2004**. The posterior inferior access region **2016** of the sacroiliac joint articular region **1044** has an inferior end **2022** on the sacroiliac joint line that is at approximately the intersection of the posterior inferior iliac spine **2006** with the lateral anterior curved boundary **2024** of the sacrum **1004**. In other words, the posterior inferior access region **2016** of the sacroiliac joint articular region **1044** has an inferior end **2022** on the sacroiliac joint line that is at approximately the superior beginning of the greater sciatic notch **2008**.

FIG. **45A** is a lateral-posterior view of the hip region **1002** of the patient **1001** of FIG. **44A**, wherein the patient **1001** is lying prone and the soft tissue **1003** surrounding the skeletal structure **1006** of the patient **1001** is shown in dashed lines. FIG. **45B** is an enlarged view of the hip region **1002** of FIG. **45A**. As shown in FIGS. **45A** and **45B**, a lateral-posterior view of the patient's hip region **1002** reveals the same features of the sacrum **1004** and ilium **1005** as discussed above with respect to FIGS. **44A** and **44B**, except from another vantage point. The vantage point provided via FIGS. **45A** and **45B** provides further understanding regarding the posterior inferior access region **2016** of the sacroiliac joint articular region **1044** and superior end **2018** and inferior end **2022** of the posterior inferior access region **2016** relative to nearby anatomical features, such as, for example, the posterior inferior overhang **2020** of the posterior superior iliac spine **2004**, the intersection of the posterior inferior iliac spine **2006** with the lateral anterior curved boundary **2024** of the sacrum **1004**, and the superior beginning of the greater sciatic notch **2008**.

FIG. **46A** is a posterior view of the hip region **1002** of the patient **1001** of FIG. **44A**, wherein the patient **1001** is lying prone and the soft tissue **1003** surrounding the skeletal structure **1006** of the patient **1001** is shown in dashed lines. FIG. **46B** is an enlarged view of the hip region **1002** of FIG. **46A**. As shown in FIGS. **46A** and **46B**, a posterior view of the patient's hip region **1002** reveals the same features of the sacrum **1004** and ilium **1005** as discussed above with respect to FIGS. **44A** and **44B**, except from yet another vantage point. The vantage point provided via FIGS. **46A** and **46B** provides yet further understanding regarding the posterior inferior access region **2016** of the sacroiliac joint articular region **1044** and superior end **2018** and inferior end **2022** of the posterior inferior access region **2016** relative to nearby anatomical features, such as, for example, the posterior inferior overhang **2020** of the posterior superior iliac spine **2004**, the intersection of the posterior inferior iliac spine **2006** with the lateral anterior curved boundary **2024** of the sacrum **1004**, and the superior beginning of the greater

sciatic notch **2008**. In addition, FIGS. **46A** and **46B** provide a view of the sacral promontory **6002**, the S1 superior articular process or S1 facet joint **6004**, and sacral ala **6006**.

a. Implantation Via Extra-articular Approach
i. Preparation of Implant Receiving Space

Now that the relevant anatomical landmarks have been identified with respect to FIGS. **44A-46B**, the methodology associated with employing any of the above-described delivery tools **20** in implanting any of the above-described implant bodies **25** in the sacroiliac joint **1000** of a patient **1001** can be discussed. In doing so, reference will be made to FIGS. **60A-60P**, which are each a step in the methodology and illustrated as the same transverse cross section taken in along a plane extending medial-lateral and ventral dorsal along section line **101-101** in FIG. **46B**. In this cross section, the anterior portion of the articular surfaces **1016** are covered by a thick layer of articular cartilage with a joint space existing between them while the dorsal or posterior portion of the articular surfaces in this cross section are covered by ligaments. FIGS. **60A-60P** are simplified for illustrative purposes and do not show these features to scale. Now referring primarily to FIG. **60A**, an embodiment of the method can include the step of placing a patient under sedation prone on a translucent operating table (or other suitable surface). The sacroiliac joint **1000** can be locally anesthetized to allow for injecting a radiographic contrast **1046** (as a non-limiting example, ISOVIEW **300** radiographic contrast) under fluoroscopic guidance into the extra-articular space **3007** of the sacroiliac joint **1000** via the extra-articular recess access region **6000** to outline the articular surfaces **1016** of the sacroiliac joint **1000** defined between the sacrum **1004** and ilium **1005**. Injection of the radiographic contrast **1046** within the sacroiliac joint **1000** can be accomplished utilizing a tubular member **1047** (such as a syringe needle) having first tubular member end **1048** which can be advanced between the articulating surfaces **1016** of the sacroiliac joint **1000** and having a second tubular member end **1049** which removably couples to a hub **1050**. The hub **1050** can be configured to removably couple to a syringe barrel **1051** (or other device to contain and deliver an amount of radiographic contrast **1046**). In the example of a syringe barrel **1051**, the syringe barrel **1051** can have an internal volume capable of receiving an amount of the radiographic contrast **1046** sufficient for outlining the articular surfaces **1016** of the sacroiliac joint **1000**, for example, under lateral fluoroscopy. A plunger **1052** can be slidably received within the barrel **1051** to deliver the radiographic contrast **1046** through the tubular member **1047** into the sacroiliac joint **1000**. The tubular member **1047** can have a gauge ranging between about 16 gauge and about 20 gauge and can further be incrementally marked on the external surface to allow determination of the depth at which the first needle end **1048** has advanced within the sacroiliac joint **1000**. As the first needle end **1048** advances into the sacroiliac joint **1000** the radiographic dye **1046** can be delivered from within the syringe barrel **1051** into the sacroiliac joint **1000** to allow visualization of the sacroiliac joint **1000** and location of the tubular needle **1047** within the sacroiliac joint **1000**.

Now referring primarily to FIG. **60B**, once the first tubular member end **1048** has been sufficiently advanced into the sacroiliac joint **1000** and the articular surfaces **1016** of the sacroiliac joint **1000** have been sufficiently visualized, the hub **1050** can be removed from the tubular member **1047** leaving the tubular member **1047** fixed within the sacroiliac joint **1000** as an initial guide for tools subsequently used to locate or place the implant body **25** non-transversely

between the articulating surfaces **1016** of the sacroiliac joint **1000** (e.g., locate the implant body **25** non-transversely to the joint plane **1030** generally defined by the articulating surfaces **1016** of the interarticular region **1044** of the sacroiliac joint **1000**) or in removal of a portion of the sacroiliac joint **1000** within the region defined by the articular surfaces **1016** to generate an implant receiving space **1029** (see FIG. **60H**). Alternately, one or more guide pins **1013** can be inserted along substantially the same path of the tubular member **1047** for fixed engagement within the sacroiliac joint **1000** and used in subsequent steps as a guide(s).

Now referring primarily to FIG. **60C**, a small incision **1053** can be made in the skin at the extra-articular recess access region **6000** aspect of the sacroiliac joint **1000**, extending proximal and distal to the tubular member **1047** along the line of the sacroiliac joint **1000** to provide a passage to access the interarticular space between the articulating surfaces **1016** (see FIG. **47B**) of the sacroiliac joint **1000**. More specifically, as can be understood from FIGS. **57-61**, in one embodiment, the small incision **1053** can be made along the joint line **2019** of the sacroiliac joint **1000** in the tissue covering the extra-articular recess access region **6000** of the sacroiliac joint **1000**. A cannulated probe **1054** can be slidably engaged with the tubular member **1047** (or guide pin **1013**) extending outwardly from the sacroiliac joint **1000** (while the sacroiliac joint **1000** may be shown in the figures as being substantially linear for illustrative purposes, it is to be understood that the normal irregular features of the sacroiliac joint have not been necessarily removed). The cannulated probe **1054** can have a probe body **1054** of generally cylindrical shape terminating in a spatulate tip **1055** at the end advanced into the sacroiliac joint **1000**. A removable cannulated probe handle **1056** couples to the opposed end of the probe body **1054**. The spatulate tip **1055** can be guided along the tubular needle **1047** or guide wire **1013** into the posterior portion of the sacroiliac joint **1000** and advanced to the anterior portion of the sacroiliac joint **1000** under lateral fluoroscopic visualization. The cannulated probe handle **1056** can then be removed providing the generally cylindrical probe body **1054** extending outwardly from the sacroiliac joint **1000** through the incision **1053** made in the skin. Alternatively, probe **1054** can be used to guide, advance or place a needle, guide wire or other instrument up to, near, or into the sacroiliac joint **1000**.

Additionally, in particular embodiments, probe handle **1056** or the opposed end of the probe body **1054**, or both, can be configured to have an interference fit or a Luer lock hub to communicate with a syringe barrel **1051** in order to advance contrast, in situ curable biocompatible materials, stem cells, or any other suitable materials through the cannulated probe **1054** or cannulated probe handle **1056**.

Now referring primarily to FIG. **60D**, a passage from the incision **1053** (see FIG. **47C**) to the sacroiliac joint **1000** can be generated by inserting a cannula **1057** into the incision. A soft tissue dilator **1058** having a blunt end **1059** can be advanced over the probe body **1054**, or a plurality of soft tissue dilators of increasing size, until the blunt end **1059** of the soft tissue dilator **1058** and the corresponding cannula end contact the extra-articular recess access region **6000** of the sacroiliac joint **1000**. The soft tissue dilator **1058** can be removed from within the cannula **1057**. The external surface of the cannula **1057** can be sufficiently engaged with the surrounding tissue to avoid having the tissue resituate within the hollow inside of the cannula **1057**. A non-limiting embodiment of the cannula **1057** provides a tubular body having substantially parallel opposed side walls which ter-

minate in a radius at both ends (lozenge shape) into which a plurality of different jigs can be inserted. Alternatively, as a non-limiting example, according to particular embodiments, cannula **1057** and corresponding dilators **1058** and alignment jigs **1060** can be configured to have tubular bodies with an elliptical or circular cross section.

In some embodiments, the cannula **1057** may be additionally configured to have within or near its walls a light source such as, for example, a fiber optic or a LED light source to assist in visualization of the working area. Also, in some embodiments, irrigation and suction tubing may communicate with the inside passage of cannula **1057**.

Now referring to FIG. **60E**, a cannulated drill bit **1070** can be advanced over the probe body **1054** and within a drill guide hole **1068** (see FIGS. **49A** and **49B**) of the first drill jig **1067**. The cannulated drill bit **1070** under fluoroscopic guidance can be advanced into the interarticular region **1044** between the articulating surfaces **1016** of the sacroiliac joint **1000** to produce a first bore **1071** (shown in broken line) to a predetermined depth. As to certain embodiments of the method, an amount of articular cartilage or other tissues from between the articular surfaces **1016** of the sacroiliac joint **1000** can be removed sufficient to allow embodiments of the implant body **25** to be implanted in replacement of the removed articular cartilage or tissue. Because the method may remove the degenerative articular cartilage or tissue between the articular surfaces **1016** of the sacroiliac joint **1000**, the articular surfaces **1016** of the sacroiliac joint **1000** can remain intact or substantially intact allowing implant body **25** to be non-transversely located between the articular surfaces **1016** of the sacroiliac joint **1000**. Other instruments can be utilized separately or in combination with a cannulated drill bit **1062** for the removal of articular cartilage or tissue between articular surfaces **1016** such as: endoscopy tools, box chisels, side cutting router bits, burs, flexible burs and bits, hole saws, curettes, lasers (such as CO₂, Nd:YAG (neodymium-doped yttrium-aluminum-garnet), argon, and ruby), and electrosurgical equipment employing electromagnetic energy.

In an embodiment, the cutting electrode of the electrosurgical equipment may be a fine micro-needle, a lancet, a knife, a wire or band loop, a snare, an energized scalpel, or the like. The electrosurgical waveforms delivered by the cutting electrode may be set to promote two types of tissue effects, namely coagulation (temperature rises within cells, which then dehydrate and shrink) or cut (heating of cellular water occurs so rapidly that cells burst). The proportion of cells coagulated to those cut can be varied, resulting in a “blended” or “mixed” effect. Additionally, a fully rectified current, or a partially rectified current, or a fulguration current where a greater amount or lateral heat is produced can be employed to find the articular surfaces of the joint and aid in advancing a probe or guide wire into a position in between the articulating surfaces. These currents can effectively degrade the cartilage and allow advance into the joint without grossly penetrating much beyond the cartilage.

In one embodiment, the electrical energy delivered via the cutting electrode can be either monopolar or bipolar and operate with high frequency currents, for example, in the range of about 300 kHz and about 1000 kHz. The waveform of the delivered electrical energy may be a pure sinusoidal current waveform where the “crest factor” can be constant at about 1.4 for every sinus waveform, and a voltage peak of approximately 300 V to enable a “pure” cutting effect with the smallest possible coagulation effect. Alternatively, the electrical energy may be delivered as amplitude modulated

current waveforms where the crest factor varies between 1.5 and 8, with decreasing crest factors providing less of a coagulation effect.

Now referring to FIG. **60F**, as to certain embodiments of the invention, the first drill jig **1067** can be removed from within the cannula **1057** and a second drill jig **1072** can be advanced over the probe body **1054** and received within the cannula **1057**; however, the invention is not limited to any particular number of drill jigs and as to certain embodiments of the method the first drill jig **1067** can include all the required drill guide hole(s) **1068** (or slots or other configurations of the drill guide) and as to other embodiments of the method a plurality of drill jigs can be utilized in serial order to provide all the drill guide holes **1068**. As to the particular embodiment of the invention shown by the figures, the first drill jig **1067** can provide one or more additional drill guide holes **1068** which guide in relation to the first bore **1071** a second or more cannulated drills **1062** of the same or different configuration to be inserted within and advanced into the sacroiliac joint **1000** to produce a second bore **1073** (generally shown in broken line as **1071/1073**) or a plurality of bores within the sacroiliac joint **1000** spaced apart in predetermined pattern to allow removal of sufficient articular cartilage **1016** or other tissue from the interarticular space of sacroiliac joint **1000** for placement of embodiments of the sacroiliac joint implant **25** within the region defined by and between the paired articular surfaces **1016** of the sacroiliac joint **1000**. As to certain methods of the invention, the first drill jig **1067** or the second drill jig **1072** or a plurality of drill jigs can be utilized in serial order to remove a portion of the sacroiliac joint **1000** for generation of an implant receiving space **1029** (see, for example, FIG. **60H**). As these embodiments of the method, articular cartilage or other tissues and sufficient subchondral bone can be removed from between the articular surfaces **1016** of the sacroiliac joint **1000** sufficient to allow placement of certain embodiments of the sacroiliac joint implant body **25**. In other embodiments, one or more transverse receiving channels **1074** aligned with the direction of the receiving space and extending in a direction perpendicular to the joint plane **1030** can be cut into at least one of the articular surfaces **1016** of said sacroiliac joint **1000** sufficient to receive certain elements of the implant body **25** including, but not limited to one or more fins **50**, as illustrated in FIG. **5** in one embodiment of the implant body **25**. The one or more transverse receiving channels **1074** can be cut a depth into the subchondral, cortical bone or cancellous bone of the sacrum **1004** and/or ilium **1005**. A transverse receiving channel **1074** in one embodiment is illustrated in FIG. **60H** as dashed lines.

Now referring primarily to FIG. **60G**, in a subsequent step, the last drill jig **1072** in the series can be removed from within the cannula **1057** and a broach jig **1075** can be advanced over the probe body **1054** and situated within the cannula **1057**. The broach jig **1075** can include a broach guide hole **1076** which receives a first broach end **1077** of a cannulated broach **1078** advanced over the probe body **1054**. The first broach end **1077** can have a configuration which can be advanced into the sacroiliac joint **1000**. As to certain embodiments of the method, the first broach end **1077** can be adapted to remove an amount of articular cartilage and other tissue from between the articular surfaces **1016** within the articular region **1044** of the sacroiliac joint **1000** for non-transverse placement of the sacroiliac joint implant body **25**. Referring to FIG. **60H**, in various other embodiments of the method, the cannulated broach **1078** can further remove a sufficient portion of the sacroiliac joint **1000** to

generate an implant receiving space 1029 to receive various embodiments of the sacroiliac joint implant 25, as illustrated in FIGS. 5, 9, and 12 by way of non-limiting examples. In yet other embodiments, the cannulated broach 1078 can further remove a sufficient portion of the sacroiliac joint 1000 to generate one or more transverse receiving channels 1074 to receive one or more fins 50 adapted to extend into the bone of the sacrum 1004 or the ilium 1005 in various embodiments of the sacroiliac joint implant 25 (see FIGS. 5, 9, and 12).

Now referring primarily to FIGS. 59 and 61, the implant receiving space 1029 and the sacroiliac joint implant body 25 can be configured having related dimensions such that placement of the insertion element 650 of the sacroiliac joint implant body 25 within the implant receiving space 1029 disposes the sacrum 1004 and the ilium 1005 in substantially immobilized relation and substantially avoids alteration of the positional relation of the sacrum 1004 and the ilium 1005 from the normal condition, or avoids driving together or driving apart the sacrum 1004 from the ilium 1005 outside of or substantially outside of the normal positional relation. In an embodiment, the insertion element 650 and the implant receiving space 1029 may be configured to immobilize the sacrum 1004 in relation to the ilium 1005 while maintaining the sacroiliac joint 1000 in substantially normal or substantially normal positional relation, or to return the sacroiliac joint 1000 to a substantially normal positional relation and thereby correct a degenerative condition of the sacroiliac joint 1000.

As a non-limiting example, configurations of an implant receiving space 1029 allow embodiments of the sacroiliac joint implant body 25 to be placed non-transversely between the articular surfaces 1016 of the extra-articular space 3007 of the sacroiliac joint 1000. While certain embodiments of the sacroiliac joint implant body 25 may only provide an insertion element 650 which locates within a correspondingly configured implant receiving space 1029 to engage at least a portion of the bone of the ilium 1005 or sacrum 1004, the invention is not so limited, and can further include one or more fins 50 engaging a portion of the bone 1073 of the sacrum 1004 and/or the ilium 1005.

As to those embodiments of the sacroiliac joint implant bodies 25 which further include one or more fins 50, the implant receiving space 1029 can further include one or more corresponding transverse receiving channels 1074, which correspondingly allow the one or more fins 50 to extend into the bone 1073 of the sacrum 1004 or the ilium 1005 (whether subchondral, cortical, cancellous, or the like). Alternatively, impact of the insertion plate 45 of the sacroiliac joint implant 25 into the implant receiving space 1029 without the transverse receiving channels 1074 can forcibly urge the one or more fins 50 into the bone 1073 of the sacrum 1004 and the ilium 1005. An anchor 30 members can be inserted through the bore 40 in the implant 25 and into the sacrum 1004 and ilium 1005 to fix the location of the fixation fusion implant 25 within the implant receiving space 1029.

Reference is now made to FIGS. 57-59. FIG. 57 is a lateral-inferior-posterior view and FIG. 58 is an inferior-posterior view of the patient's hip skeletal structure 7, and accessing the extra-articular space 3007 via an extra-articular recess access region 6000. The S1 through S4 foramina can be seen at the respective indicators S1, S2, S3 and S4 in FIGS. 57 and 58.

Referring to FIG. 57, the delivery tool 20 has been configured such that the anchor arm 115 is oriented so as to deliver the anchor member 30 through anchor bore 40 of the

implant body 25 into the sacrum 1004 and then optionally further into the ilium 1005. In other words, the anchor 30 is inserted through the bore 40 within the attachment element 652 and driven medial to lateral through the sacrum 1004 first and then into the implant followed by the ilium 1005 (optional). In the embodiment of FIG. 57, the anchor 30 may be a bone screw the same as or similar to an S2 alar iliac (S2AI) screw. Such a screw may penetrate the sacrum 1004 just lateral to the lateral edge of the S1 foramen and just superior of the superior edge of the S1 foramen. Thus, the anchor 30 can enter the bone of sacrum 1004 near the first sacral foramen (S2AI trajectory) then can further enter the bone of the ilium 1005. The implant body 25, as with any of the implantation locations and implant bodies 25 discussed herein can optionally be employed to be configured to serve as an attachment point for structural components of a spinal support system via an attachment fitting 500 mechanically attached in an adjustable locked engagement with the attachment element 652 of the implant body 25. In one non-limiting example, the attachment fitting 500 may be attached to an end of a spanning element of a spinal support system such as a rod 2096, as illustrated in FIG. 3.

Referring to FIG. 59, the insertion element 650 of the implant body 25 may be situated within the extra-articular region 3007 in one embodiment. Further, the implant body 25 is inserted into the extra-articular region 3007 via an extra-articular recess access region 6000. As illustrated in FIG. 58, this extra-articular recess access region 6000 is opposite to the posterior inferior overhang 2020 of the posterior superior iliac spine 2004 from the caudal portion 1086 of the sacroiliac joint articular region 1014 and posterior inferior access region 2016 leading to the sacroiliac joint articular region 1044 employed to implant the implant 25 in the caudal portion 1086 of the sacroiliac joint articular region 1044 in other embodiments, as discussed herein below.

As can be understood from FIG. 59, the insertion element 650 of the implant body 25 is oriented in the extra-articular region 3007. In the embodiment shown in FIG. 59, in which the insertion element 650 is an insertion plate 45, the orientation of the insertion plate 45 is generally coplanar with the plane of the extra-articular region 3007 and the narrow fins 50 extend into the sacrum 1004 and ilium 1005 bone defining each side of the extra-articular region 3007.

As illustrated in FIG. 59, in some embodiments, the insertion element 650 of the implant body 25 is oriented within the extra-articular region 3007 such that the longitudinal axis LAI of the insertion element 650 is generally perpendicular to the posterior boundary segment 3008 of the boundary 3000 of the sacroiliac joint articular region 1014. Also, the distal end 42 of the implant body 25, when implanted in the extra-articular region 3007, points towards the anterior-inferior corner 3010 of the boundary 3000 of the sacroiliac joint articular region 1014. The distal end 42 of the implant body 25 may extend across the posterior boundary segment 3008 of the extra-articular region 3007 and into the sacroiliac joint articular region 1044. Thus, when implanting the insertion element 650 of the implant body 25 via the extra-articular recess access region 6000, the general direction of travel for the implant distal end 42 is towards the anterior-inferior corner 3010, and the insertion element 650 can be positioned substantially within the extra-articular region 3007 or, alternatively, the insertion element 650 can be further advanced to also occupy a portion of the sacroiliac joint articular region 1044.

As discussed herein above, to implant the implant body 25 in the extra-articular region 3007, the delivery tool 20 is

configured in one embodiment to drive the anchor **30** medial to lateral through the implant bore **40** into the sacrum **1004** and, optionally, further into the ilium **1005**. However, in some embodiments, the delivery tool **20** and implant bore **40** may have as-manufactured configurations that allow the anchor **30** to be driven lateral to medial through the ilium **1005** into one or more additional bores **670** (see FIG. **11A**).

While the preceding discussion is given in the context of the implant body **25** being implanted non-transversely in the extra-articular space **3007** of the sacroiliac joint **1000**, in other embodiments, the implant body **25** may be implanted in other locations within the sacroiliac joint **1000**. For example, as disclosed in U.S. patent application Ser. No. 12/998,712, which is incorporated herein by reference, in some embodiments, the implant body **25** may be implanted non-transversely in the caudal portion **1086** (see FIG. **50A**) of the sacroiliac joint **1000** by the similar procedures or steps as above described with the incision and generation of the passage to the superior articular portion of the sacroiliac joint **1000**. The implant body **25** may also be implanted in the sacroiliac joint **1000** in such a manner so as to extend between the cranial and caudal portions, as also disclosed in U.S. patent application Ser. No. 12/998,712.

ii. Insertion of Insertion Element of Implant Body into Implant Receiving Space

To begin a discussion of employing the delivery tool **20** to implant the implant body **25** in the sacroiliac joint **1000** once the implant receiving space **1029** has been created, reference is made to FIGS. **60I**, **57**, **58**, and **59**. As shown in FIGS. **60I**, **57**, **58**, and **59**, once the implant receiving space **1029** has been created as discussed above with respect to FIGS. **60A-60H**, the implant body **25** can be supported off of the distal end **120** of the implant arm **110** of the delivery tool **20** and positioned such that the distal end **42** of the implant body **25** (specifically the insertion plate **45**) begins to enter the sacroiliac joint articular region **1044** via the extra-articular recess access region **6000**. In entering the sacroiliac joint space, insertion element **650** of the implant body **25** is oriented generally parallel to, and aligned with the contour of the articulating surfaces **1016** of the sacroiliac joint **1000**.

In various embodiments the contour of the insertion plate **45** may be aligned along the direction of the articulating surfaces **1016** defining the extra-articular recess of the sacroiliac joint **1000**. In one embodiment, the implant receiving space **1029** may be prepared to receive a planar insertion plate **45**, as illustrated in FIG. **60I**. In another embodiment, the insertion element **650** may be custom contoured to conform with the existing contour of the articulating surfaces **1016** based on medical images of the sacroiliac joint **1000** obtained prior to producing the implant body **20**. In an additional embodiment, the insertion element **650** may be produced so as to be deformable by the surgeon to adjust the contour of the insertion element **650** to approximately match the contour of the articulating surfaces **1016**. In another additional embodiment, the insertion element **650** may be a threaded cylindrical element as described previously herein. In this other additional embodiment, the threaded cylindrical element may be twisted into a cylindrical bore formed in the joint space.

Referring back to FIG. **60I**, the longitudinal axis LCA2 of the implant arm **110** of the delivery tool **20** has a generally anterior trajectory that is located within the joint plane **1030**. Alternatively, according to particular embodiments, as a non-limiting example, the longitudinal axis LCA2 of the implant arm **110** of the delivery tool **20** can have a trajectory which can be defined as being generally lateral or, in

particular embodiments, generally posterior. In some embodiments, when the implant body **25** is being delivered into the joint space, the implant arm **110** can be said to be at least one of generally superior or cephalad to the sciatic notch.

As illustrated in FIGS. **60J** and **53**, the insertion element **650** is fully received in the prepared sacroiliac space **1029** such that the plane of the insertion element **650** is oriented generally parallel to, and aligned with, the sacroiliac joint line **2019** (i.e., the plane of the insertion element **650** is generally located within the joint plane **1030**), and the implant body's fins **50** are generally transverse to the joint plane **1030** and, in some embodiments, have even entered the bone material forming the sacrum and ilium articular surfaces of the sacroiliac joint (see, e.g., FIGS. **50C** and **50D**). As can be understood from FIG. **50J**, the longitudinal axis IBA of the implant body **25** and the longitudinal axis LCA2 of the implant arm **110** may be coaxially aligned with each other and generally located in the sacroiliac joint plane **1030**.

In addition, FIGS. **57** and **58** illustrate the sleeve **100** now received in the collar **165** of the anchor arm **115**. As can be understood from FIGS. **60K**, **57**, and **58**, the distal end of the sleeve **100** may extend through an incision in the patient's soft tissue such that the distal end of the sleeve **100** is positioned generally against the lateral surface of the ilium **1005**. The longitudinal axis of the sleeve **100** and collar **165** of the anchor arm **115** can be understood to be generally coaxially aligned with the longitudinal axis of the bore **40** of the implant body **25**.

Referring now to FIG. **59**, the sacroiliac joint space boundary **3000** is defined along the sacrum **1004** and outlines the sacroiliac joint articular region **1044**. The implant **25** positioned for implantation within the extra-articular space **3007** of the sacroiliac joint **1000**. As shown in FIG. **59**, the sacroiliac joint space boundary includes an inferior boundary segment **3002**, an anterior boundary segment **3004**, a superior boundary segment **3006**, and a posterior boundary segment **3008**. The inferior boundary segment **3002** is immediately adjacent, and extends along, the sciatic notch **2024**.

The inferior boundary segment **3002** and anterior boundary segment **3004** intersect to form an anterior-inferior corner **3010**. The anterior boundary segment **3004** and superior boundary segment **3006** intersect to form an anterior-superior corner **3012**. The superior boundary segment **3006** and posterior boundary segment **3008** intersect to form a superior-posterior corner **3014**. The posterior boundary segment **3008** and posterior inferior access region **2016** intersect to form a superior-posterior corner **3016** of the posterior inferior access region **2016**. The inferior boundary segment **3002** and posterior inferior access region **2016** intersect to form an inferior-posterior corner **3018** of the posterior inferior access region **2016**.

The inferior boundary segment **3002** extends between corners **3010** and **3018**. The anterior boundary segment **3004** extends between corners **3010** and **3012**. The superior boundary segment **3006** extends between corners **3012** and **3014** and provides an access into the cranial portion **1087** of the sacroiliac joint. The posterior boundary segment **3008** extends between corners **3014** and **3016**. The posterior inferior access region **2016** extends between corners **3016** and **3018** and provides an access into the caudal region **1086** of the sacroiliac joint. The posterior boundary segment **3008** separates articular region **1044** and extra-articular region **3007**, which includes the sacral fossa on the sacrum **1004**

and the corresponding iliac tuberosity on the ilium **1005** and defined by the extra-articular region boundary **3009**.

As shown in FIG. **59**, the insertion element **650** of the implant body **25** is inserted via the implant arm **110** of the delivery tool **20** into the extra-articular space **3007** of the sacroiliac joint **1000**. The implant **25** enters the extra-articular recess access region **6000**, and is further advanced into the extra-articular space **3007** of the sacroiliac joint **1000** in an orientation such that the implant arm **110** and implant plate **45** are in the joint plane **1030** (see, for example, FIGS. **60I-60J**). Thus, the distal end **42** of the implant body **25** is heading generally perpendicular to, and towards, the anterior boundary segment **3004**. Thus, when implanting the insertion element **650** of the implant body **25** via the extra-articular recess access region **6000**, the general direction of travel for the implant distal end **42** is towards the anterior-inferior corner **3010**, and the insertion element **650** can be positioned substantially within the extra-articular region **3007** or, alternatively, the insertion element **650** can be further advanced to also occupy a portion of the sacroiliac joint articular region **1044**.

iii. Insertion of Anchor

FIG. **58** is a posterior-inferior view of the hip region **1002** of the patient **1001**. As can be understood from FIGS. **60L** and **58**, the anchor **30** is positioned in the lumen of the sleeve **100**. A driving tool **105** (e.g., screw driver) is extended through the lumen of the sleeve **100** so the distal end of the tool **105** is engaged with a proximal end of the anchor member **30** (e.g., screw). As shown in FIG. **60M**, the tool **105** is used to drive the anchor **30** distally through into the bore **40** of the implant **25** generally transverse to the joint line plane **1030** and into the bone of the sacrum **1004**, in this embodiment. As a result, as indicated in FIG. **60N**, the implant assembly **15** formed of the implant body **25** and anchor **30** is secured at the implantation site such that the implant body **25** is located in the prepared space **1029** of the sacroiliac joint space, and the anchor **30** extends through into the bore **40** of the implant **25** into the bone of the sacrum **1005** and into generally transverse to the joint space plane **1030** and optionally into the bone of the ilium **2004**, as illustrated in FIG. **60N**. The tool **105** and sleeve **100** can be removed from the anchor arm collar **165**, and the incision associated with the sleeve **100** can be closed. Additionally, tool **105** can be a cutting tool **105** (e.g., drill bit, hole punch, or etc.) which can be used in similar steps as above describe to remove bone or other tissues in the path where anchor **30** is to be placed. As indicated in FIG. **60O**, the distal end of the implant arm **110** is decoupled from the proximal end of the implant **25** and removed. The incision associated with the implant arm can be closed.

As illustrated in FIG. **60P**, in certain embodiments, the implant body **25** can be configured to have more than one implant bore **40** to receive additional anchors **30A**. The anchors **30** and **30A** prevent migration of the implant body **25** within the joint space. The anchors **30** and **30A** also can draw the ilium and sacrum together about the implant body **25**, increasing the sturdiness of the fixation of the implant **25** in the joint space, as demonstrated by the anchor **30A** in FIG. **60P**. Where the anchor **30** extends through the implant bore **40** and into the bone of both the sacrum **1004** and ilium **1005**, the anchor **30** can be used to draw the articular surfaces **1016** of the sacroiliac joint **1000** against the external surfaces of the insertion element **350** of the implant body **25**. With the insertion element **350** implanted in the sacroiliac joint, the healing processes will cause the surfaces **1016** to fuse together about the insertion element **350**.

FIG. **61** is a posterior view of the implantation area **1029** and the implant body **25** implanted within the implantation area **1029**. In this view, the insertion element **650** situated in the joint space is obscured by the attachment element **652**. As can be understood from FIG. **61**, the extra-articular recess access region **6000** and implanted in the extra-articular space **3007** of the sacroiliac joint **1000**. The anchor **30** can be understood to have been driven into the implant bore **40** transversely to the joint plane **1030** via a route in the sacrum **1004** that avoids contact with vascular and neurological structures, thereby avoiding potentially life threatening injury to such structures. The ability to blindly, yet safely, drive the anchor member **30** into the implant bore **40** while the implant **25** is hidden in the joint space is made possible by the cooperating configurations of the implant body **25** and the delivery tool **20**. Specifically, the longitudinal axis **LCA1** of the anchor arm **165** is coaxially aligned with the longitudinal axis **BA** of the implant bore **40** when the implant body **25** is supported off of the implant arm **110** of the delivery tool **20**, thereby making it possible to safely drive the anchor **30** through the implant bore **40** and into the ilium **1005** bone and/or sacrum bone **1004** when the implant body **25** is hidden in the joint space on account of being delivered to the joint space via the delivery tool **20**.

Anchor trajectory and placement may be guided and confirmed with imaging studies before the end of the surgical procedure or afterwards. For example, a surgeon may use fluoroscopy (and/or arteriography) to obtain an antero-posterior view, lateral view, an inlet view, an outlet-oblique view, Judet views of the pelvis, an internal (obturator) oblique view, a Ferguson view, an external (iliac) oblique view or other relevant views and further use radiographic bony landmarks such as the superimposed greater sciatic notches, superimposed iliac cortical densities or alar slope, sacral promontory, first sacral endplate, sacral foramina, arcuate sacral lines, iliopectineal line, ilioischial line, acetabular teardrop lines bony corridors of S1 or S2, superimposed acetabula, ventral and dorsal surfaces of the sacrum, etc.; or using an angiogram to identify vascular structures such as the superior gluteal artery, internal iliac artery and vein, iliolumbar vein, etc.

b. Implantation Via Intra-Articular Approach

i. Preparation of Implant Receiving Space

Now that the relevant anatomical landmarks have been identified with respect to FIGS. **44A-46B**, the methodology associated with employing any of the above-described delivery tools **20** in implanting any of the above-described implant bodies **25** in the sacroiliac joint **1000** of a patient **1001** can be discussed. In doing so, reference will be made to FIGS. **47A-47P**, which are each a step in the methodology and illustrated as the same transverse cross section taken in along a plane extending medial-lateral and anterior posterior along section line **99-99** in FIG. **46B**. In this cross section, articular surfaces **1016** are covered by a thick layer of articular cartilage with a joint space existing between them, the FIGS. **47A-47P** are simplified for illustrative purposes and do not show these features to scale. Now referring primarily to FIG. **47A**, an embodiment of the method can include the step of placing a patient under sedation prone on a translucent operating table (or other suitable surface). The sacroiliac joint **1000** can be locally anesthetized to allow for injecting a radiographic contrast **1046** (as a non-limiting example, ISOVIEW **300** radiographic contrast) under fluoroscopic guidance into the inferior aspect of the sacroiliac joint **1000** to outline the articular surfaces **1016** of the sacroiliac joint (**1000**) defined between the sacrum **1004** and ilium **1005**, the sacroiliac joint **1000** having an interarticular

region **1044**. Injection of the radiographic contrast **1046** within the sacroiliac joint **1000** can be accomplished utilizing a tubular member **1047** (such as a syringe needle) having first tubular member end **1048** which can be advanced between the articulating surfaces **1016** of the sacroiliac joint **1000** and having a second tubular member end **1049** which removably couples to a hub **1050**. The hub **1050** can be configured to removably couple to a syringe barrel **1051** (or other device to contain and deliver an amount of radiographic contrast **1046**). In the example of a syringe barrel **1051**, the syringe barrel **1051** can have an internal volume capable of receiving an amount of the radiographic contrast **1046** sufficient for outlining the articular surfaces **1016** of the sacroiliac joint **1000**, for example, under lateral fluoroscopy. A plunger **1052** can be slidably received within the barrel **1051** to deliver the radiographic contrast **1046** through the tubular member **1047** into the sacroiliac joint **1000**. The tubular member **1047** can have a gauge ranging between about 16 gauge and about 20 gauge and can further be incrementally marked on the external surface to allow determination of the depth at which the first needle end **1048** has advanced within the sacroiliac joint **1000**. As the first needle end **1048** advances into the sacroiliac joint **1000** the radiographic dye **1046** can be delivered from within the syringe barrel **1051** into the sacroiliac joint **1000** to allow visualization of the sacroiliac joint **1000** and location of the tubular needle **1047** within the sacroiliac joint **1000**.

Now referring primarily to FIG. 47B, once the first tubular member end **1048** has been sufficiently advanced into the sacroiliac joint **1000** and the articular surfaces **1016** of the sacroiliac joint **1000** have been sufficiently visualized, the hub **1050** can be removed from the tubular member **1047** leaving the tubular member **1047** fixed within the sacroiliac joint **1000** as an initial guide for tools subsequently used to locate or place the implant body **25** non-transversely between the articulating surfaces **1016** of the sacroiliac joint **1000** (e.g., locate the implant body **25** non-transversely to the joint plane **1030** generally defined by the articulating surfaces **1016** of the interarticular region **1044** of the sacroiliac joint **1000**) or in removal of a portion of the sacroiliac joint **1000** within the region defined by the articular surfaces **1016** to generate an implant receiving space **1029** (see FIG. 47H). Alternately, one or more guide pins **1013** can be inserted along substantially the same path of the tubular member **1047** for fixed engagement within the sacroiliac joint **1000** and used in subsequent steps as a guide(s).

Now referring primarily to FIG. 47C, a small incision **1053** can be made in the skin at the posterior superior (or as to certain embodiments inferior) aspect of the sacroiliac joint **1000**, extending proximal and distal to the tubular member **1047** along the line of the sacroiliac joint **1000** to provide a passage to access the interarticular space between the articulating surfaces **1016** (see FIG. 47B) of the sacroiliac joint **1000**. More specifically, as can be understood from FIGS. 45A-45B, in one embodiment, the small incision **1053** can be made along the joint line **2019** of the sacroiliac joint **1000** in the tissue covering the posterior inferior access region **2016** of the sacroiliac joint articular region **1044**. A cannulated probe **1054** can be slidably engaged with the tubular member **1047** (or guide pin **1013**) extending outwardly from the sacroiliac joint **1000** (while the sacroiliac joint may be shown in the figures as being substantially linear for illustrative purposes, it is to be understood that the normal irregular features of the sacroiliac joint have not been removed). The cannulated probe **1054** can have a probe body **1054** of generally cylindrical shape terminating in a spatulate tip **1055** at the end advanced into the sacroiliac

joint **1000**. A removable cannulated probe handle **1056** couples to the opposed end of the probe body **1054**. The spatulate tip **1055** can be guided along the tubular needle **1047** or guide wire **1013** into the posterior portion of the sacroiliac joint **1000** and advanced to the anterior portion of the sacroiliac joint **1000** under lateral fluoroscopic visualization. The cannulated probe handle **1056** can then be removed providing the generally cylindrical probe body **1054** extending outwardly from the sacroiliac joint **1000** through the incision **1053** made in the skin. Alternatively, probe **1054** can be used to guide, advance or place a needle, guide wire or other instrument up to, near, or into the sacroiliac joint **1000**.

Additionally, in particular embodiments, probe handle **1056** or the opposed end of the probe body **1054**, or both, can be configured to have an interference fit or a Luer lock hub to communicate with a syringe barrel **1051** in order to advance contrast, in situ curable biocompatible materials, stem cells, or any other suitable materials through the cannulated probe **1054** or cannulated probe handle **1056**.

Now referring primarily to FIG. 47D, a passage from the incision **1053** (see FIG. 47C) to the sacroiliac joint **1000** can be generated by inserting a cannula **1057** into the incision. A soft tissue dilator **1058** having a blunt end **1059** can be advanced over the probe body **1054**, or a plurality of soft tissue dilators of increasing size, until the blunt end **1059** of the soft tissue dilator **1058** and the corresponding cannula end contact the posterior aspect of the sacroiliac joint **1000**. More specifically, as can be understood from FIGS. 44A-46B, in one embodiment, the ends of the dilator **1058** and cannula **1057** contact the joint line **2019** of the sacroiliac joint **1000** at the posterior inferior access region **2016** of the sacroiliac joint articular region **1044**. The soft tissue dilator **1058** can be removed from within the cannula **1057**. The external surface of the cannula **1057** can be sufficiently engaged with the surrounding tissue to avoid having the tissue resituate within the hollow inside of the cannula **1057**. A non-limiting embodiment of the cannula **1057** provides a tubular body having substantially parallel opposed side walls which terminate in a radius at both ends (lozenge shape) into which a plurality of different jigs can be inserted. Alternatively, as a non-limiting example, according to particular embodiments, cannula **1057** and corresponding dilators **1058** and alignment jigs **1060** can be configured to have tubular bodies with an elliptical or circular cross section.

In some embodiments, the cannula **1057** may be additionally configured to have within or near its walls a light source such as, for example, a fiber optic or a LED light source to assist in visualization of the working area. Also, in some embodiments, irrigation and suction tubing may communicate with the inside passage of cannula **1057**.

Now referring primarily to FIGS. 48A-48C, a cannula alignment jig **1060** can be advanced over the probe body **1054** (or guide pins **1013**) and received within the cannula **1057**. Substantially, identical cross hairs **1063**, **1064** can be disposed on the upper jig surface **1065** and the lower jig surface **1066**. Alignment of the cross hairs **1063**, **1064** under x-ray with the sacroiliac joint **1000** can confirm that the cannula **1057** has proper orientation in relation to the paired articular surfaces **1016** of the sacroiliac joint **1000**. The cannula **1057** properly oriented with the paired articular surfaces **1016** can then be disposed in fixed relation to the sacroiliac joint by placement of fasteners through the cannula **1057** into the sacrum **1004** or the ilium **1005**.

Now referring to FIGS. 49A and 49B, a first drill jig **1067** can be advanced over the probe body **1054** (or guide pins **1013**) and received within the cannula **1057**. The probe body

1054 (or guide pins 1013) extending outwardly from the sacroiliac joint 1000 passes through a drill guide hole 1068 of the first drill jig 1067 (or a plurality of guide pins 1013 can extend through a corresponding plurality of guide pin holes 1069). The drill guide hole 1068 can take the form of a circular hole as shown in the Figures, a slot, or other configuration to restrict the movement of the drill bit 1062 (see FIG. 47E) within the drill jig 1060 and provide a guide for a drill bit 1062 in relation to the sacroiliac joint 1000. Guide pin holes 1069 can receive guide pins which can be positioned between the articular surfaces 1016 of the sacroiliac joint 1000 to demarcate the zone of desired treatment or safe working zones while using, for example, lateral fluoroscopy. As a non-limiting example, a first guide pin 1013 can be advanced through a first guide pin hole 1069, or alternatively a guide pin 1013 is first inserted into the sacroiliac joint 1000 and subsequently a guide jig 1067 is advanced over the guide pin 1013, the first guide pin 1013 can enter near inferior end 2022 of the posterior inferior access region 2016 of the sacroiliac joint articular region 1044 via the sacroiliac joint line 2019 to border a portion of the greater sciatic notch 2008 thereby allowing a medical person, computer guided surgical system, or other observer to more easily highlight under x-ray a border which should not be crossed during the procedure due to the presence of nerve and other structures. Additionally, as a non-limiting example, first guide pin 1013 can be configured as an electrode, insulated from the operator and the patient's soft tissues, and may be connected to a monitor to signal to an operator or surgeon when implant body 25, configured with a stimulating electrode (NM), as discussed below, comes into contact with first guide pin. Similarly, a second guide pin 1013 can be placed in another guide pin hole 1069 to demarcate a second limit to a desired zone of treatment, or safe working zone. For example, a second guide pin 1013 can enter near the superior end 2018 of the posterior inferior access region 2016 of the sacroiliac joint articular region 1044 via the sacroiliac joint line 2019 to be positioned to border an area of the sacroiliac joint 1000 such as a transition zone between the extra-articular 3007 and the interarticular region 1044 which, for example, has been highlighted by contrast material as above described.

Referring to FIGS. 49C-49K, a cannula 1057 may be used to facilitate access to the surgical region during a procedure to implant the implant assembly 25 (not shown). In one embodiment, the cannula 1057 may be used in conjunction with a sacroiliac joint repair procedure via a known surgical access region including, but not limited to, the posterior inferior access region 2016 as illustrated in FIGS. 49C-49K. The cannula 1057 may include a cannula body 1057H forming a wall enclosing an internal volume 1057J, which opens to a proximal opening 1057A and a distal opening 1057B. Upon insertion of the cannula 1057 within the surgical access region, the internal volume 1057J may be maintained, thereby functioning as an opening through which surgical instruments, appliances, fasteners, and any other associated surgical equipment or supplies may be inserted or removed and through which the surgical procedure may be visually monitored.

The outer surface of the cannula body 1057H may include one or more contoured regions or projections to enhance the close fit of the cannula 1057 between the skeletal structures surrounding the surgical access region 2016. The outer surface of the body 1057H may form a cannula sacral contour 1057C on one side and may additionally form a cannula iliac contour 1057D on a side opposite to the cannula sacral contour 1057C. The cannula 1057 may also

include a distal projection 1057E which extends distally beyond the cannula sacral contour 1057C and may be shaped to fit within a portion of the greater sciatic notch 2008 (see FIG. 49I). In addition, the outer distal surface of the cannula body 1057H may form a PSIS contact area 1057F to enhance the fit of the portion of the cannula 1057 contacting the posterior superior iliac spine (PSIS) 2004 (see FIG. 49G).

The cannula body 1057H may further define one or more additional bores configured to reversibly receive handles and/or fasteners used to situate the cannula within the surgical region and/or to reversibly receive fasteners used to fix the cannula in place within the surgical region during the surgical procedure. The cannula body 1057H may define a fastener bore 1057K passing through the cannula body 1057H from the outer surface into the internal volume 1057J of the cannula 1057. The cannula bore may open at one end to a cannula fastener bore proximal opening 1057G, which may be in communication with the internal volume 1057J of the cannula 1057. The cannula bore may also open at an opposite end to a cannula fastener bore distal opening 1057L which may be further configured to permit a fastener 1057Z to i) extend generally perpendicular to the cannula PSIS contact area 1057F; and/or, ii) be in a divergent relation relative to distal projection 1057E. Furthermore, the cannula 1057 may have a handle 1057Y extending from the cannula body 1057H for inserting, removing, and/or otherwise manipulating the cannula 1057 during a surgical procedure. As illustrated in FIG. 49C, the handle 1057Y may be reversibly attached to the cannula body 1057 via a handle bore 1057M formed with the cannula body 1057H. The handle bore 1057M may be provided with fastener features including, but not limited to, threads, that may cooperatively engage corresponding fastener features at a distal end 1057N of the handle 1057Y in order to implement the reversible attachment of the handle 1057Y to the cannula 1057.

Referring again to FIGS. 49C to 49K, a surgical procedure employing the cannula 1057 may be conducted using a method described herein below. A cannula 1057 may be positioned near a sacroiliac joint line 2019 and in an area including the posterior inferior access region 2016 such that the sacroiliac joint line 2019 may be visible and/or accessible via a cannula proximal opening 1057A, as illustrated in FIG. 49H. The cannula 1057 may be further positioned to align the distal extension 1057E with a portion of the greater sciatic notch 2008, as illustrated in FIG. 49I. The cannula 1057 may be further positioned to align the cannula PSIS contact area 1057F with a portion of a posterior superior iliac spine 2004 as illustrated in FIG. 49G. The cannula 1057 may then be disposed in fixed relation to the sacroiliac joint by placement of fasteners 1057Z through the cannula 1057 into the sacrum 1004 or the ilium 1005, as illustrated in FIG. 49I.

Now referring to FIG. 47E, a cannulated drill bit 1070 can be advanced over the probe body 1054 and within a drill guide hole 1068 (see FIGS. 49A and 49B) of the first drill jig 1067. The cannulated drill bit 1070 under fluoroscopic guidance can be advanced into the interarticular region 1044 between the articulating surfaces 1016 of the sacroiliac joint 1000 to produce a first bore 1071 (shown in broken line) to a determined depth. As to certain embodiments of the method, an amount of articular cartilage or other tissues from between the articular surfaces 1016 of the sacroiliac joint 1000 can be removed sufficient to allow embodiments of the implant body 25 to be implanted in replacement of the removed articular cartilage or tissue. Because the method removes the degenerative articular cartilage or tissue

between the articular surfaces **1016** of the sacroiliac joint **1000**, the articular surfaces **1016** of the sacroiliac joint **1000** can remain intact or substantially intact allowing implant body **25** to be non-transversely located between the articular surfaces **1016** of the sacroiliac joint **1000**. Other instruments can be utilized separately or in combination with a cannulated drill bit **1062** for the removal of articular cartilage or tissue between articular surfaces **1016** such as: endoscopy tools, box chisels, side cutting router bits, burs, flexible burs and bits, hole saws, curettes, lasers (such as CO₂, Nd:YAG (neodymium-doped yttrium-aluminum-garnet), argon, and ruby), and electro-surgical equipment employing electromagnetic energy.

In an embodiment, the cutting electrode of the electro-surgical equipment may be a fine micro-needle, a lancet, a knife, a wire or band loop, a snare, an energized scalpel, or the like. The electro surgical waveforms delivered by the cutting electrode may be set to promote two types of tissue effects, namely coagulation (temperature rises within cells, which then dehydrate and shrink) or cut (heating of cellular water occurs so rapidly that cells burst). The proportion of cells coagulated to those cut can be varied, resulting in a “blended” or “mixed” effect. Additionally, a fully rectified current, or a partially rectified current, or a fulguration current where a greater amount or lateral heat is produced can be employed to find the articular surfaces of the joint and aid in advancing a probe or guide wire into a position in between the articulating surfaces. These currents can effectively degrade the cartilage and allow advance into the joint without grossly penetrating much beyond the cartilage.

In one embodiment, the electrical energy delivered via the cutting electrode can be either monopolar or bipolar and operate with high frequency currents, for example, in the range of about 300 kHz and about 1000 kHz. The waveform of the delivered electrical energy may be a pure sinusoidal current waveform where the “crest factor” can be constant at about 1.4 for every sinus waveform, and a voltage peak of approximately 300 V to enable a “pure” cutting effect with the smallest possible coagulation effect. Alternatively, the electrical energy may be delivered as amplitude modulated current waveforms where the crest factor varies between 1.5 and 8, with decreasing crest factors providing less of a coagulation effect.

Now referring to FIG. 47F, as to certain embodiments of the invention, the first drill jig **1067** can be removed from within the cannula **1057** and a second drill jig **1072** can be advanced over the probe body **1054** and received within the cannula **1057**; however, the invention is not limited to any particular number of drill jigs and as to certain embodiments of the method the first drill jig **1067** can include all the required drill guide hole(s) **1068** (or slots or other configurations of the drill guide) and as to other embodiments of the method a plurality of drill jigs can be utilized in serial order to provide all the drill guide holes **1068**. As to the particular embodiment of the invention shown by the Figures, the first drill jig **1067** can provide one or more additional drill guide holes **1068** which guide in relation to the first bore **1071** a second or more cannulated drills **1062** of the same or different configuration to be inserted within and advanced into the sacroiliac joint **1000** to produce a second bore **1073** (generally shown in broken line as **1071/1073**) or a plurality of bores within the sacroiliac joint **1000** spaced apart in predetermined pattern to allow removal of sufficient articular cartilage **1016** or other tissue from the interarticular space of sacroiliac joint **1000** for placement of embodiments of the sacroiliac joint implant **25** within the region defined by and between the paired articular surfaces **1016** of the

sacroiliac joint **1000**. As to certain methods of the invention, the first drill jig **1067** or the second drill jig **1072** or a plurality of drill jigs can be utilized in serial order to remove a portion of the sacroiliac joint **1000** for generation of an implant receiving space **1029** (see, for example, FIG. 47H). As these embodiments of the method, articular cartilage or other tissues and sufficient subchondral bone can be removed from between the articular surfaces **1016** of the sacroiliac joint **1000** sufficient to allow placement of certain embodiments of the sacroiliac joint implant body **25**. In other embodiments, one or more transverse receiving channels **1074** aligned with the direction of the receiving space and extending in a direction perpendicular to the joint plane **1030** can be cut into at least one of the articular surfaces **1016** of said sacroiliac joint **1000** sufficient to receive certain elements of the implant body **25** including, but not limited to one or more fins **50**, as illustrated in FIG. 5 in one embodiment of the implant body **25**. The one or more transverse receiving channels **1074** can be cut a depth into the subchondral, cortical bone or cancellous bone of the sacrum **1004** and/or ilium **1005**. A transverse receiving channel **1074** in one embodiment is illustrated in FIG. 47H as dashed lines.

Now referring primarily to FIG. 47G, in a subsequent step, the last drill jig **1072** in the series can be removed from within the cannula **1057** and a broach jig **1075** can be advanced over the probe body **1054** and situated within the cannula **1057**. The broach jig **1075** can include a broach guide hole **1076** which receives a first broach end **1077** of a cannulated broach **1078** advanced over the probe body **1054**. The first broach end **1077** can have a configuration which can be advanced into the sacroiliac joint **1000**. As to certain embodiments of the method, the first broach end **1077** can be adapted to remove an amount of articular cartilage and other tissue from between the articular surfaces **1016** within the articular region **1044** of the sacroiliac joint **1000** for non-transverse placement of the sacroiliac joint implant body **25**. As to other embodiments of the method, the cannulated broach **1078** can further remove a sufficient portion of the sacroiliac joint **1000** to generate an implant receiving space **1029** to receive various embodiments of the sacroiliac joint implant **25** having a flattened elongate insertion plate **45**, as illustrated in FIGS. 5, 9, and 12 in various embodiments by way of non-limiting examples. In yet other embodiments, the cannulated broach **1078** can further remove a sufficient portion of the sacroiliac joint **1000** to generate one or more transverse receiving channels **1074** to receive one or more fins **50** adapted to extend into the bone of the sacrum **1004** or the ilium **1005** in various embodiments of the sacroiliac joint implant **25** (see FIGS. 5, 9, and 12).

Now referring primarily to FIGS. 50A-50D, the implant receiving space **1029** and the sacroiliac joint implant body **25** can be configured having related dimension relations such that placement of the insertion plate **45** of the sacroiliac joint implant body **25** within the implant receiving space **1029** disposes the sacrum **1004** and the ilium **1005** in substantially immobilized relation and substantially avoids alteration of the positional relation of the sacrum **1004** and the ilium **1005** from the normal condition, or avoids driving together or driving apart the sacrum **1004** from the ilium **1005** outside of or substantially outside of the normal positional relation. In an embodiment, the insertion plate **45** and the implant receiving space **1029** may be configured to immobilize the sacrum **1004** in relation to the ilium **1005** while maintaining the sacroiliac joint **1000** in substantially normal or substantially normal positional relation, or to

return the sacroiliac joint **1000** to a substantially normal positional relation and thereby correct a degenerative condition of the sacroiliac joint **1000**.

As a non-limiting example, configurations of an implant receiving space **1029** allow embodiments of the sacroiliac joint implant body **25** to be placed non-transversely between the caudal portions **1086** of the articular surfaces **1016** of the sacroiliac joint **1000**. While certain embodiments of the sacroiliac joint implant body **25** may only provide an insertion plate **45** which locates within a correspondingly configured implant receiving space **1029** to engage at least a portion of the bone of the ilium **1005** or sacrum **1004**, the invention is not so limited, and can further include one or more fins **50** engaging a portion of the bone **1073** of the sacrum **1004** and/or the ilium **1005**.

As to those embodiments of the sacroiliac joint implant bodies **25** which further include one or more fins **50**, the implant receiving space **1029** can further include one or more corresponding transverse receiving channels **1074**, which correspondingly allow the one or more fins **50** to extend into the bone **1073** of the sacrum **1004** or the ilium **1005** (whether subchondral, cortical, cancellous, or the like). Alternatively, impact of the insertion plate **45** of the sacroiliac joint implant **25** into the implant receiving space **1029** without the transverse receiving channels **1074** can forcibly urge the one or more fins **50** into the bone **1073** of the sacrum **1004** and the ilium **1005**. An anchor **30** members can be inserted through the bore **40** in the implant **25** and into the sacrum **1004** and ilium **1005** to fix the location of the fixation fusion implant **25** within the implant receiving space **1029**.

While the preceding discussion is given in the context of the implant body **25** being implanted non-transversely in the caudal portion **1086** of the sacroiliac joint **1000**, in other embodiments, the implant body **25** may be implanted in other locations within the sacroiliac joint **1000**. For example, as disclosed in U.S. patent application Ser. No. 12/998,712, which is incorporated herein by reference, in some embodiments, the implant body **25** may be implanted non-transversely in the cranial portion **1087** (see FIG. **50A**) of the sacroiliac joint **1000** by the similar procedures or steps as above described with the incision and generation of the passage to the superior articular portion of the sacroiliac joint **1000**. The implant body **25** may also be implanted in the sacroiliac joint **1000** in such a manner so as to extend between the cranial and caudal portions, as also disclosed in U.S. patent application Ser. No. 12/998,712.

ii. Insertion of Insertion Element of Implant Body into Implant Receiving Space

To begin a discussion of employing the delivery tool **20** to implant the implant body **25** in the sacroiliac joint **1000** once the implant receiving space **1029** has been created, reference is made to FIGS. **47I**, **51A**, **51B** and **52**. FIG. **51A** is generally the same view as FIG. **45A**, and FIG. **51B** is an enlarged view of the hip region of FIG. **51A**. FIG. **52** is generally the same enlarged view as FIG. **44B**. As shown in FIGS. **47I**, **51A**, **51B** and **52**, once the implant receiving space **1029** has been created as discussed above with respect to FIGS. **47A-47H**, the implant body **25** can be supported off of the distal end **120** of the implant arm **110** of the delivery tool **20** and positioned such that the distal end **42** of the implant body **25** (specifically the insertion plate **45**) begins to enter the sacroiliac joint articular region **1044** via the posterior inferior access region **2016**, which is described in detail above with respect to FIGS. **44A-46B**. As can be understood from FIGS. **51A-52**, in entering the sacroiliac joint space, the implant body **25** is oriented such that the

plane of the insertion plate **45** is oriented generally parallel to, and aligned with, the sacroiliac joint line **2019**. The longitudinal axis **LCA2** of the implant arm **110** of the delivery tool **20** has a generally anterior trajectory that is located within the joint plane **1030**. Alternatively, according to particular embodiments, as a non-limiting example, the longitudinal axis **LCA2** of the implant arm **110** of the delivery tool **20** can have a trajectory which can be defined as being generally lateral or, in particular embodiments, generally posterior. In some embodiments, when the implant body **25** is being delivered into the joint space, the implant arm **110** can be said to be at least one of generally superior or cephalad to the sciatic notch.

FIG. **53** is the same view as FIG. **52**, except the insertion plate **45** of the implant body **25** has now been fully inserted into the prepared space **1029** in the sacroiliac joint **1000**. As illustrated in FIGS. **47J** and **53**, the insertion plate **45** is fully received in the prepared sacroiliac space **1029** such that the plane of the insertion plate **45** is oriented generally parallel to, and aligned with, the sacroiliac joint line **2019** (i.e., the plane of the insertion plate **45** are generally located within the joint plane **1030**), and the implant body's fins **50** are generally transverse to the joint plane **1030** and, in some embodiments, have even entered the bone material forming the sacrum and ilium articular surfaces of the sacroiliac joint (see, e.g., FIGS. **50C** and **50D**). As can be understood from FIG. **47J**, the longitudinal axis **IBA** of the implant body **25** and the longitudinal axis **LCA2** of the implant arm **110** may be coaxially aligned with each other and generally located in the sacroiliac joint plane **1030**.

In addition, FIG. **53** illustrates the sleeve **100** is now received in the collar **165** of the anchor arm **115**. As can be understood from FIGS. **47K** and **53**, the distal end of the sleeve **100** may extend through an incision in the patient's soft tissue such that the distal end of the sleeve **100** is positioned generally against the lateral surface of the ilium **1005**. The longitudinal axis of the sleeve and collar of the anchor arm can be understood to be generally coaxially aligned with the longitudinal axis of the bore **40** of the implant body **25**.

FIG. **54** is generally the same view as FIG. **53**, except the ilium **1005** is removed to show the sacroiliac joint space boundary **3000** defined along the sacrum **1004** and outlining the sacroiliac joint articular region **1044**, the implant **25** positioned for implantation within the sacroiliac joint articular region **1044**. As shown in FIG. **54**, the sacroiliac joint space boundary includes an inferior boundary segment **3002**, an anterior boundary segment **3004**, a superior boundary segment **3006**, and a posterior boundary segment **3008**. The inferior boundary segment **3002** is immediately adjacent, and extends along, the sciatic notch **2024**.

The inferior boundary segment **3002** and anterior boundary segment **3004** intersect to form an anterior-inferior corner **3010**. The anterior boundary segment **3004** and superior boundary segment **3006** intersect to form an anterior-superior corner **3012**. The superior boundary segment **3006** and posterior boundary segment **3008** intersect to form a superior-posterior corner **3014**. The posterior boundary segment **3008** and posterior inferior access region **2016** intersect to form a superior-posterior corner **3016** of the posterior inferior access region **2016**. The inferior boundary segment **3002** and posterior inferior access region **2016** intersect to form an inferior-posterior corner **3018** of the posterior inferior access region **2016**.

The inferior boundary segment **3002** extends between corners **3010** and **3018**. The anterior boundary segment **3004** extends between corners **3010** and **3012**. The superior

boundary segment **3006** extends between corners **3012** and **3014** and provides an access into the cranial portion **1087** of the sacroiliac joint. The posterior boundary segment **3008** extends between corners **3014** and **3016**. The posterior inferior access region **2016** extends between corners **3016** and **3018** and provides an access into the caudal region **1086** of the sacroiliac joint. The posterior boundary segment **3008** separates articular region **1044** and extra-articular region **3007**, which includes the sacral fossa on the sacrum **1004** and the corresponding iliac tuberosity on the ilium **1005** and defined by the extra-articular region boundary **3009**.

As shown in FIG. **54**, the insertion plate **45** of the implant body **25** is inserted via the implant arm **110** of the delivery tool **20** into the caudal region **1086** of the sacroiliac joint articular region **1044**. As shown via the insertion plate **45** and implant arm **110** shown in solid lines, in one embodiment, the implant **25** enters the posterior inferior access region **2016**, and is further advanced into the caudal region **1086** of the sacroiliac joint articular region **1044**, in an orientation such that the implant arm **110** and implant plate **45** are in the joint plane **1030** (see, for example, FIGS. **47I-47J**) and the longitudinally extending edge **3050** of the implant plate **45** next to the inferior boundary segment **3002** is generally parallel to, and immediately adjacent to, the inferior boundary segment **3002**. Thus, the distal end **42** of the implant is heading generally perpendicular to, and towards, the anterior boundary segment **3004**.

As shown in FIG. **54** via the insertion plate **45** and implant arm **110** shown in dashed lines, in one embodiment, the insertion plate **45** enters the posterior inferior access region **2016**, and is further advanced into the caudal region **1086** of the sacroiliac joint articular region **1044**, in an orientation such that the implant arm **110** and plane of the insertion plate **45** are in the joint plane **1030** (see, for example, FIGS. **47I-47J**) and the longitudinally extending edge **3050** of the insertion plate **45** next to the inferior boundary segment **3002** is somewhere between being generally parallel to the inferior boundary segment **3002** (as illustrated by the solid-lined implant **25** in FIG. **54**) or forming an angle **AJ** with the inferior boundary segment **3002** of up to approximately **50** degrees. Thus, the distal end **42** of the implant shown in dashed lines can be said to head anywhere from generally perpendicular to, and towards, the anterior boundary segment **3004** to heading generally towards the superior-anterior corner **3012**, or points in between.

In one embodiment, the insertion plate **45** may be first directed into the joint space as illustrated by the solid-lined implant body **25** in FIG. **54** after which the implant body **25** is rotated within the joint space to be positioned somewhere between, and including, the angled position depicted by the dashed-lined implant body **25**. In other embodiments, the insertion plate **45** may be first directed into the joint space as illustrated by the dashed-lined implant body **25** in FIG. **54** after which the implant body **25** is rotated within the joint space to be positioned somewhere between, and including, the parallel position depicted by the solid-lined implant body **25**.

iii. Insertion of Anchor

FIG. **55** is a posterior-inferior view of the hip region **1002** of the patient **1001**, wherein the soft tissue **1003** surrounding the skeletal hip bones is shown in dashed lines. As can be understood from FIGS. **47L** and **55**, the anchor **30** is positioned in the lumen of the sleeve **100**. A driving tool **105** (e.g., screw driver) is extended through the lumen of the sleeve **100** so the distal end of the tool **105** is engaged with a proximal end of the anchor member **30** (e.g., screw). As shown in FIG. **47M**, the tool **105** is used to drive the anchor

30 distally through into the bore **40** of the implant **25** generally transverse to the joint line plane **1030** and into the bone of the sacrum **1004**, in this embodiment. As a result, as indicated in FIG. **47N**, the implant assembly **15** formed of the implant **25** and anchor **30** is secured at the implantation site such that the implant **25** is located in the prepared space **1029** of the sacroiliac joint space, and the anchor **30** extends through into the bore **40** of the implant **25** into the bone of the sacrum **1005** and into the implant bore **40** generally transverse to the joint space plane **1030**. The tool **105** and sleeve **100** can be removed from the anchor arm collar **165**, and the incision associated with the sleeve **100** can be closed. Additionally, tool **105** can be a cutting tool **105** (e.g., drill bit, hole punch, or etc.) which can be used in similar steps as above describe to remove bone or other tissues in the path where anchor **30** is to be placed. As indicated in FIG. **47O**, the distal end of the implant arm **110** is decoupled from the proximal end of the implant **25** and removed. The incision associated with the implant arm can be closed.

In other embodiments, illustrated in FIG. **47P**, the anchor **30** may enter a bore **40** situated in a more medial position relative to the insertion plate **45**; the implant body **25** of this embodiment is illustrated in FIG. **9**. In this embodiment, the anchor **30** may enter the bore **40**, penetrate the bone of the sacrum **1004**, pass through a second bore formed within the insertion plate **45** and aligned with the first bore **40**, and further penetrate the bone of the ilium **1005**.

As illustrated in FIG. **47Q**, in certain embodiments, the implant body **25** can be configured to have more than one implant bore **40** to receive additional anchors **30A** and **30B**. The anchors **30**, **30A**, and **30B** prevent migration of the implant body **25** within the joint space. The anchors **30**, **30A**, and **30B** also can draw the ilium and sacrum together about the implant body **25**, increasing the sturdiness of the fixation of the implant in the joint space, as demonstrated by the anchor **30** in FIG. **47P** and by anchor **30B** in FIG. **47Q**. Where the anchor **30** extends through the implant bore **40** and into the bone of both the sacrum **1004** and ilium **1005**, the anchor **30** can be used to draw the articular surfaces **1016** of the sacroiliac joint **1000** against the external surfaces of the insertion plate **45** of the implant body **25**. With the insertion plate **45** implanted in the sacroiliac joint, the healing processes will cause the surfaces **1016** to fuse together about the insertion plate **45**.

FIG. **56** is a posterior view of the implantation area and the implant body **25** implanted within the implantation area. In this view, the insertion plate **45** situated in the joint space is obscured by the attachment element **652**. As can be understood from FIG. **56**, the implant body **25** can be seen positioned in the posterior inferior access region **2016** and implanted in the caudal area of the sacroiliac joint space. The anchor **30** can be understood to have been driven into the implant bore **40** transversely to the joint plane **1030** via a route in the ilium **1005** that avoids contact with vascular and neurological structures, thereby avoiding potentially life threatening injury to such structures. The ability to blindly, yet safely, drive the anchor member **30** into the implant bore **40** while the implant **25** is hidden in the joint space is made possible by the cooperating configurations of the implant body **25** and the delivery tool **20**. Specifically, the longitudinal axis **LCA1** of the anchor arm **165** is coaxially aligned with the longitudinal axis **BA** of the implant bore **40** when the implant body **25** is supported off of the implant arm **110** of the delivery tool **20**, thereby making it possible to safely drive the anchor **30** through the implant bore **40** and into the ilium **1005** bone and/or sacrum bone **1004** when the implant

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body 25 is hidden in the joint space on account of being delivered to the joint space via the delivery tool 20.

The foregoing merely illustrates the principles of the invention. Various modifications and alterations to the described embodiments will be apparent to those skilled in the art in view of the teachings herein. It will thus be appreciated that those skilled in the art will be able to devise numerous systems, arrangements and methods which, although not explicitly shown or described herein, embody the principles of the invention and are thus within the spirit and scope of the present invention. From the above description and drawings, it will be understood by those of ordinary skill in the art that the particular embodiments shown and described are for purposes of illustrations only and are not intended to limit the scope of the present invention. References to details of particular embodiments are not intended to limit the scope of the invention.

What is claimed is:

1. A sacroiliac joint fusion implant assembly for use on a pelvic region including a sacrum, an ilium, and a sacroiliac joint defined there between, the sacroiliac joint fusion implant assembly comprising:

1) an implant body comprising:

a) an insertion element comprising an elongate body with a proximal insertion element end and a distal insertion element end, the insertion element adapted to be positioned within the sacroiliac joint, the insertion element comprising an insertion plate including a medial face, a lateral face opposite to the medial face, and one or more bores, wherein:

- i) each of the one or more bores comprises a bore cross-sectional profile and a bore axis situated along a bore centerline comprising a line connecting each additional bore's cross-sectional profile centroids;
- ii) each of the one or more bores is situated on the medial face or lateral face and is directed inward along the bore centerline;
- iii) each of the one or more bores is configured to receive a distal end of an additional orthopedic fastener; and
- iv) each of the one or more bores is a blind bore extending partially through the insertion plate to the lateral face or medial face; and

b) an attachment element mechanically attached to the proximal insertion element end; wherein the attachment element comprises an anchor fitting formed within the attachment element or mechanically attached to the attachment element, wherein the anchor fitting is configured to overlay a posterior aspect of only one of the sacrum and the ilium when the insertion element is positioned within the sacroiliac joint; and

2) an anchor comprising a threaded shank and a head, wherein the anchor fitting is configured to receive the anchor inserted within a predetermined range of anchor insertion trajectories so as to anchor the implant body to the pelvic region.

2. The sacroiliac joint fusion implant assembly of claim 1, wherein the insertion plate further comprises one or more elongate fins wherein each of the one or more fins projects perpendicularly outward from the medial face or the lateral face and extends longitudinally between the insertion element end and the distal insertion element end.

3. The sacroiliac joint fusion implant assembly of claim 2, wherein the fins and the insertion plate taper toward a narrow insertion plate leading edge.

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4. The sacroiliac joint fusion implant assembly of claim 3, wherein the insertion plate leading edge is configured for insertion into the sacroiliac joint.

5. The sacroiliac joint fusion implant assembly of claim 1, wherein one of the one or more bores is configured to receive a distal end of the anchor projecting from the anchor fitting after insertion of the anchor into the anchor fitting within the predetermined range of anchor insertion trajectories.

6. The sacroiliac joint fusion implant assembly of claim 5, wherein the one of the one or more bores is configured to receive a distal end of the anchor projecting from the anchor fitting has a cross-sectional profile chosen from: square, rectangular, circular, oval, triangular and any combination thereof.

7. The sacroiliac joint fusion implant assembly of claim 1, wherein the attachment element is permanently attached at a fixed position and angle to the proximal end of the insertion element, wherein the angle formed between the attachment element and the insertion element ranges from 30° to 120°.

8. The sacroiliac joint fusion implant assembly of claim 7, wherein the attachment element and insertion element are formed as a continuous structure.

9. The sacroiliac joint fusion implant assembly of claim 1, wherein the attachment element and insertion element are attached in a hinged attachment, wherein the angle formed between the attachment element and insertion element ranges from 30° to 120°.

10. The sacroiliac joint fusion implant assembly of claim 9, wherein the anchor fitting comprises a bore formed within the attachment element, wherein the bore is an open bore passing from a proximal attachment element surface to a distal attachment element surface.

11. The sacroiliac joint fusion implant assembly of claim 10, wherein the bore has a cross-sectional profile chosen from: square, rectangular, circular, oval, triangular and any combination thereof.

12. The sacroiliac joint fusion implant assembly of claim 11, wherein the bore is configured to allow the insertion of an anchor at any angle of up to 45° relative to an axis perpendicular to a region of the attachment element in close proximity to the bore.

13. The sacroiliac joint fusion implant assembly of claim 1, wherein the anchor is chosen from: a cortical screw, a cancellous screw, and a Steffee screw.

14. The sacroiliac joint fusion implant assembly of claim 13, wherein the anchor is a Steffee screw and the anchor fitting is a Steffee plate formed within the attachment element.

15. The sacroiliac joint fusion implant assembly of claim 13, wherein the anchor is a dual-threaded bone screw comprising a head and a shaft, wherein the shaft comprises a proximal threaded segment comprising a first threading pattern and a distal threaded segment comprising a second threading pattern.

16. The sacroiliac joint fusion implant assembly of claim 15, wherein the first threading pattern and the second threading pattern are independently chosen from a threading pattern chosen from a cortical pattern compatible with cortical bone and a cancellous pattern compatible with cancellous bone.

17. The sacroiliac joint fusion implant assembly of claim 1, wherein the attachment element further comprises an attachment fitting attached to a guide formed within the attachment element, the attachment fitting configured to attach to an element of a spinal stabilization system.

18. The sacroiliac joint fusion implant assembly of claim 17, wherein the guide comprises a guide bore configured to receive an attachment fitting comprising a head of a polyaxial pedicle screw, wherein a distal end of the polyaxial screw is inserted through the guide bore within a predetermined range of attachment fitting insertion angles. 5

19. The sacroiliac joint fusion implant assembly of claim 18, wherein the head of the polyaxial pedicle screw comprises at least two sides forming a lower surface of an upward-facing groove configured to receive a rod and further forming a threaded fitting configured to receive a locking nut. 10

20. The sacroiliac joint fusion implant assembly of claim 1, wherein the attachment element extends outward from only one of the medial face or the lateral face of the insertion plate. 15

21. The sacroiliac joint fusion implant assembly of claim 20, wherein the attachment element further comprises an attachment fitting, the attachment fitting configured to attach to an element of a spinal stabilization system. 20

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