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(71) Applicant: **TREACE MEDICAL CONCEPTS, INC.** [US/US]; 203 Fort Wade Road, Suite 150, Ponte Vedra, Florida 32081 (US).

(72) Inventor: **TREACE, John T.**; 216 San Juan Drive, Ponte Vedra Beach, Florida 32082 (US).

(74) Agent: **LAVANWAY, JR., Paul J.** et al.; FREDRIKSON & BYRON, P.A., 200 South Sixth Street, Suite 4000, Minneapolis, Minnesota 55402-1425 (US).

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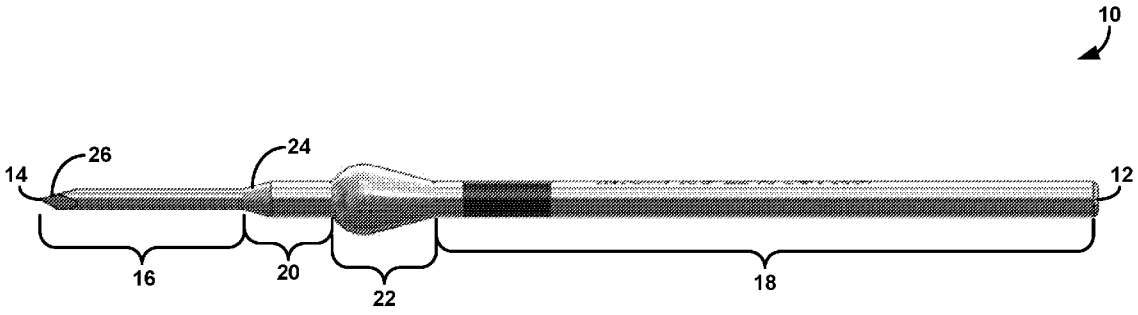


FIG. 1

(57) Abstract: A driving pin can be used for installing a bone plate on a bone. In some examples, the driving pin has a driving pin body extending from a proximal end to a distal end. The driving pin body may define at least three regions of different cross-sectional thickness, including a bone penetrating region adjacent the distal end, a driving region adjacent the proximal end, and a bone plate orienting region between the bone penetrating region and the driving region. In general, the bone penetrating region has a smaller cross-sectional thickness than the bone plate orienting region and the bone plate orienting region has a smaller cross-sectional thickness than the driving region. The bone plate orienting region may be sized to conform to the size of a fixation hole extending through bone plate.

WO 2020/014660 A1

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MULTI-DIAMETER BONE PIN FOR INSTALLING AND ALIGNING BONE FIXATION PLATE WHILE MINIMIZING BONE DAMAGE

RELATED APPLICATIONS

[0001] This application claims the benefit of US Provisional Application No. 62/697,391, filed July 12, 2018, the entire contents of which are incorporated herein by reference.

TECHNICAL FIELD

[0002] This disclosure relates to bone fixation and, more particularly, to devices and techniques for fixating bones.

BACKGROUND

[0003] Bones, such as the bones of a foot, may be anatomically misaligned. In certain circumstances, surgical intervention is required to correctly align the bones to reduce patient discomfort and improve patient quality of life. Surgical intervention may involve cutting one or more of the misaligned bones and then physically realigning the bones into an anatomically corrected position. A bone plate or multiple bone plates may be used to hold the bones in the anatomically corrected position, helping to prevent the bones from shifting back to their misaligned position.

SUMMARY

[0004] In general, this disclosure is directed a driving pin that can be used for installing a bone plate on a bone as well as related systems, kits, and techniques. In some examples, the driving pin has a driving pin body extending from a proximal end to a distal end. The driving pin body may define at least three regions of different cross-sectional thickness, including a bone penetrating region adjacent the distal end, a driving region adjacent the proximal end, and a bone plate orienting region between the bone penetrating region and the driving region. In general, the bone penetrating region has a smaller cross-sectional thickness than the bone plate orienting region and the bone plate orienting region has a smaller cross-sectional thickness than the driving region. The bone plate orienting region may be sized to conform to the size of a fixation hole extending through a bone plate.

[0005] In one example, a bone plate system is described that includes a bone plate and a driving pin. The bone plate includes a body and a fixation hole. The body defines a length extending from a first end to a second end, a top surface, and a bone facing surface opposite

the top surface. The fixation hole extends through a thickness of the body from the top surface to the bone facing surface and defines a fixation hole diameter. The driving pin extends from a proximal end to a distal end and defines at least three regions of different cross-sectional thickness, including a bone penetrating region adjacent the distal end, a driving region adjacent the proximal end, and bone plate orienting region between the bone penetrating region and the driving region. The example specifies that the bone penetrating region has a smaller cross-sectional thickness than the bone plate orienting region, the bone plate orienting region has a smaller cross-sectional thickness than the driving region, and the bone plate orienting region has a size corresponding to the fixation hole diameter.

[0006] In another example, a driving pin is described. The driving pin includes a driving pin body extending from a proximal end to a distal end and defining at least three regions of different cross-sectional thickness, including a bone penetrating region adjacent the distal end, a driving region adjacent the proximal end, and a bone plate orienting region between the bone penetrating region and the driving region. The example specifies that the bone penetrating region has a smaller cross-sectional thickness than the bone plate orienting region and the bone plate orienting region has a smaller cross-sectional thickness than the driving region.

[0007] In another example, a method is described that includes inserting a bone penetrating region of a driving pin adjacent a distal end of the driving pin through a fixation hole of a bone plate. The method also includes positioning a bone plate orienting region of the driving pin co-linear with the fixation hole of the bone plate and coupling a driving region of the driving pin adjacent a proximal end of the driving pin with a driver. The example specifies that the bone penetrating region has a smaller cross-sectional thickness than the bone plate orienting region, the bone plate orienting region has a smaller cross-sectional thickness than the driving region, and the bone plate orienting region has a size corresponding to the fixation hole of the bone plate.

[0008] The details of one or more examples are set forth in the accompanying drawings and the description below. Other features, objects, and advantages will be apparent from the description and drawings, and from the claims.

BRIEF DESCRIPTION OF DRAWINGS

[0009] FIG. 1 is side view of an example driving pin according to the disclosure.

[0010] FIGS. 2–5 are different illustrations showing an example deployment of the driving pin of FIG. 1.

[0011] FIG. 6 illustrates the driving pin of FIG. 1 inserted into a bone at an initial placement position.

[0012] FIG. 7 illustrates the driving pin of FIG. 1 inserted into the bone of FIG. 6 at a modified placement position.

[0013] FIG. 8 illustrates the initial driving pin placement position of FIG. 6 overlaid with the modified driving pin placement position of FIG. 7.

DETAILED DESCRIPTION

[0014] The present disclosure is generally directed to driving pins for installing bone plates, bone plate systems, kits, and associated techniques. A driving pin according to the disclosure can be used to help install a bone plate for internal fixation of a bone or bones during a surgical procedure, such as a bone alignment, osteotomy, fusion procedure, fracture repair, and/or other procedures where one or more bones are to be set in a desired position. Such a procedure can be performed, for example, on bones (e.g., adjacent bones separated by a joint or different portions of a single bone) in the foot or hand, where bones are relatively small compared to bones in other parts of the human anatomy. In one example, a procedure utilizing an embodiment of the driving pin can be performed to correct an alignment between a metatarsal (e.g. a first metatarsal) and a cuneiform (e.g., a first/medial cuneiform), such as a bunion correction. An example of such a procedure is a lapidus procedure. In another example, the procedure can be performed by modifying an alignment of a metatarsal (e.g. a first metatarsal). An example of such a procedure is a basilar metatarsal osteotomy procedure.

[0015] In various examples, the driving pin may be inserted into a bone of the foot, such as a metatarsal (e.g., first metatarsal) and/or cuneiform (e.g., medial cuneiform). For example, the driving pin may be used to install a bone plate having one or more fixation holes though which a bone fixation member is installed into a metatarsal and one or more fixation holes though which a bone fixation member is installed into a cuneiform (e.g., with the bone plate crossing the tarsal-metatarsal joint).

[0016] FIG. 1 is side view of an example driving pin 10 according to the disclosure. Driving pin 10 can be used to install a bone plate on a bone. For example, driving pin 10 may be connected to a driver (e.g., impact driver, rotary driver, drill) that uses driving pin 10 to impart a force for opening a hole in a bone underlying a bone plate. Additionally or alternatively, a clinician utilizing driving pin 10 can apply a force through a hammer or other hand-powered instrument to drive the driving pin. In either case, after creating the hole

and/or orienting the bone plate using driving pin 10, the driving pin can be removed from the bone and bone plate. A bone fixation member (e.g., bone screw) can then be inserted into the opening created by driving pin 10 to permanently hold the bone plate to the bone.

[0017] In the illustrated example, driving pin 10 defines a body that extends from a proximal end 12 to a distal end 14. The body defines multiple regions of different cross-sectional thickness which, in the illustrated example, is shown as at least three regions of different cross-sectional thickness. For example, the body of driving pin 10 may define a bone penetrating region 16 adjacent the distal end, a driving region 18 adjacent the proximal end, and bone plate orienting region 20 between the bone penetrating region and the driving region. Bone penetrating region 16 can have a smaller cross-sectional thickness than the bone plate orienting region 20. Bone plate orienting region 20 may have a smaller cross-sectional thickness than driving region 18 or, in other implementations, can have the same cross-sectional thickness or a larger cross-sectional thickness than driving region 18.

[0018] Configuring driving pin 10 with multiple cross-sectional thicknesses can be useful to provide different functionalities while limiting unnecessary trauma to the bone in which the driving pin is engaged. For example, bone penetrating region 16 can be sized comparatively small to minimize bone damage and ease insertion of the distal end of the driving pin. Bone plate orienting region 20 may be larger and be sized complementary to the dimeter of a fixation hole of the bone plate in which the driving pin is to be inserted. This can provide close conformance between the driving pin and the bone plate, e.g., for accurately rotating the bone plate about the driving pin to orient the bone plate during installation. Driving region 18 may be larger and sized for engagement with a driver to be used in the process. In some configurations, driving pin 10 is provided as part of a kit that includes other driving instruments (e.g., pins, k-wires) and has the same diameter as one or more of those other instruments to provide a uniform driving connection size across the instruments. In other words, driving pin 10 may be part of a kit (e.g., where all the components of the kit art contained in a sterile case) having one or more (and optionally two or more) other instruments, each having a substantially same diameter shaft and each being configured to couple to a same driver for driving the instruments.

[0019] In general, driving pin 10 have any have desired cross-sectional shape, including polygonal shapes, arcuate shapes, and combinations thereof. In some configurations, at least bone penetrating region 16, driving region 18, and bone plate orienting region 20 of the driving pin have a circular cross-sectional shape.

[0020] While driving pin 10 have a variety of different sizes, in some examples, bone penetrating region 16 has a diameter ranging from 0.1 mm to 2 mm and/or bone plate orienting region 20 has a diameter ranging from 0.5 to 3 mm and/or driving region 18 has a diameter ranging from 1.6 mm to 3.7 mm. For example, bone penetrating region 16 may have a diameter ranging from 1 mm to 2 mm, and bone plate orienting region 20 may have a diameter ranging from 1 mm to 2 mm.

[0021] As noted, bone plate orienting region 20 may be sized complementary to the dimeter of a fixation hole of a bone plate in which the driving pin is to be inserted. In some examples, bone plate orienting region 20 has an outer diameter that is less than 20 percent smaller than the diameter of the fixation hole of the bone plate in which the driving pin is to be inserted, such as less than 10 percent smaller, less than 5 percent smaller, or less than 2 percent smaller. For example, bone plate orienting region 20 may have a cross-sectional size plus or minus 0.2 mm or less of the size of the fixation hole of the bone plate, such as a size plus or minus 0.1 mm or less, or plus or minus 0.1 mm or less. This can provide close conformance between the driving pin and the bone plate, e.g., for accurately rotating the bone plate about the driving pin to orient the bone plate during installation. In applications where a drill guide 60 is used (as discussed below) and the drill guide is secured (e.g., threaded) into an inner diameter of the fixation hole of the bone plate, the drill guide may provide a smaller diameter opening than the fixation hole through which driving pin 10 can be inserted. Accordingly, any of the relative sizes and dimensions discussed herein, including immediately above, as being relative to the cross-sectional size or diameter of a fixation hole may instead be provided relative to an internal cross-sectional size or diameter of a drill guide inserted into a fixation hole.

[0022] Driving pin 10 can have one or more regions of different cross-sectional thickness than bone penetrating region 16, driving region 18, and bone plate orienting region 20. For example, in the illustrated example, driving pin 10 includes a fourth region 22 of greater cross-sectional thickness than at least bone penetrating region 16 and bone plate orienting region 20. In the illustrated configuration, fourth region 22 also has a cross-sectional thickness greater than driving region 18. Fourth region 22 is positioned proximally of bone plate orienting region 20 and can have a cross-sectional thickness greater than that of a bone plate fixation hole diameter and/or drill guide into which driving pin 10 is configured to be inserted. Fourth region 22 can function as a feature that limits that downward insertion depth of driving pin 10 as it is being inserted through a bone plate and/or drill guide. When included, fourth region 22 may be integral (e.g. permanently formed with) a remainder of the

driving pin body or may be part of a multi-piece assembly that is separately attachable to the driving pin.

[0023] Fourth region 22 can have any desired cross-sectional shape (e.g., round, spherical, rectangular, triangular, elliptical), and the cross-sectional shape may be the same as or different than that of adjacent sections of the driving pin. In some examples, fourth region 22 has a cross-sectional thickness ranging from 1.5mm to 12mm, such as from 2mm to 5mm.

[0024] Driving pin 10 may define a sharp transition between the regions of different cross-sectional thickness or may have a tapered transition between the regions of different cross-sectional thickness. In the example of FIG. 1, driving pin 10 has a tapered cross-sectional dimension 24 transitioning between driving region 18 and bone plate orienting region 20. The illustrated example also has a driving region that tapers to a point 26 at the distal end 14 of the driving pin.

[0025] Driving pin 10 can be used as part of a bone plate system to install a bone plate. FIGS. 2–5 are different illustrations showing an example deployment of driving pin 10 to install an example bone plate. Additional details on example bone realignment techniques and devices with which driving pin 10 may be used are described in US Patent 9,622,805, titled "BONE POSITIONING AND PREPARING GUIDE SYSTEMS AND METHODS," filed on December 28, 2015 and issued April 18, 2017, and US Patent 10,245,088, titled "BONE PLATING SYSTEM AND METHOD," filed on January 7, 2016 and issued on April 2, 2019. The entire contents of each of these documents are hereby incorporated by reference.

[0026] With reference to FIG. 2, driving pin 10 is illustrated as part of a bone plate system that includes a bone plate 50. Bone plate 50 defines a length extending from a first end 52 to a second end 54. The bone plate has a top surface and a bone facing surface opposite the top surface. Bone plate 50 may also include at least one fixation hole 56 extending through a thickness of the body from the top surface to the bone facing surface. For example, bone plate 50 may include one or more fixation holes 56 adjacent one end of the bone plate and one or more additional fixation holes 58 adjacent an opposite end. Each fixation hole 56, 58 may define a fixation hole cross-sectional size (e.g., diameter), which may be the same or different for each fixation hole defined by the bone plate.

[0027] The size and configuration of bone plate 50 may vary, e.g., depending on the specific patent and the procedure in which the bone plate is being used. In one example, bone plate 50 is configured for fusion of metatarsal (e.g., first metatarsal) to a cuneiform (e.g., medial cuneiform) across a tarsal-metatarsal joint. For example, bone plate 50 may have a length

configured to position first end 52 on a first metatarsal 102 of a foot and second end 54 on a medial cuneiform 100 of the foot.

[0028] Driving pin 10 may be configured for use with bone plate 50 (or a bone plate having a different configuration). For example, bone penetrating region 16 may have a smaller cross-sectional size than the fixation hole of the bone plate. Bone plate orienting region 20 may have a cross-sectional size substantially equivalent to that of than the fixation hole of the bone plate. Driving region 18 and/or fourth region 22 may have a cross-sectional size larger than that of the fixation hole of the bone plate.

[0029] In some applications, a clinician may utilize a drill guide 60 to help guide driving pin 10 through the fixation hole(s) of the bone plate during operation. When used, drill guide 60 can extend from the top surface of the bone plate about the fixation hole. Bone plate orienting region 20 of driving pin 10 may or may not have a length equal to or greater than a length of the of the drill guide to accommodate use of the use of drill guide 60.

[0030] In use, a clinician may insert bone penetrating region 16 of driving pin 10 through fixation hole 56 and/or 58 of bone plate 50. The clinician can couple driving region 18 of driving pin 10 to a driver (if a powered driver is to be used). The clinician can engage the driver or otherwise apply force to drive driving pin 10 through the fixation hole and into the underlying bone over which the fixation hole is positioned. The clinician can drive the driving pin down until, for example, fourth region 22 of the driving pin contacts the top of the drill guide 60 (when used) or bone plate 50 (when drill guide 60 is not used). When driven into the underlying bone, bone plate orienting region 20 of driving pin 10 may be co-linear with the fixation hole and/or drill guide of the bone plate.

[0031] With driving pin 10 holding bone plate 50 into the underlying bone, the clinician may rotate the bone plate around the bone plate orienting region 20 of the driving pin to adjust a position of one or more fixation holes adjacent an opposite end of the bone plate. Accordingly, bone plate orienting region 20 can act as a pivot point for aligning the bone plate on and over the bone portions to be fixated using the bone plate. With the bone plate appropriately positioned, the clinician can remove the driving pin from the fixation hole and insert a bone fixation member into the fixation hole to permanently anchor the bone plate to the underlying bone. In some examples, the bone anchoring member is a bone screw. When drill guide 60 is used, the drill guide can be removed from bone plate 50 before the bone fixation member is inserted into the hole created by drive pin 10.

[0032] A driving pin according to the disclosure can be useful to create an opening in a bone for subsequently installing a bone fixation member. The length of driving pin 10 inserted

into the bone during use may have a diameter less than that of a drill bit that may otherwise be used by a clinician to create the opening. For example, a drill bit otherwise used to create an opening in a bone for subsequently installing a bone fixation member may have a diameter substantially the same as that of the fixation hole. Further, the depth to which the drill bit is inserted into the bone may not be precisely controlled. This may create bone trauma issues, particularly when a clinician needs to realign a bone plate after creating one or more initial holes in the bone.

[0033] For example, FIG. 6 is a sectional view of an example bone 100 showing an example initial installation position for bone plate 50. In this example, driving pin 10A is shown inserted through a fixation hole of the bone plate to a maximum depth of insertion. A hypothetical drill bit opening 62A is shown overlaying the opening in bone 100 created by driving pin 10A. Drill bit opening 62A represents the opening in bone 100 that may be created if a drill bit is used instead of driving pin 10A.

[0034] After positioning bone plate 50 and creating an opening in bone 100 as shown in FIG. 6, a clinician may check the position of the bone plate. For example, the clinician may generate a fluoroscopic image (x-ray) of the bone and plate attached thereto (which may be a temporary or provisional attachment) to check the position of the plate relative to an intended position desired by the clinician. If the clinician determines that bone plate 50 is not accurately positioned, the clinician may reorient bone plate 50 one bone 100 and create a new opening in bone 100 at the new position of the bone plate.

[0035] For example, FIG. 7 is a sectional view of bone 100 showing an example modified installation position for bone plate 50. In this example, driving pin 10B (which may be the same driving pin as driving pin 10A) is shown inserted through a fixation hole of the bone plate to a maximum depth of insertion. A hypothetical drill bit opening 62B is shown overlaying the opening in bone 100 created by driving pin 10B. Drill bit opening 62B represents the opening in bone 100 that may be created if a drill bit is used instead of driving pin 10B.

[0036] FIG. 8 illustrates the initial driving pin placement position of FIG. 6 overlaid with the modified driving pin placement position of FIG. 7. As FIG. 8 illustrates, drill bit opening 62A significantly overlaps with drill bit opening 62B in the intersection region 70. This can create a cavity within bone 100 that is larger than the diameter of the fixation member inserted through bone plate 50 (and larger than the drill bit used to create either individual opening). As a result, the fixation member inserted into the opening in bone 100 at the modified installation position may not securely engage in bone 100. By contrast, the opening

created by driving pin 10A does not intersect, or only slightly intersects, the opening created by driving pin 10B. This can help ensure that a fixation member inserted into the opening in bone 100 at the modified installation position securely engages the bone.

[0037] Various examples have been described. These and other examples are within the scope of the following claims.

CLAIMS:

1. A bone plate system comprising:

a bone plate comprising:

a body defining a length extending from a first end to a second end, a top surface, and a bone facing surface opposite the top surface, and

a fixation hole extending through a thickness of the body from the top surface to the bone facing surface, the fixation hole defining a fixation hole diameter;

a driving pin for using in installing the bone plate on a bone, wherein the driving pin extends from a proximal end to a distal end and defines at least three regions of different cross-sectional thickness, including a bone penetrating region adjacent the distal end, a driving region adjacent the proximal end, and bone plate orienting region between the bone penetrating region and the driving region,

wherein the bone penetrating region has a smaller cross-sectional thickness than the bone plate orienting region, the bone plate orienting region has a smaller cross-sectional thickness than the driving region, and the bone plate orienting region has a size corresponding to the fixation hole diameter.

2. The system of claim 1, further comprising a drill guide extending from the top surface of the bone plate about the fixation hole, wherein the bone plate orienting region of the driving pin has a length equal to or greater than a length of the of the drill guide.

3. The system of either of claims 1 or 2, wherein the bone penetrating region, the driving region, and the bone plate orienting region each have a circular cross-sectional shape.

4. The system of any of the foregoing claims, wherein:

the bone penetrating region has a diameter ranging from 0.1 mm to 2 mm;

the bone plate orienting region has a diameter ranging from 0.5 to 3 mm; and

the driving region has a diameter ranging from 1.6 mm to 3.7 mm.

5. The system of claim 4, wherein:

the bone penetrating region has a diameter ranging from 1 mm to 2 mm; and

the bone plate orienting region has a diameter ranging from 1 mm to 2 mm.

6. The system of any of the foregoing claims, wherein the driving pin further defines a fourth region of greater cross-sectional thickness than the bone penetrating region, the driving region, and the bone plate orienting region, and the fourth region is positioned proximally of the bone plate orienting region and has a cross-sectional thickness greater than the fixation hole diameter.

7. The system of claim 6, wherein the fourth region has a diameter ranging from 1.5 mm to 12 mm.

8. The system of either of claims 6 or 7, wherein the fourth region has a different cross-sectional shape than a remainder of the driving pin.

9. The system of any of the foregoing claims, wherein the bone plate orienting region has a diameter within 0.1 mm of the fixation hole diameter.

10. The system of any of the foregoing claims, wherein the bone plate has a length configured to position the first end on a first metatarsal of a foot and the second end on a medial cuneiform of the foot.

11. The system of any of the foregoing claims, wherein the bone plate further comprises a second fixation hole have a same diameter as the fixation hole diameter.

12. A driving pin for using in installing a bone plate on a bone comprising:

a driving pin body extending from a proximal end to a distal end and defining at least three regions of different cross-sectional thickness, including a bone penetrating region adjacent the distal end, a driving region adjacent the proximal end, and a bone plate orienting region between the bone penetrating region and the driving region,

wherein the bone penetrating region has a smaller cross-sectional thickness than the bone plate orienting region and the bone plate orienting region has a smaller cross-sectional thickness than the driving region.

13. The driving pin of claim 12, wherein the bone plate orienting region is configured to be inserted into and is complementary in size with a fixation hole of a bone plate.

14. The driving pin of either of claims 12 or 13, wherein the bone penetrating region, the driving region, and the bone plate orienting region each have a circular cross-sectional shape.

15. The driving pin of any of claims 12–14, wherein:
the bone penetrating region has a diameter ranging from 0.1 mm to 2 mm;
the bone plate orienting region has a diameter ranging from 0.5 to 3 mm; and
the driving region has a diameter ranging from 1.6 mm to 3.7 mm.

16. The driving pin of claim 15, wherein:
the bone penetrating region has a diameter ranging from 1 mm to 2 mm; and
the bone plate orienting region has a diameter ranging from 1 mm to 2 mm.

17. The driving pin of any of claims 12–16, wherein the driving pin further defines a fourth region of greater cross-sectional thickness than the bone penetrating region, the driving region, and the bone plate orienting region, and the fourth region is positioned proximally of the bone plate orienting region and has a cross-sectional thickness greater than the fixation hole diameter.

18. The driving pin of claim 17, wherein the fourth region has a diameter ranging from 1.5 mm to 12 mm.

19. The driving pin of either of claims 17 or 18, wherein the fourth region has a different cross-sectional shape than a remainder of the driving pin.

20. The driving pin of any of claims 12–19, wherein the driving region tapers to a point at the distal end.

21. The driving pin of any of claims 12–20, further comprising a tapered cross-sectional dimension transition between the driving region and the bone plate orienting region.

22. A method comprising:
inserting a bone penetrating region of a driving pin adjacent a distal end of the driving pin through a fixation hole of a bone plate;

positioning a bone plate orienting region of the driving pin co-linear with the fixation hole of the bone plate,

coupling a driving region of the driving pin adjacent a proximal end of the driving pin with a driver,

wherein the bone penetrating region has a smaller cross-sectional thickness than the bone plate orienting region, the bone plate orienting region has a smaller cross-sectional thickness than the driving region, and the bone plate orienting region has a size corresponding to the fixation hole of the bone plate.

23. The method of claim 22, wherein inserting the bone penetrating region through the fixation hole further comprises engaging the driver and driving the bone penetrating region into a bone underlying the fixation hole on which the bone plate is positioned.

24. The method of either of claims 22 or 23, wherein:

the bone plate further comprises a drill guide extending from the top surface of the bone plate about the fixation hole,

inserting the bone penetrating region comprises inserting the bone penetrating region through the drill guide, and

positioning the bone plate orienting region co-linear with the fixation hole comprises positioning the bone plate orienting region co-linear with the drill guide.

25. The method of claim 24,

wherein the driving pin further defines a fourth region of greater cross-sectional thickness than the bone penetrating region, the driving region, and the bone plate orienting region, and

inserting the bone penetrating region comprises inserting the bone penetrating region until the fourth region contacts the drill guide.

26. The method of any of claims 22–25, further comprising rotating the bone plate about the bone plate orienting region of the driving pin to adjust a position of one or more secondary fixation holes on the bone plate.

27. The method of any of claims 22–26, further comprising removing the driving pin from the fixation hole and inserting a bone anchoring member into the fixation hole to permanently anchor the bone plate to the underlying bone.

28. The method of claim 27, wherein the bone anchoring member is a bone screw.

29. The method of any of claims 22–28, wherein:
the bone penetrating region has a diameter ranging from 0.1 mm to 2 mm;
the bone plate orienting region has a diameter ranging from 0.5 to 3 mm; and
the driving region has a diameter ranging from 1.6 mm to 3.7 mm.

30. The method of claim 29, wherein:
the bone penetrating region has a diameter ranging from 1 mm to 2 mm; and
the bone plate orienting region has a diameter ranging from 1 mm to 2 mm.

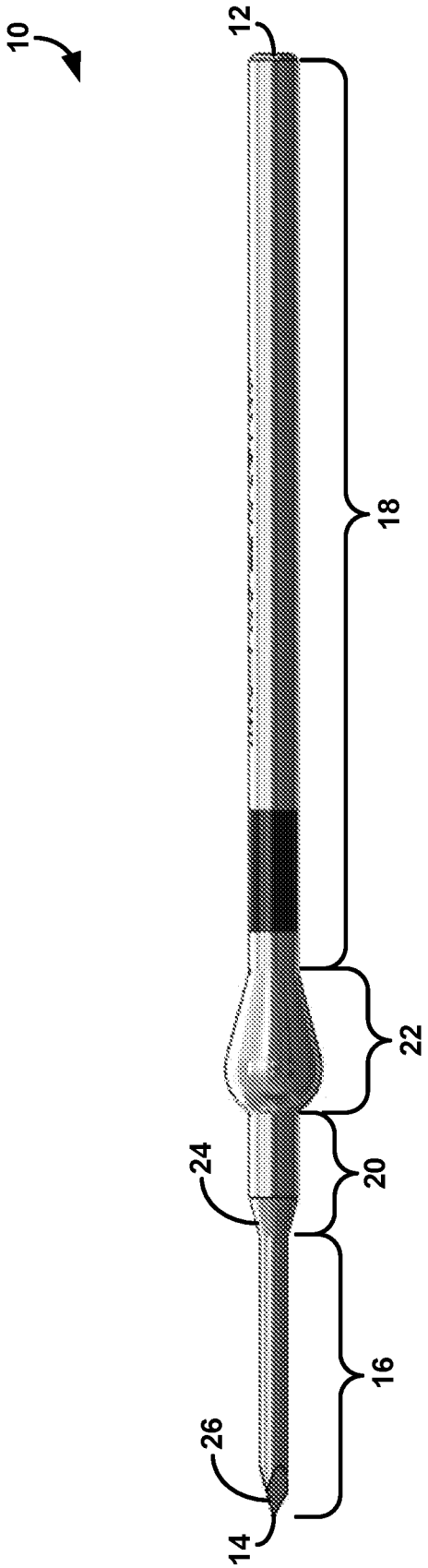


FIG. 1

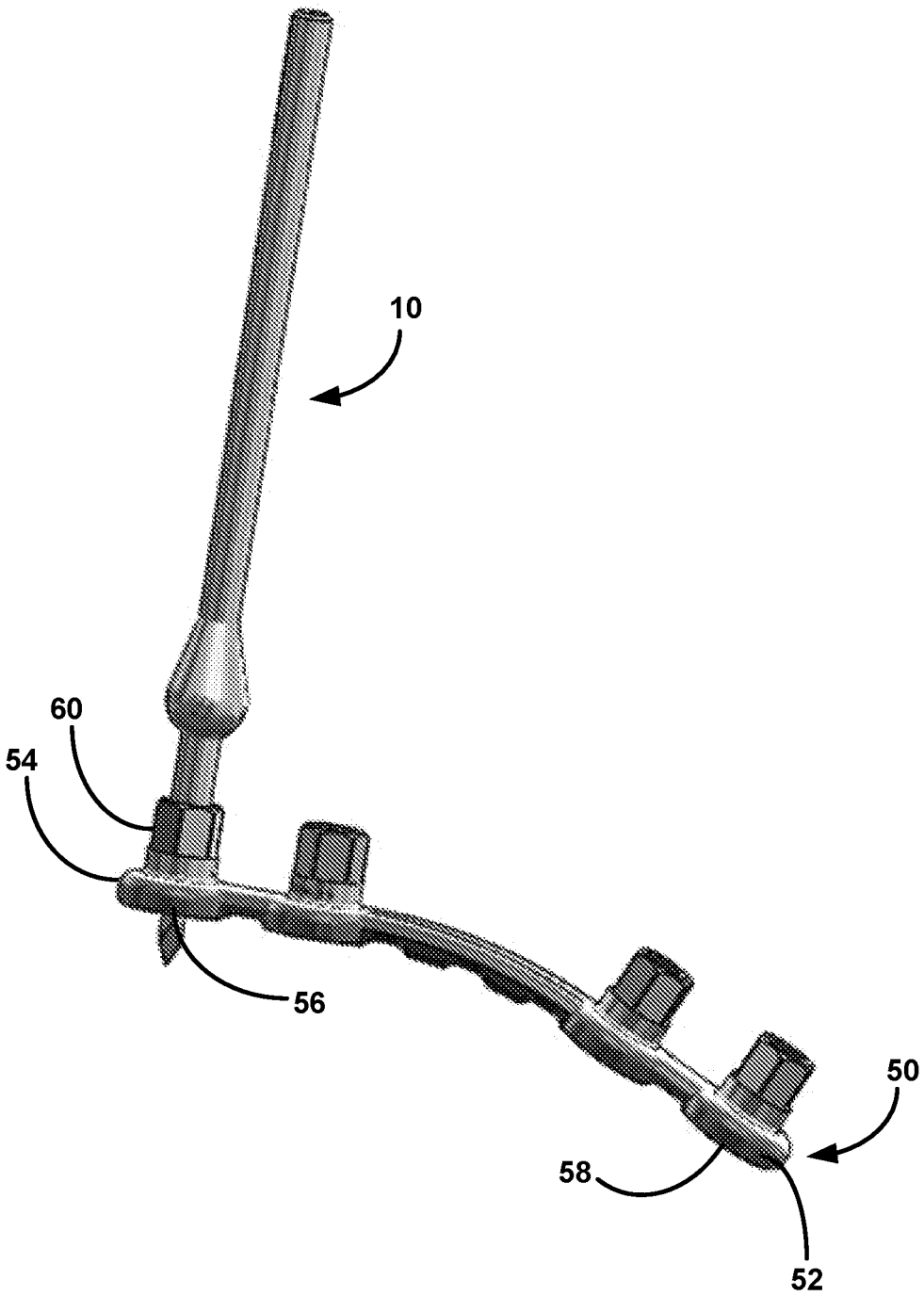


FIG. 2

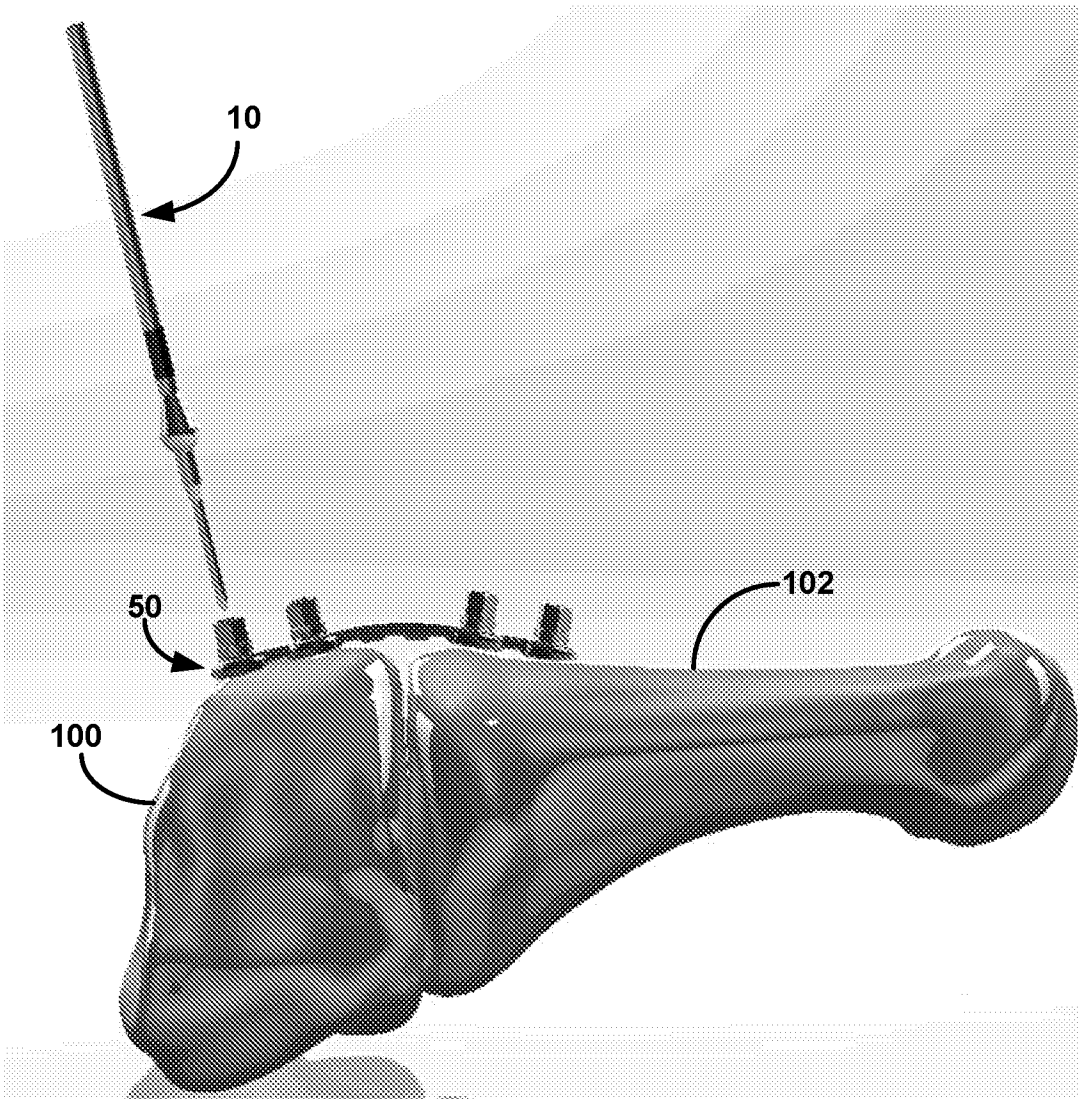


FIG. 3

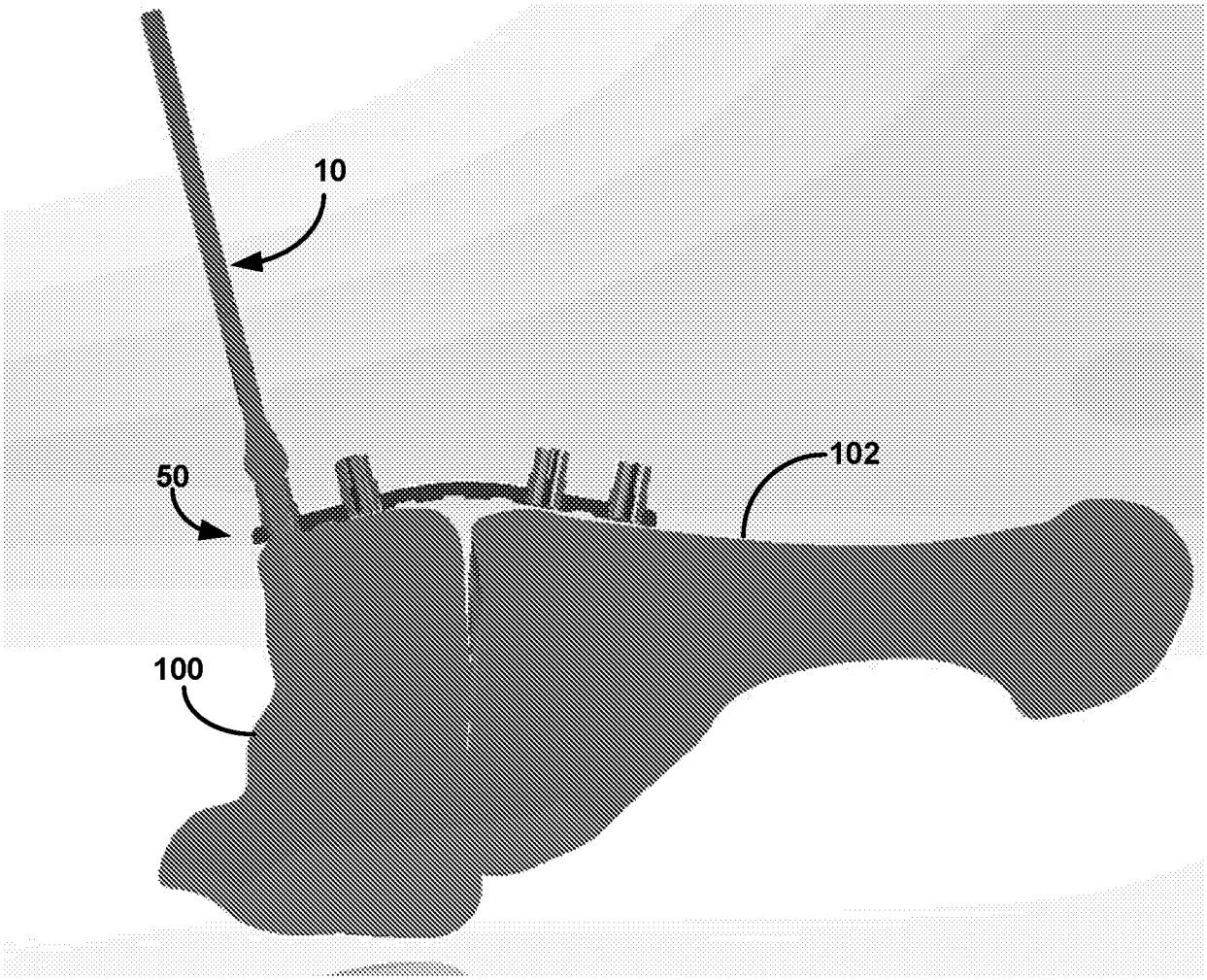


FIG. 4

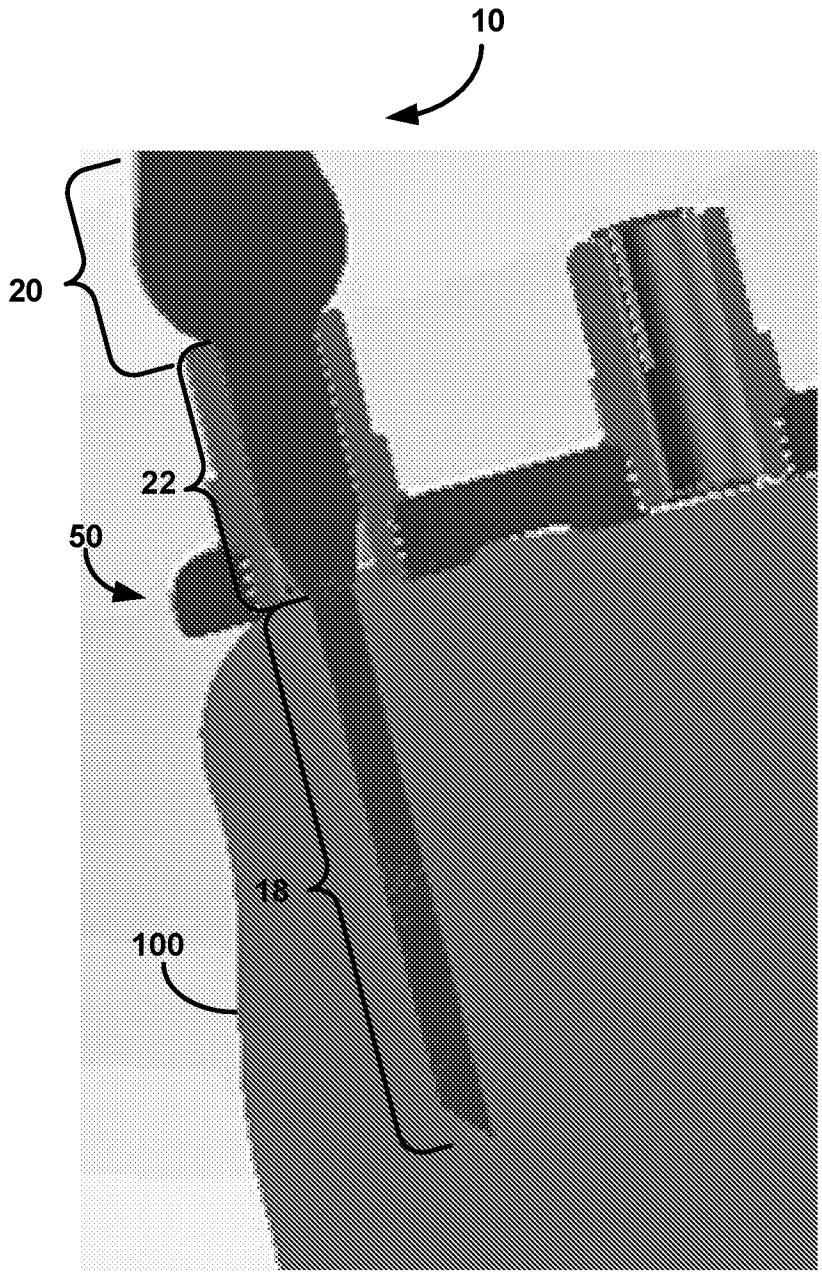


FIG. 5

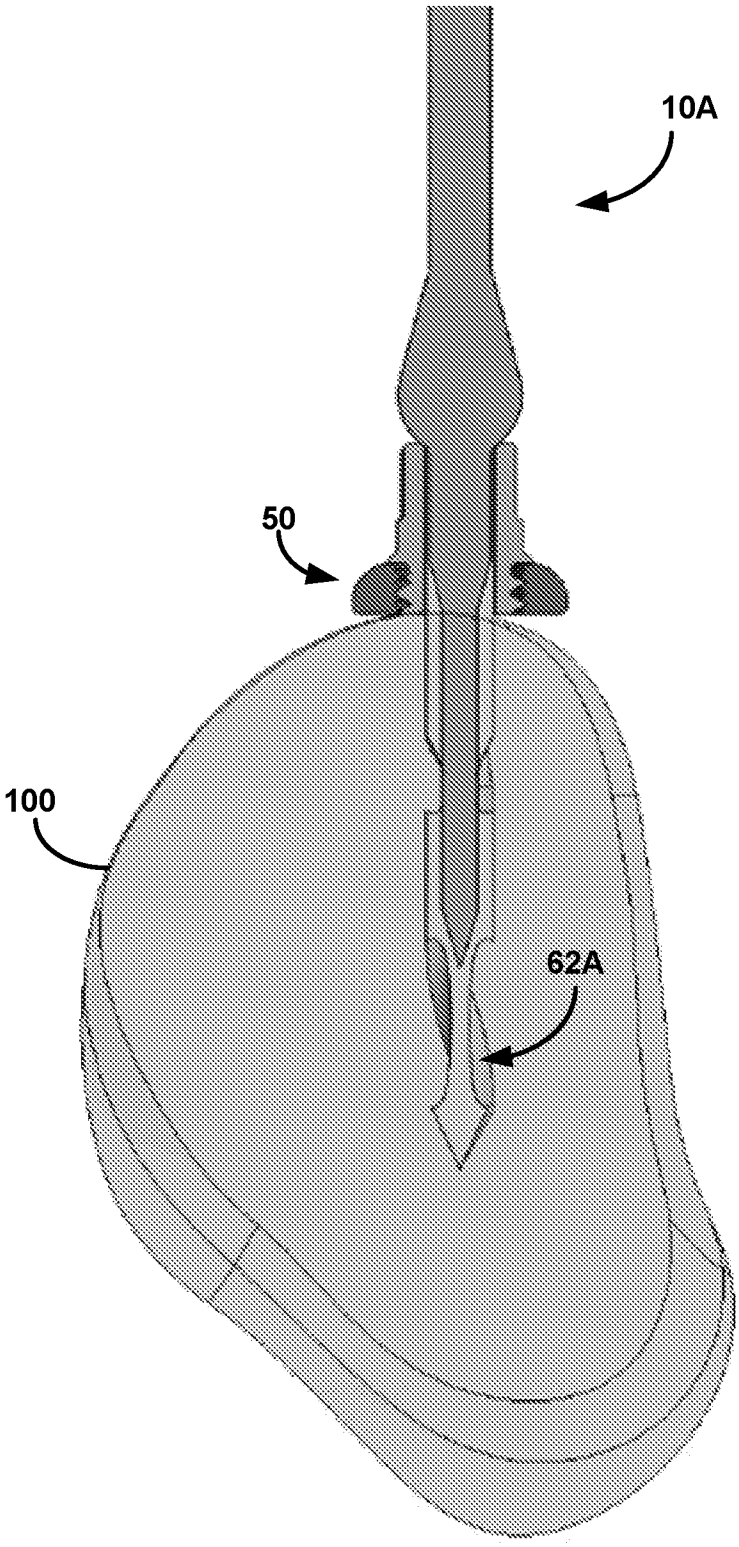


FIG. 6

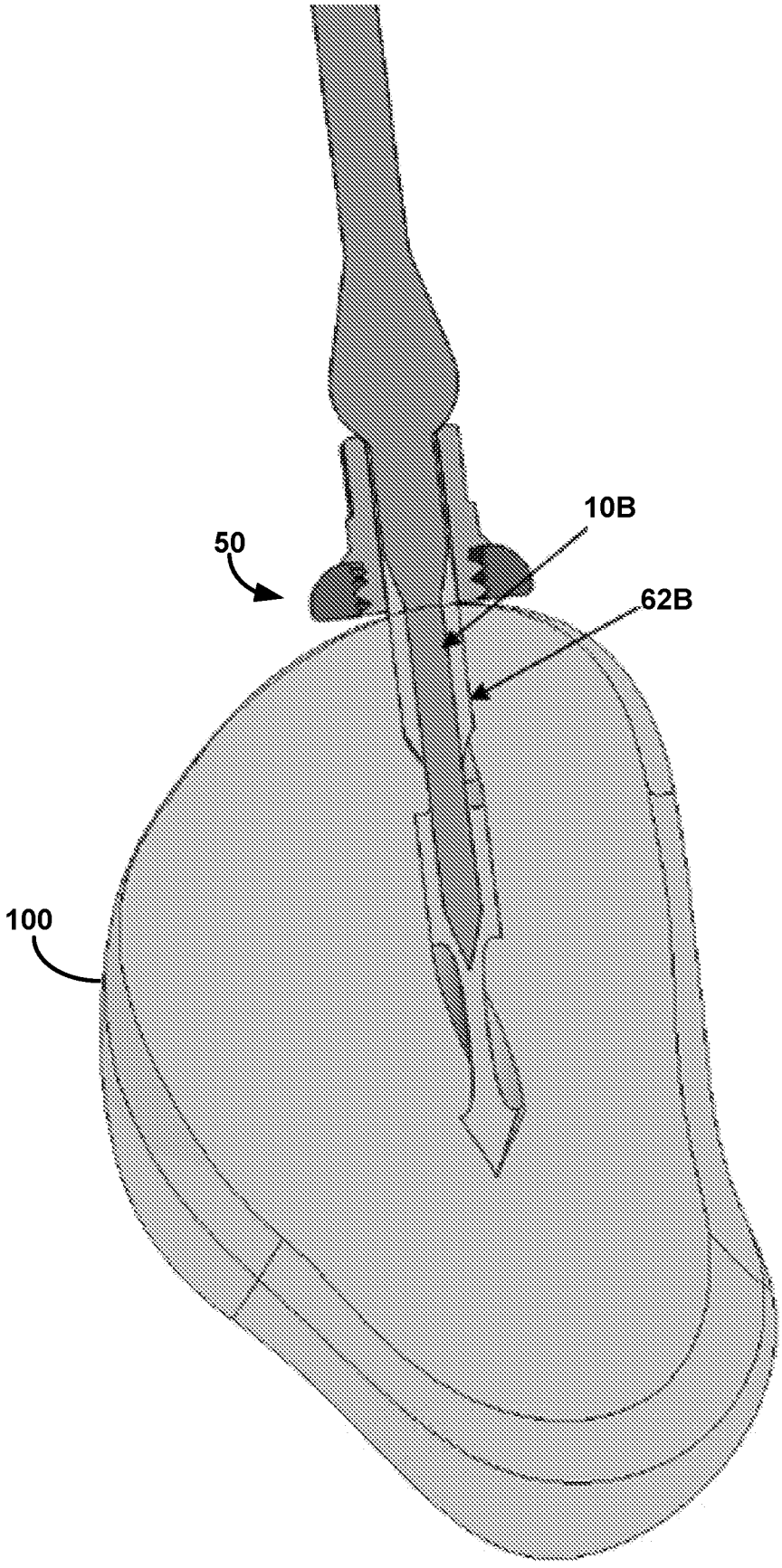


FIG. 7

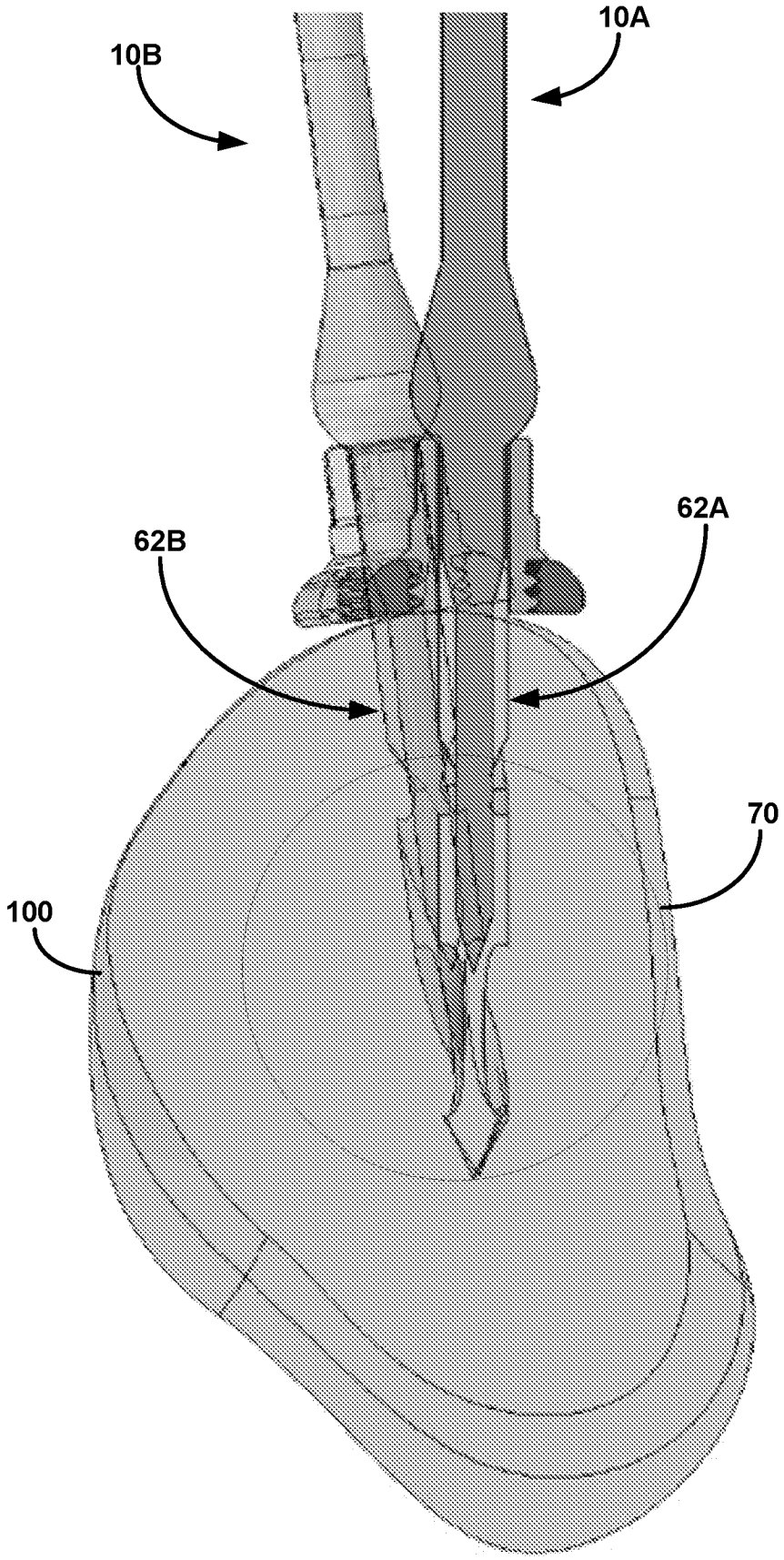


FIG. 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US19/41685

A. CLASSIFICATION OF SUBJECT MATTER

IPC - A61B 17/17, 17/58, 17/60, 17/80, 17/88 (2019.01)

CPC - A61B 17/1728, 17/8061, 17/808

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
See Search History document

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2016/0235454 A1 (TREACE MEDICAL CONCEPTS, INC.) 18 August 2016, figures 2B-2C, paragraphs [0034], [0041], [0045]	1, 3/1, 12-13, 14/12-14/13
Y		2, 3/2, 22-23, 24/22-24/23
A		25/24/22, 25/24/23
Y	US 9,375,242 B2 (WORCEL, A.) 28 June 2016, figure 1, column 5, lines 58-60	2, 3/2, 22-23, 24/22-24/23
A		25/24/22, 25/24/23
Y	US 2018/0140339 A1 (OSTEOCERTUS, LLC) 24 May 2018, figure 51, paragraph [0099]	22-23, 24/22-24/23
A		25/24/22, 25/24/23
A	US 2007/0055249 A1 (JENSEN, D. G. et al.) 8 March 2007, paragraphs [0041], [0044]-[0045]	25/24/22, 25/24/23

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"D" document cited by the applicant in the international application
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
4 September 2019 (04.09.2019)	04 OCT 2019
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Authorized officer Shane Thomas Telephone No. PCT Helpdesk: 571-272-4300

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US19/41685

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

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

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

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☒ Claims Nos.: 4-11, 15-21, 26-30
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

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

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

Remark on Protest

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

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

☐ No protest accompanied the payment of additional search fees.