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CORRECTED PUBLICATION

(54) **BONE PLATE WITH ELEVATED SUTURE HOLE STRUCTURES**

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CPC ***A61B 17/8061*** (2013.01)

(57) **ABSTRACT**

The present invention relates to an improved bone plate for use in repairing bone fractures, the bone plate having a first upper surface and a first opposed bone-facing surface, the first bone-facing surface shaped to generally conform to a plate-facing surface of the bone, a bone plate thickness, at least one fastener hole extending between the first upper surface and the first bone-facing surface, and a suture hole structure extending from at least a portion of a boundary or boundary edge of the bone plate and having a second upper surface and a second opposed bone-facing surface, a suture hole structure thickness, at least one suture hole extending between the second upper surface and the second bone-facing surface, wherein the suture hole structure thickness is less than the bone plate thickness, and the second bone-facing surface of the suture hole structure is elevated above the first bone-facing surface of the bone plate by a distance greater than 0 mm. The present invention also relates to the method of fixation of the device.

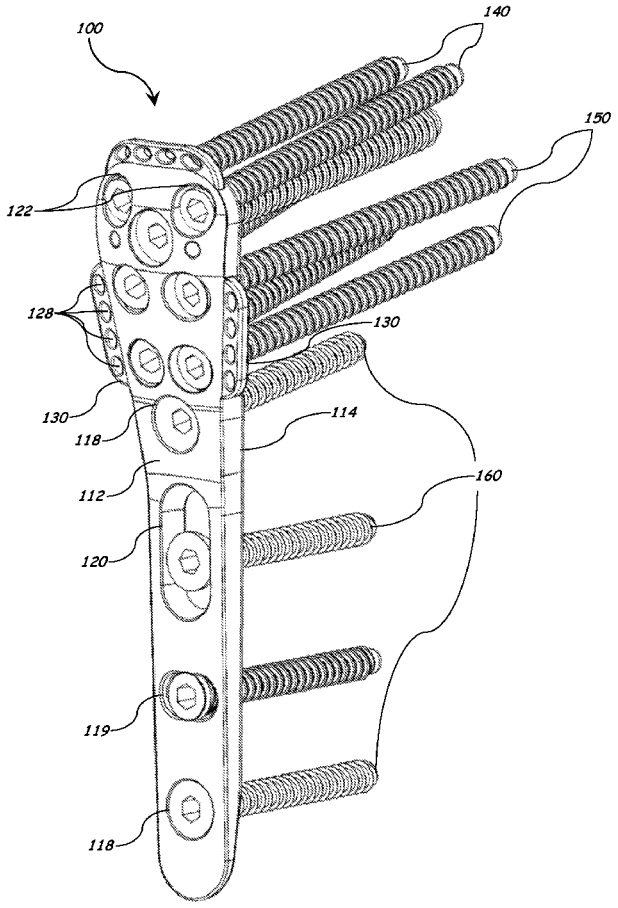


Figure 1E

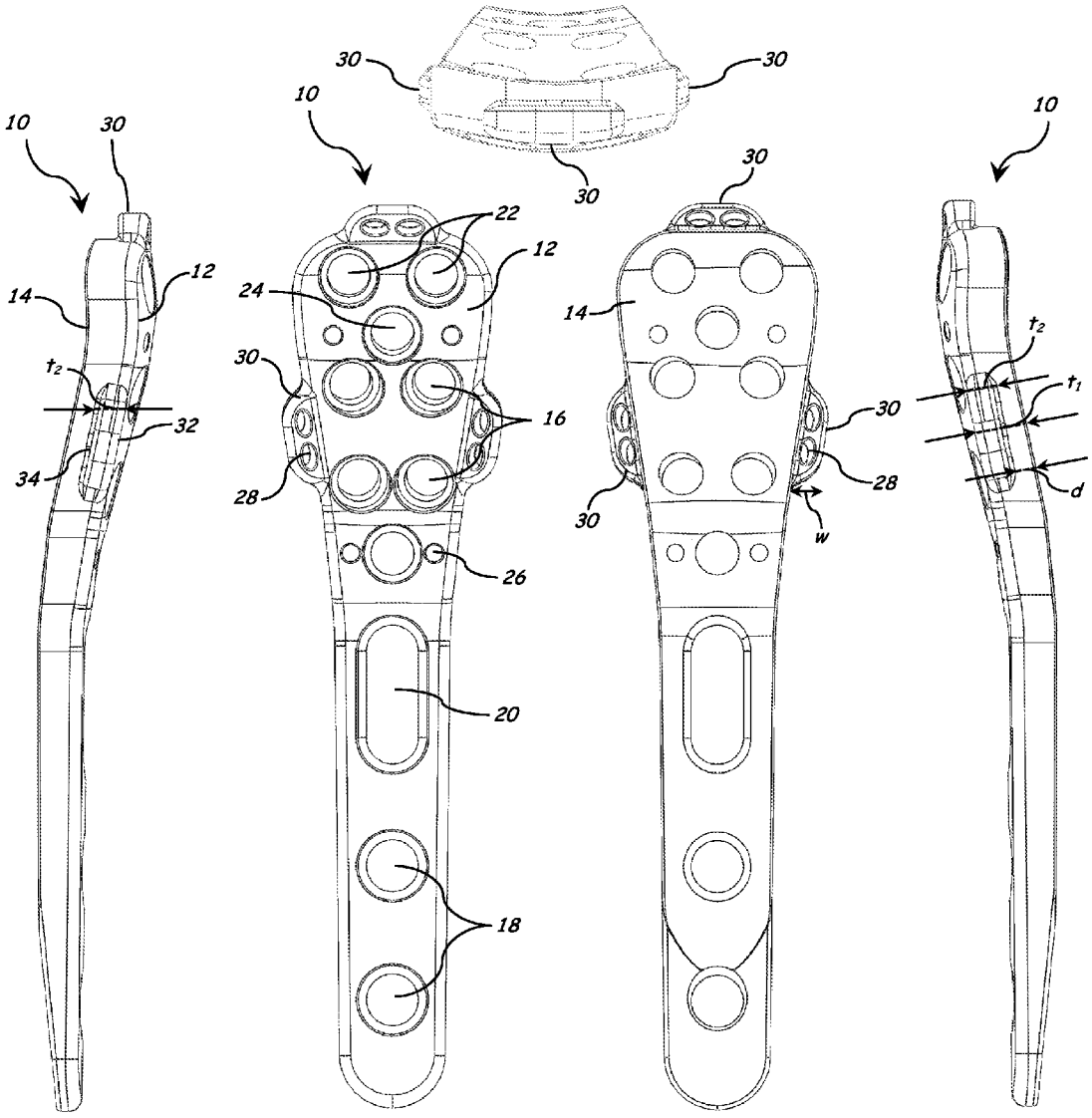


Figure 1C Figure 1A Figure 1B Figure 1D

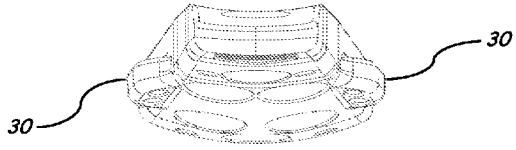


Figure 1F

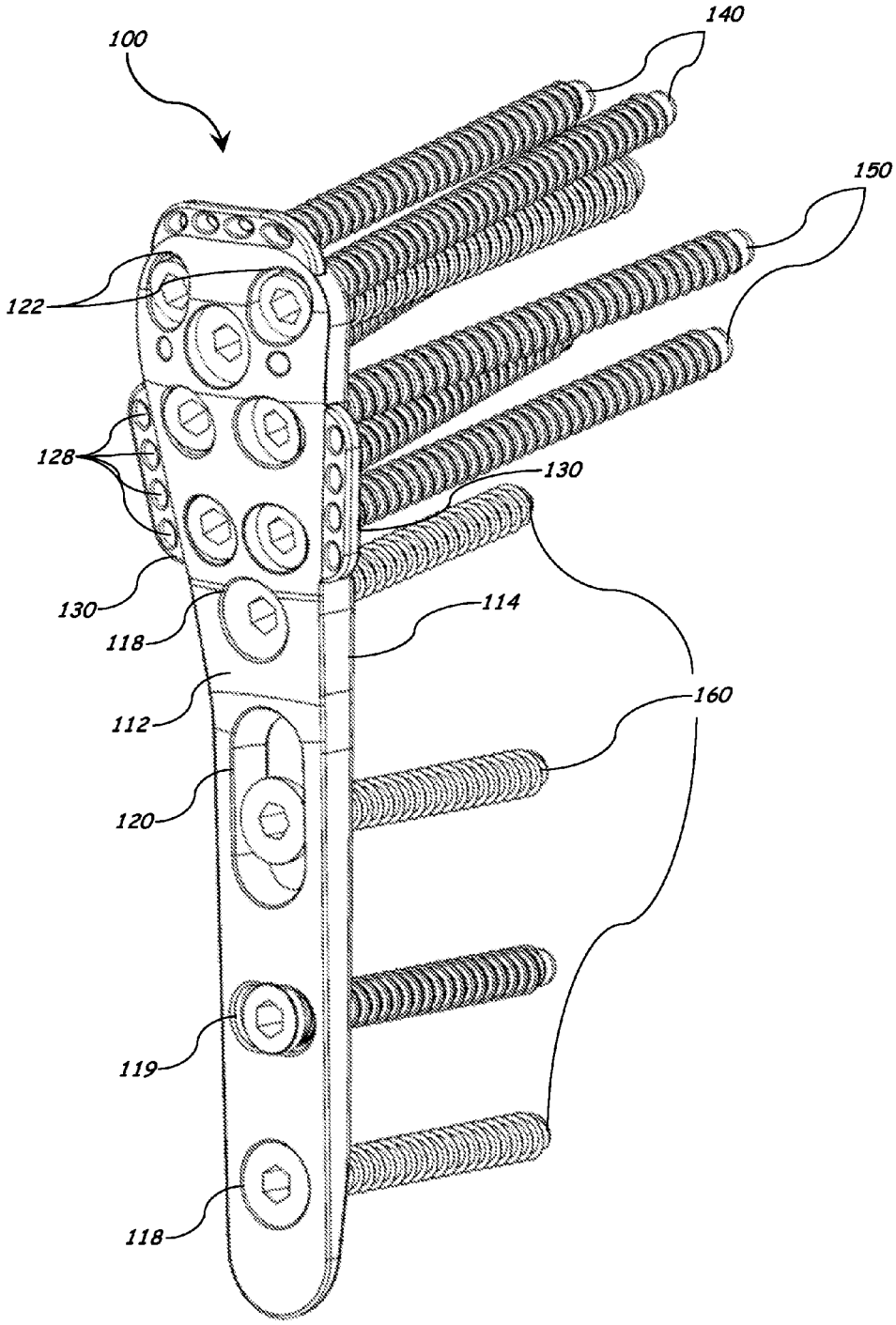


Figure 2A

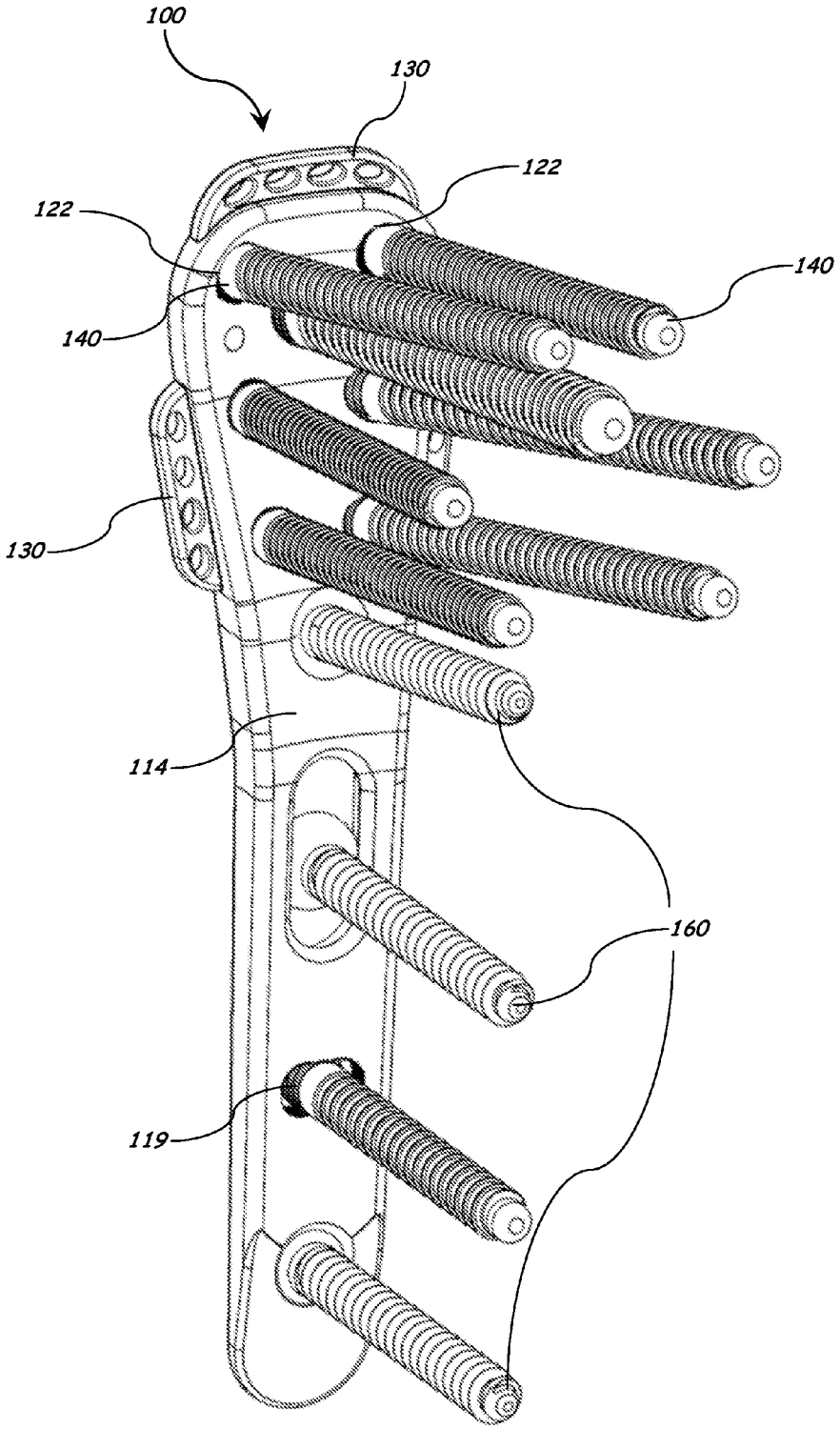


Figure 2B

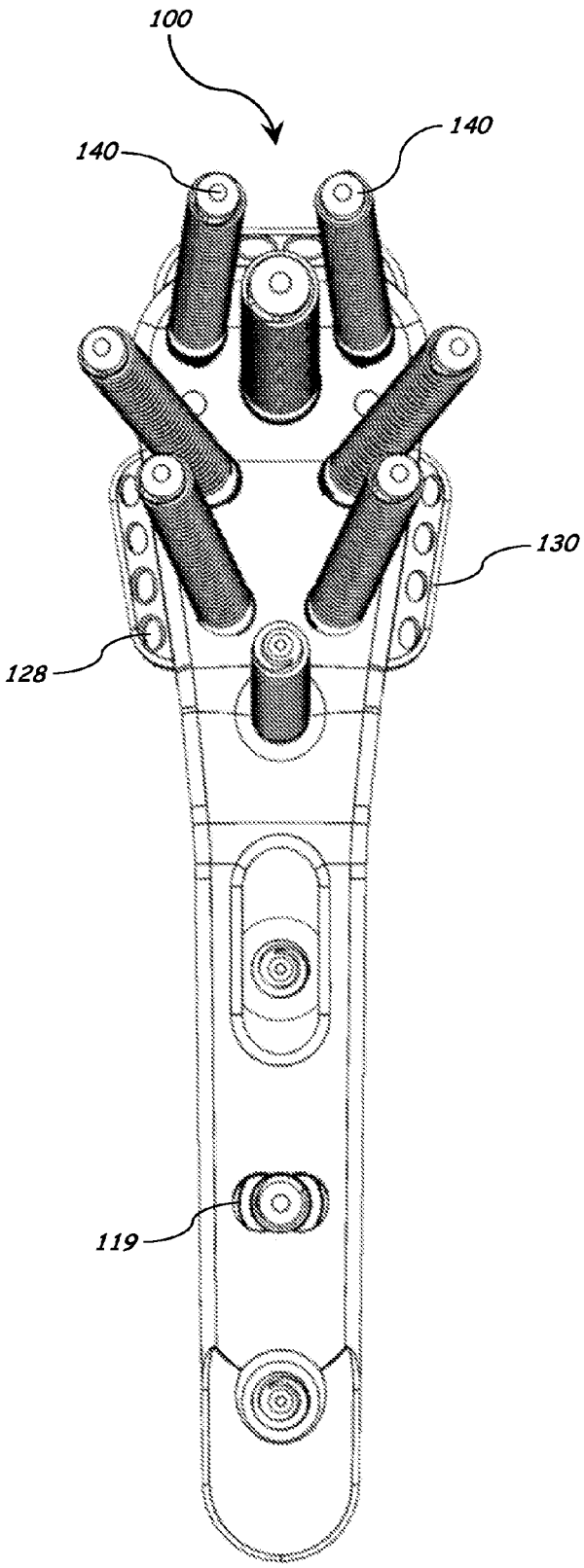
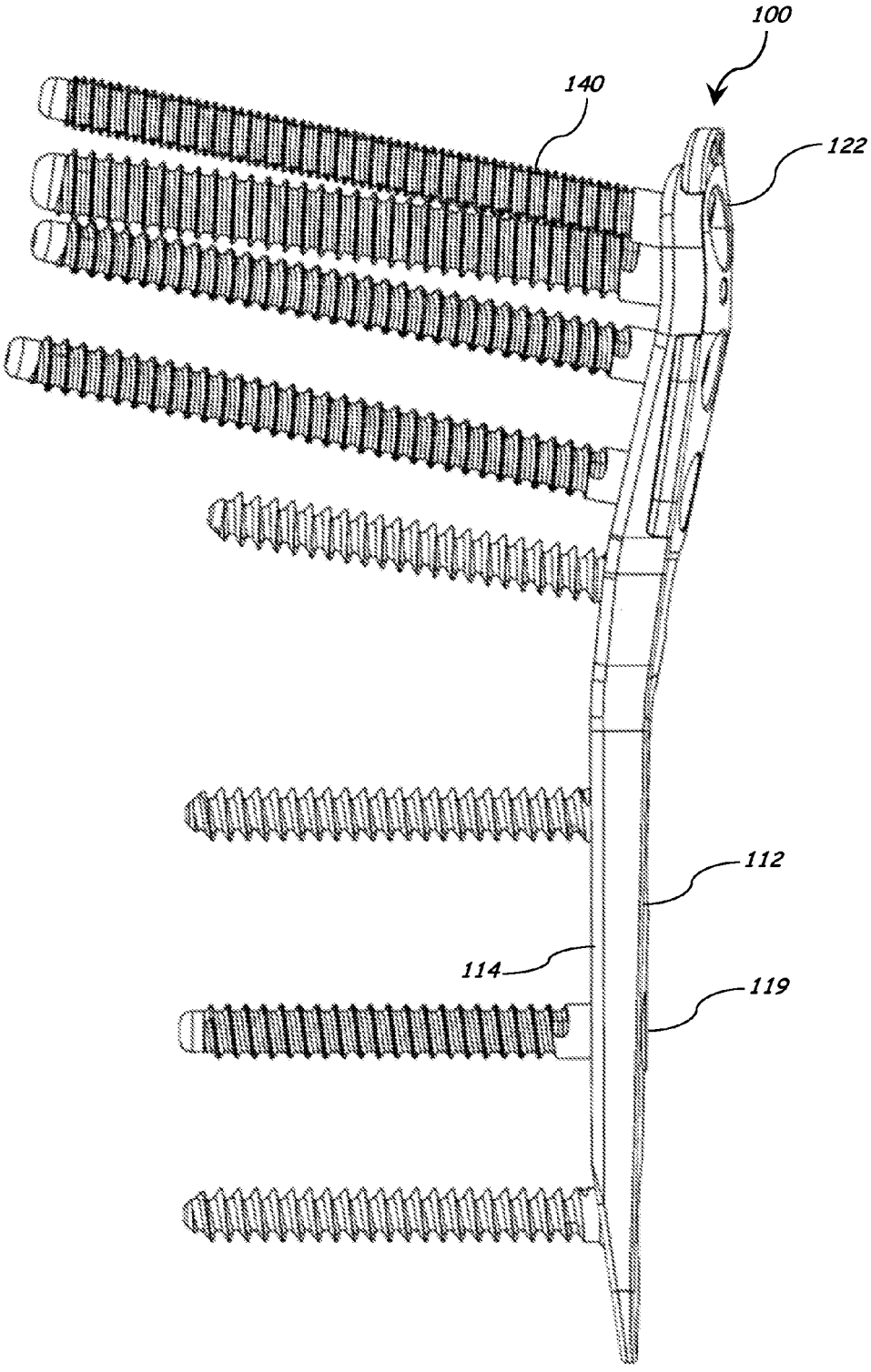


Figure 2C



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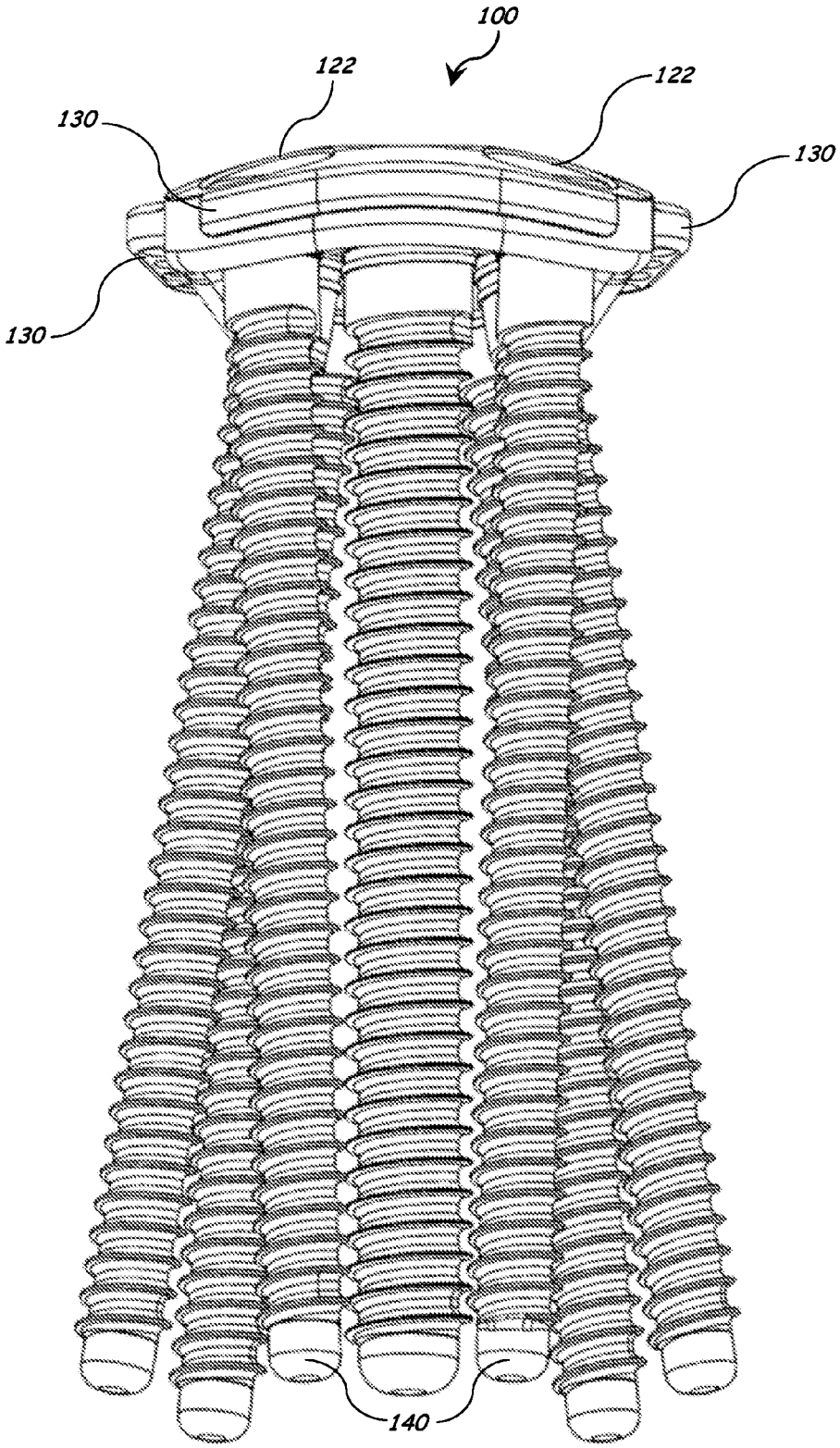


Figure 2E

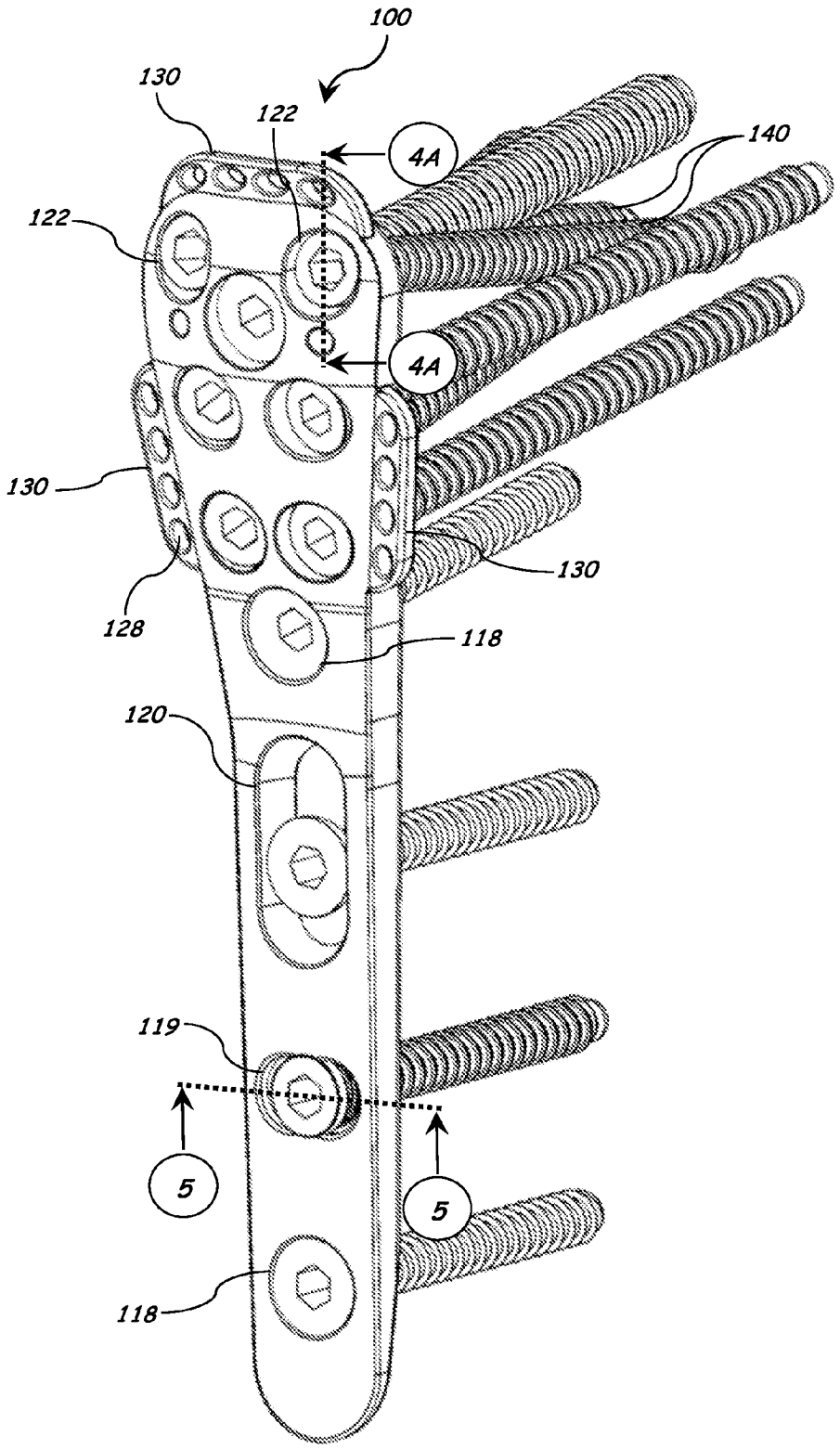


Figure 3A

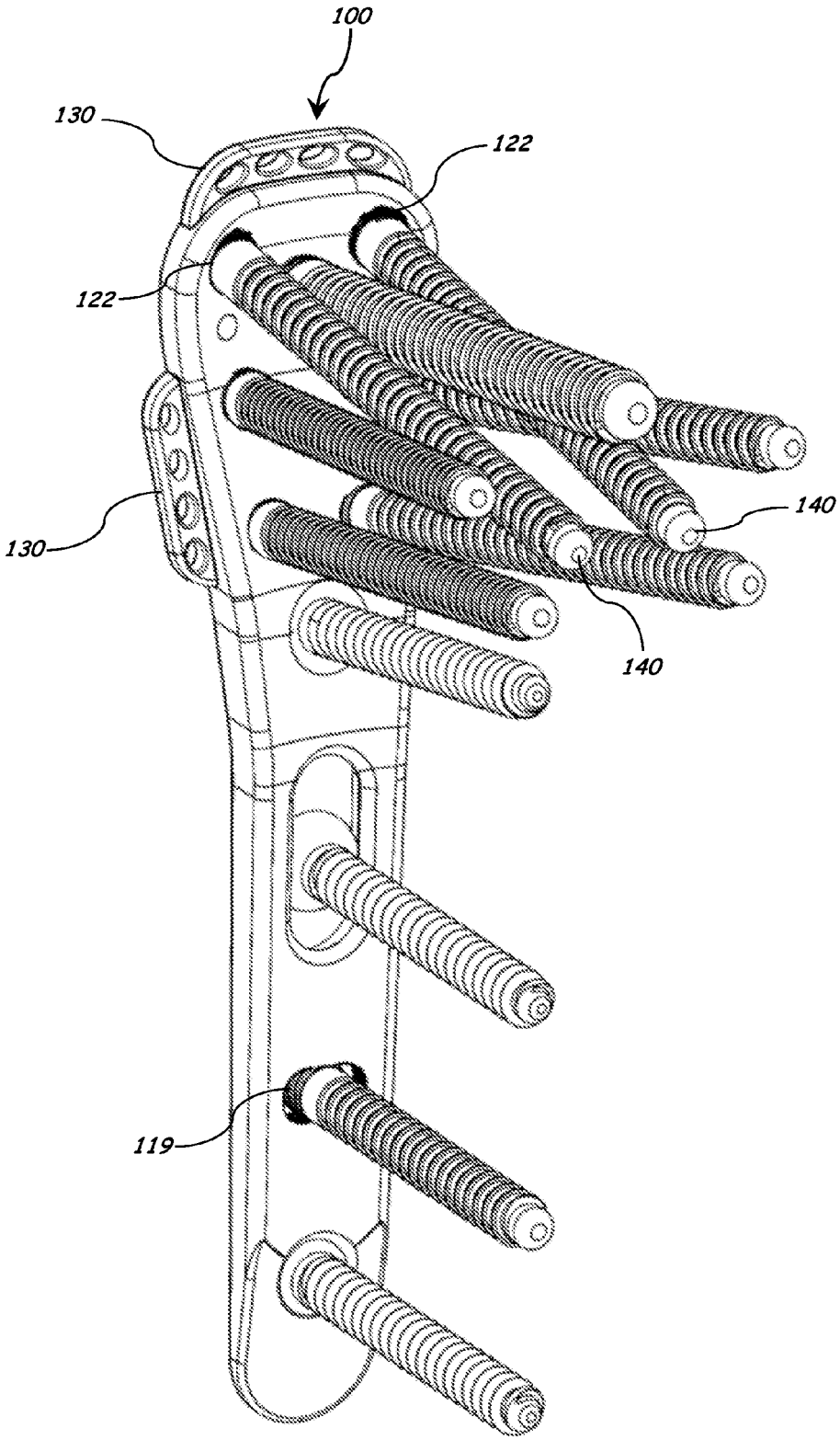


Figure 3B

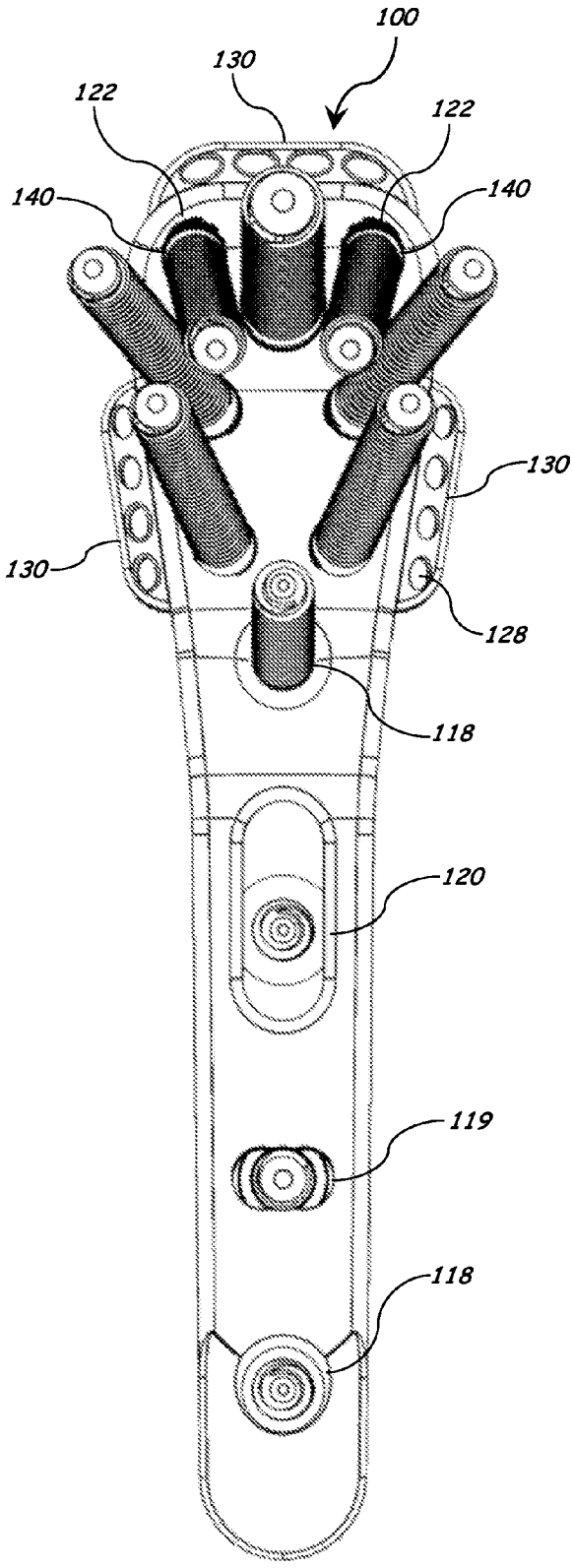


Figure 3C

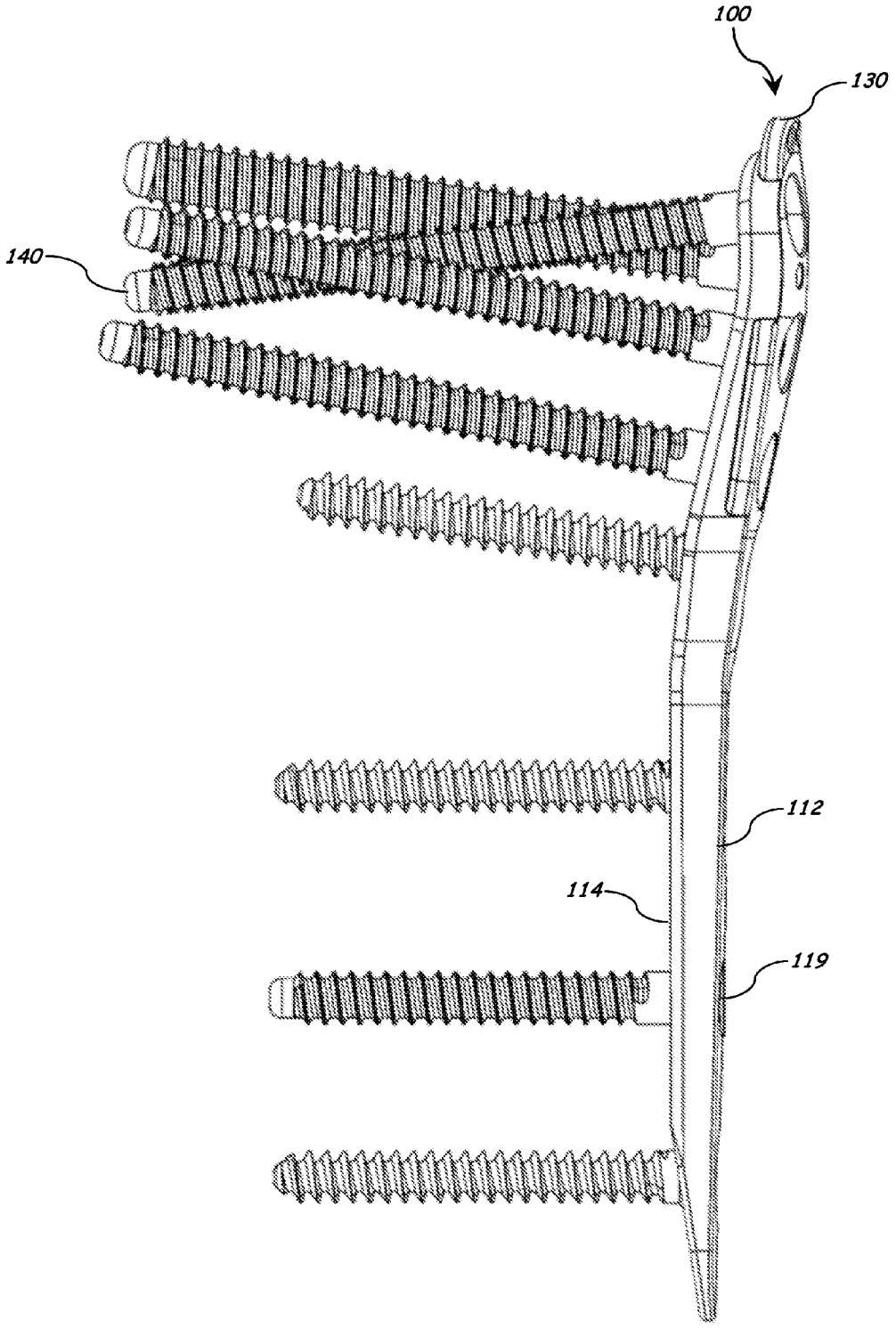
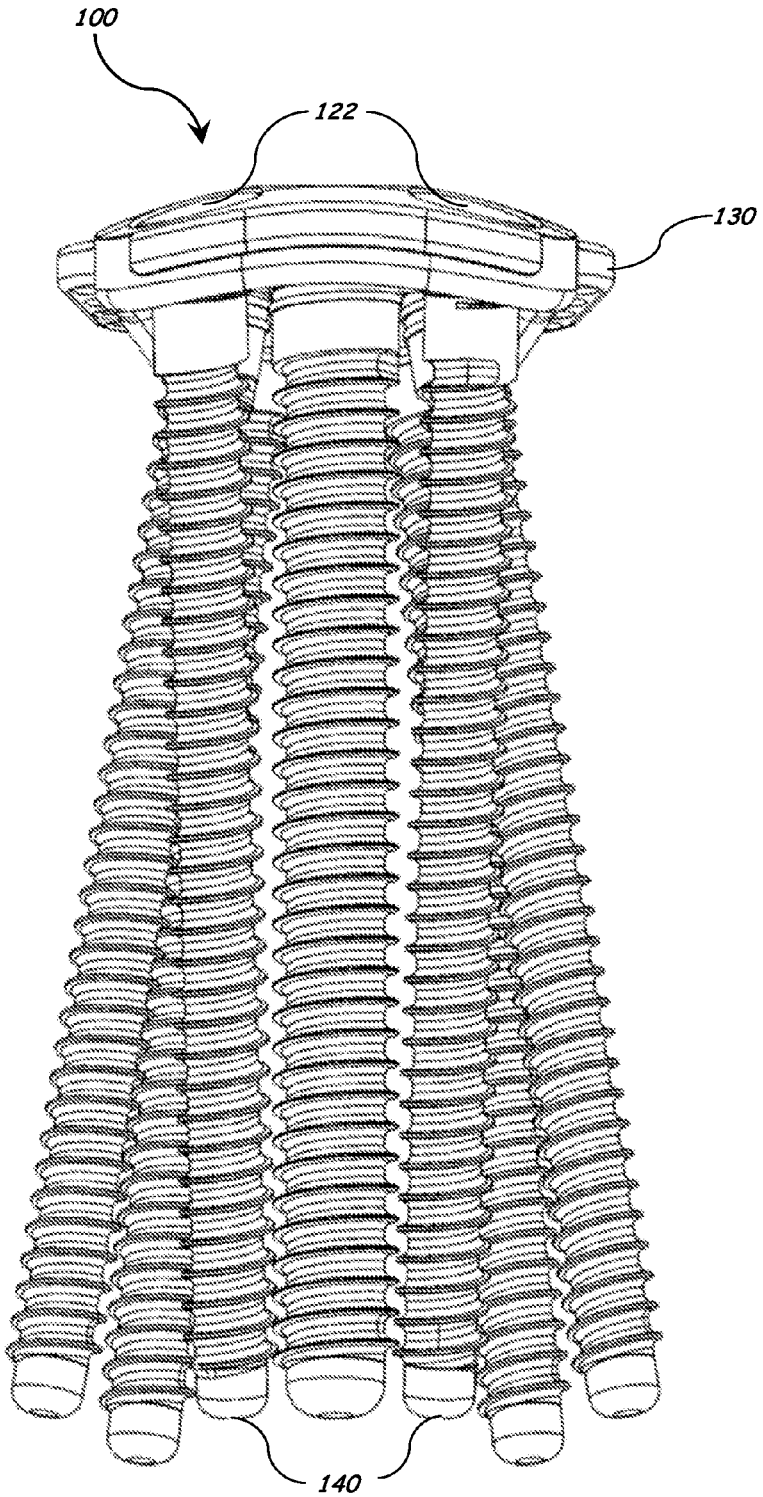


Figure 3D



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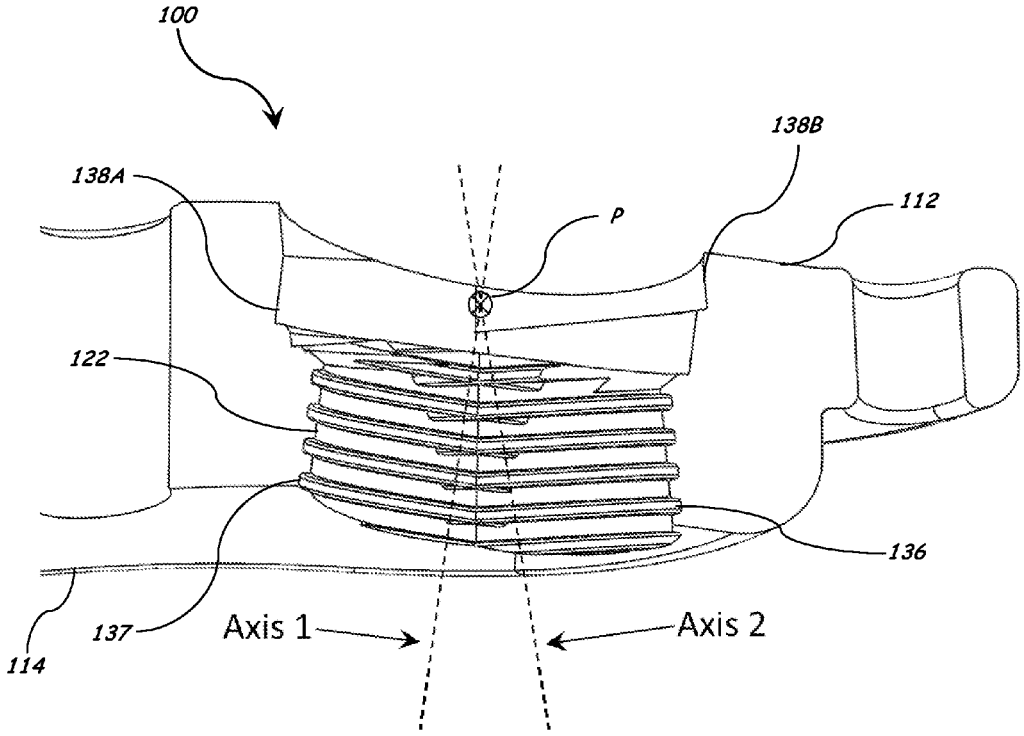


Figure 4A

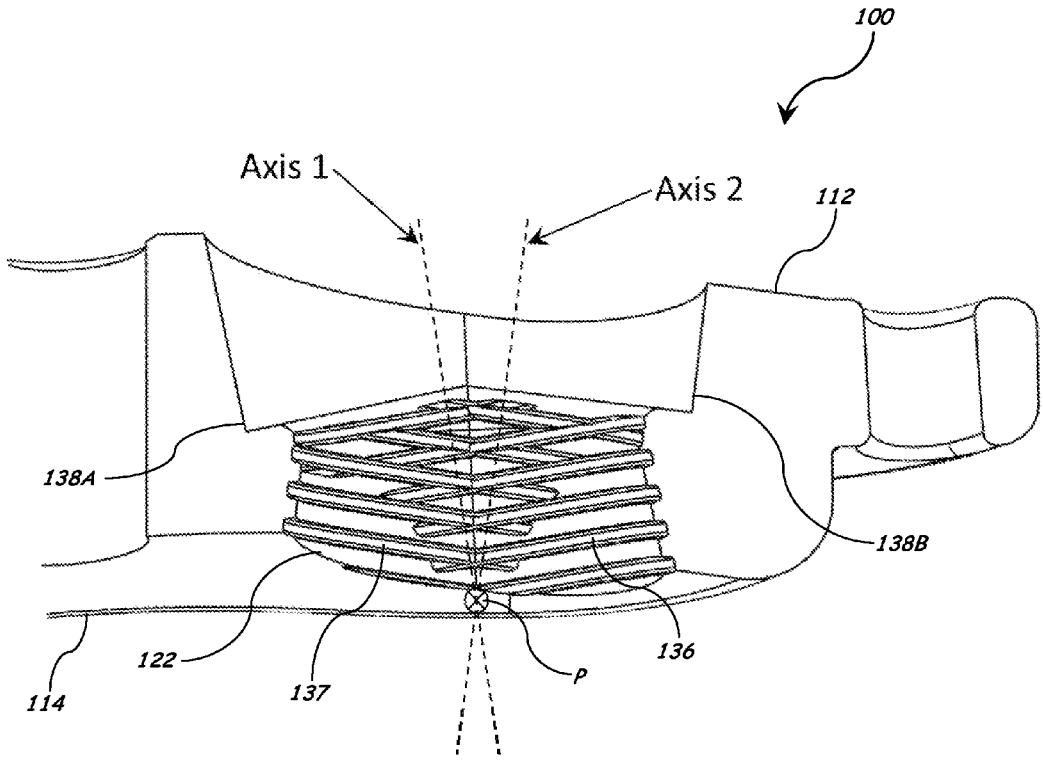
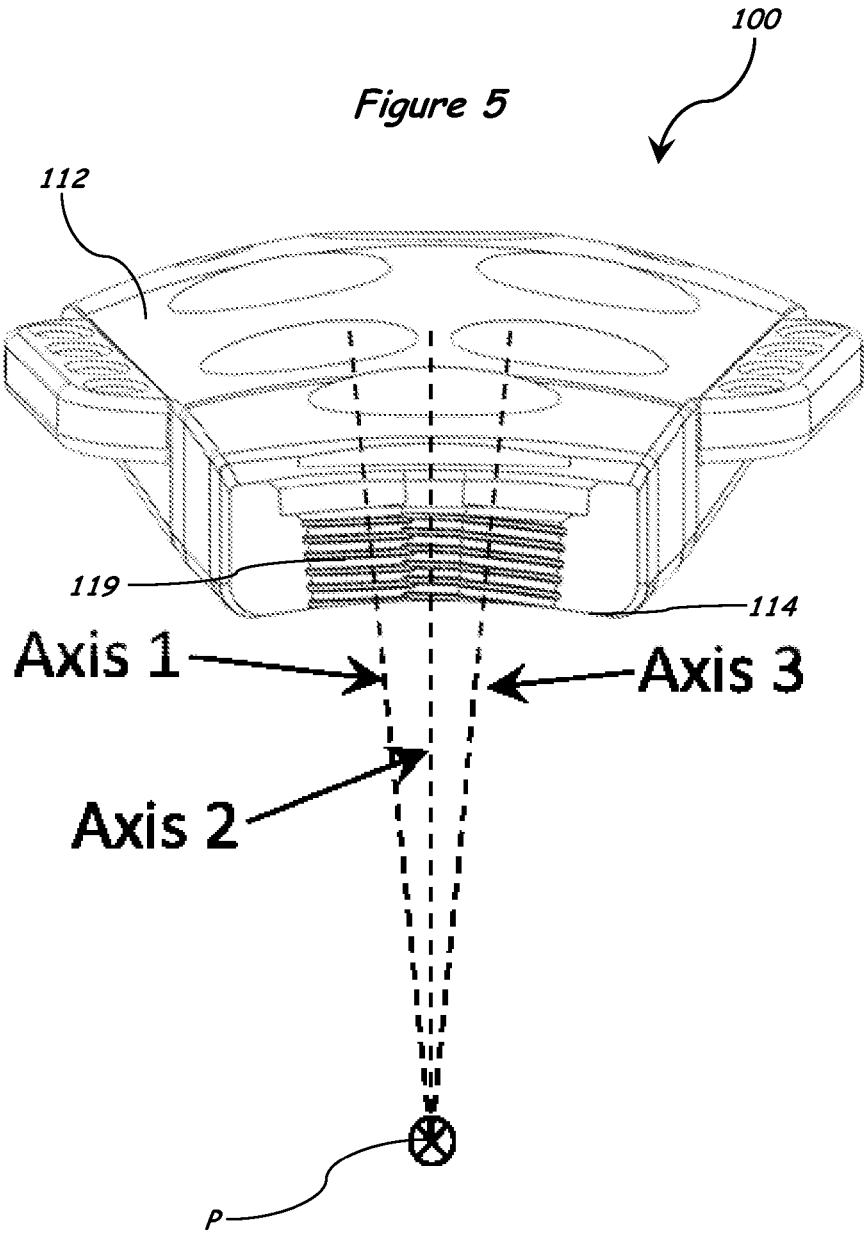


Figure 4B

Figure 5



BONE PLATE WITH ELEVATED SUTURE HOLE STRUCTURES

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims priority to U.S. provisional patent application Ser. No. 61/712,257, filed Dec. 12, 2013, entitled "Humeral Fracture Plate with Suture Hole Projections", the contents of which are hereby incorporated by reference in their entirety.

FIELD OF INVENTION

[0002] This invention relates to a bone plate for use in repairing bone fractures.

BACKGROUND OF THE INVENTION

[0003] Proximal humerus fractures are most commonly repaired with open reduction and internal fixation using plates and screws attached via bi-cortical or uni-cortical fixation. The preferred method to gain access to the fracture site is by making a large incision through the skin and muscles. Once the fracture has been exposed, the fragments of bone are approximated to the plate, including fragments that are attached to muscles via tendons. These muscles (e.g., rotator cuff) are attached to the plate via suture holes designed into it. Problems arise when the plate is first attached to the bone since it is difficult to pass the sutures between the plate and the bone. Thus, manufactures have provided bone plates with suture holes including undulations or suture-clearance recesses or lateral channels formed into the bottom surface and the edge of the plate and placed in relative proximity with corresponding suture holes such that a straight or curved suture needle and attached suture material may be passed through the hole even when the plate is fixed to the bone. This solution still presents challenges during surgery as there is insufficient space or clearance between the bone plate and the bone. Additionally, the superior screws often have the problem of exiting the humeral head superiorly, thus these screws must be able to be adjusted inferiorly to be directed completely into the humeral head.

[0004] The present invention seeks to remedy these problems. The object of the invention is to provide an internal fixation system with a plate which provides the surgeon with flexibility, ease of use, and operational efficiency such that a suture can be easily and quickly passed through a suture hole.

[0005] Another object of the invention is to provide a bone plate that supports both unidirectional and surgeon-directed or omnidirectional fixation of the screws relative to the plate.

SUMMARY OF INVENTION

[0006] This invention achieves the objective with a bone plate having a first upper surface and a first opposed bone-facing surface, the first bone-facing surface shaped to generally conform to a plate-facing surface of the bone, a bone plate thickness, at least one fastener hole extending between the first upper surface and the first bone-facing surface, and a suture hole structure extending from at least a portion of a boundary or boundary edge of the bone plate and having a second upper surface and a second opposed bone-facing surface, a suture hole structure thickness, at least one suture hole extending between the second upper surface and the second bone-facing surface, wherein the suture hole structure thickness is less than the bone plate thickness, and the second bone-facing surface of the suture hole structure is elevated above the first bone-facing surface of the bone plate by a distance greater than 0 mm.

[0007] In another embodiment of the invention, the second upper surface of the suture hole structure is flush with and, optionally, has a substantially similar contour as the contour of that portion of the first upper surface of the bone plate where the suture hole structure extends from.

[0008] In accord with another embodiment, the fastener hole of the bone plate comprises two or more sets of threads with intersecting axes, wherein the angle of each axis is predetermined during manufacturing.

[0009] In a further development of the invention, the intersecting axes of sets of threads of the fastener hole lie in a plane substantially parallel to at least one of a longitudinal plane which divides the plate into left and right portions and a transverse plane which divides the bone plate into proximal and distal portions.

[0010] Various bone fasteners, such as screws and pegs, can be used with the current invention, for example, those with partially spherical or conical heads with or without external threads engageable with the threads on the inner wall surface of the fastener hole.

[0011] These and other features of various embodiments can be understood from a review of the following detailed description in conjunction with the accompanying drawings.

[0012] It is to be understood that both the foregoing general description and the following detailed description and accompanying drawings are exemplary and explanatory and are not restrictive of the present invention, as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] The present invention and its developments will become more fully understood from, but not limited by, the detailed description and the accompanying drawings, wherein:

[0014] FIG. **1**A shows a top view of a bone plate with elevated suture hole structures;

[0015] FIG. **1**B shows a bottom view of the bone plate according to FIG. **1**A;

[0016] FIG. **1**C shows a side view of the bone plate according to FIG. **1**A;

[0017] FIG. **1**D shows another side view of the bone plate according to FIG. **1**A;

[0018] FIG. **1**E shows an end view of the bone plate according to FIG. **1**A;

[0019] FIG. **1**F shows another end view of the bone plate according to FIG. **1**A;

[0020] FIG. **2**A shows a top perspective view of a bone plate with the bone screws inserted and the top two screws angled superiorly;

[0021] FIG. **2**B shows a bottom perspective view of the bone plate according to FIG. **2**A;

[0022] FIG. **2**C shows another bottom perspective view of the bone plate according to FIG. **2**A;

[0023] FIG. **2**D shows a side perspective view of the bone plate according to FIG. **2**A;

[0024] FIG. **2**E shows an end perspective view of the bone plate according to FIG. **2**A;

[0025] FIG. **3**A shows a top perspective view of the bone plate according to FIG. **2**A with the top two screws angled inferiorly;

[0026] FIG. **3**B shows a bottom perspective view of the bone plate according to FIG. **3**A;

[0027] FIG. **3**C shows another bottom perspective view of the bone plate according to FIG. **3**A;

[0028] FIG. **3**D shows a side perspective view of the bone plate according to FIG. **3**A;

[0029] FIG. **3**E shows an end perspective view of the bone plate according to FIG. **3**A;

[0030] FIG. **4**A shows a cross sectional view of the bone plate shown in FIG. **3**A taken along sectional line **4**A-**4**A of FIG. **3**A;

[0031] FIG. **4**B shows an alternative embodiment of the threaded hole shown in FIG. **4**A; and

[0032] FIG. **5** shows a cross sectional view of the bone plate shown in FIG. **3**A taken along sectional line **5**-**5** of FIG. **3**A.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0033] The following detailed description and the appended drawings describe and illustrate various bone plate systems, methods, and components. The description and drawings are exemplary in nature and are provided to enable one skilled in the art to make and use one or more exemplary bone plate systems and/or components, and/or practice one or more exemplary methods. They are not intended to limit the scope of the claims in any manner.

[0034] The use of "e.g.," "etc.," "for instance," "in example," and "or" and grammatically related terms indicates non-exclusive alternatives without limitation, unless otherwise noted. The use of "optionally" and grammatically related terms means that the subsequently described element, event, feature, or circumstance may or may not be present/occur, and that the description includes instances where said element, event, feature, or circumstance occurs and instances where it does not. The use of "exemplary" refers to "an example of" and is not intended to convey a meaning of an ideal or preferred embodiment. The use of "attached" and "coupled" grammatically related terms refers to the fixed, releasable, or integrated association of two or more elements and/or devices with or without one or more other elements in between. Thus, the term "attached" or "coupled" and grammatically related terms includes releasably attaching or fixedly attaching two or more elements and/or devices in the present or absence of one or more other elements in between. As used herein, the terms "proximal" and "distal" are used to describe opposing axial ends of the particular elements or features being described in relation to anatomical placement.

[0035] While the systems, methods, and components described herein are exemplified by systems and methods for internal fixation of humeral bones, the systems, methods, and components described and illustrated herein can be used to treat any short and long bones within the body of a human, including, but not limited to, animals. Skilled artisans will be able to select a suitable ailment and/or bone within the body of an animal to utilize a system and/or method described herein according to a particular embodiment based on various considerations, including the type of ailment and/or the structural arrangement at a treatment site. Example bones considered suitable to utilize a system, method, and/or component described herein include, but are not limited to, humerus, ulna, radius, clavicle, femur, tibia, fibula, tarsals, metatarsals, carpals, metacarpals and phalanges.

[0036] FIGS. **1**A-F shows a bone plate configuration in accordance with the invention. Bone plate **10** may be shaped and configured for, but not limited to, fractures of the humerus. The bone plate **10** includes an upper surface **12**, a lower or opposed bone-facing or bone-contacting surface **14** and a plurality of fastener holes **16**, **18**, **20**, **22**, **24** and k-wire holes **26** extending between the upper surface **12** and the opposed bone-facing surface **14** for receiving corresponding bone fasteners (not shown) and guide-wires (not shown) respectively. The bone-facing surface **14** can be shaped to substantially conform to or mate with a corresponding plate-facing surface of the bone (not shown) and may be provided with radiused or scalloped cutouts between fastener holes to limit and/or minimize contact between the bone-facing surface **14** and the bone. Limiting and/or minimizing contact between the bone plate **10** and bone has a number of biological and mechanical advantages including reduced damage to blood supply and easier plate removal. Bone plate **10** may have various sizes (various diameters and/or lengths) and may be constructed from biocompatible materials such as titanium, alloys of titanium, cobalt chrome, stainless steel, ceramics, composite materials such as carbon fiber-reinforced PEEK, resorbable materials, and combinations thereof, although one of ordinary skill in the art will know and appreciate that any biocompatible material may be used.

[0037] Referring now to FIGS. **1**C-D, the upper surface **12** and the opposed bone-facing surface **14** run substantially parallel defining a first nominal thickness "t_1" of the bone plate **10**. The bone plate **10** further includes a plurality of elevated suture hole projections or structures **30** each extending from at least a portion of a boundary or boundary edge of the bone plate **10**. Each suture hole structure **30** includes an upper surface **32** and an opposed bone-facing surface **34** defining a second nominal thickness "t_2" of the suture hole structure **30** wherein the thickness "t_2" may be less than the thickness "t_1" of the bone plate **10**, and the bone-facing surface **34** or at least a portion thereof of the suture hole structure **30** is elevated above the bone-facing surface **14** of the bone plate **10** by a distance "d" as shown in FIGS. **1**C-D. The distance "d" may be in the range of about 1-4 mm. Alternatively, the distance "d" can be lesser or greater, depending on a specific surgical application.

[0038] The suture hole structures **30** can be dimensioned and configured to provide a low profile for reducing soft tissue irritation and minimizing patient discomfort. The suture hole structure **30** may have a width "w" of about 1-4 mm. The width "w" may also be lesser or greater, depending on a specific surgical application. The upper surface **32** and the lower bone-facing surface **34** of the suture hole structure **30** may be substantially parallel, at an angle relative to one another, or tapered inwardly and/or outwardly along its length or width. The upper surface **32** and the lower bone-facing surface **34** of the suture hole structure **30** each may also have a convex or concave shape, or a combination thereof.

[0039] The suture hole structures **30** each comprises a plurality of suture holes **28** extending between the upper surface **32** and the bone-facing surface **34**. The suture hole structure **30** may be provided with any number of suture holes **28** as may be suitable for a specific surgical application. Alternatively, the suture hole structure **30** may have only one suture hole **28**. The shape of the suture holes **28** can be circular, oval or non-circular. The suture holes **28** can be

of a size adequate for passing a suture with a curved or straight suture needle and can be non-threaded for reducing suture damage.

[0040] The upper surface **32** of the suture hole structure **30** may be flush with the upper surface **12** of the bone plate **10**. Alternatively, the upper surface **32** of the suture hole structure **30** can be slightly higher or lower than the upper surface **12** of the bone plate **10** and/or can have a substantially similar contour to a contour of the portion of the boundary or boundary edge of the bone plate **10** from which the suture hole structure **30** extends. The suture hole structure **30** may be at an angle with respective to the bone plate **10**. The suture hole structure **30** may have at least a portion of its body being as thick or thicker than the bone plate **10** as long as at least a portion of the bone-facing surface **34** of the suture hole structure **30** is elevated above the bone-facing surface **14** of the bone plate **10** to provide a suture-clearance or spacing "d" for easy access to the suture holes **28**.

[0041] The suture hole structure **30** can be permanently or removably attached or coupled to the bone plate **10** by any attachment means known to one skilled in the art. The suture hole structures **30** and the bone plate **10** can be an unitary device machined from a single block of materials, or can also be a multi-component device which can be assembled before or during surgery to provide the surgeon the flexibility in designing the bone plate to meet his or her needs.

[0042] An alternative embodiment of the present invention (not shown) includes a bone plate substantially similar to the bone plate **10** in FIGS. **1**A-F, wherein the suture hole structure or structures may be folded toward the bone to provide a low profile implant. One method of manufacturing such an implant is to have the portion of the suture hole structure proximate the boundary or boundary edge of the bone plate be thinner than the remaining part of the suture hole structure to allow the surgeon to bend or fold the suture hole structure toward the bone after passing a suture for reducing soft tissue irritation and minimizing patient discomfort. Another design may require a hinged mechanism for coupling the suture hole structure to the perimeter of the bone plate.

[0043] Still another embodiment of the invention (not shown) comprises a bone plate substantially similar to the bone plate **10** in FIGS. **1**A-F, wherein the bone plate is provided with a rail extending along its periphery or boundary edge. One or more suture hole structures similar to the suture hole structure **30** are coupled to the rail. This configuration provides the surgeon the flexibility to reposition the suture hole structure(s) anywhere on or along the bone plate to meet his or her specific surgical applications and needs.

[0044] According to another embodiment, the bone plate **10** can be provided with a single continuous suture hole structure (not shown) surrounding the boundary or boundary edge of the bone plate **10**. This feature provides the surgeon the flexibility of attaching any muscles associated with the fractured bone to any locations on the plate to meet his or her needs for a specific surgical application.

[0045] These and other similar variations and modifications may be made without departing from the scope of the present invention.

[0046] Referring to FIGS. **2**A-E, **3**A-E, bone plate **100** is configured substantially similar to bone plate **10** with screws **140**, **160** inserted. Bone plate **100** comprises elevated suture hole structures **130** each includes a plurality of suture holes **128**. The bone plate **100** is further provided with, but not limited to, two fastener holes **122** each formed with two sets of threads having intersecting axes, also referred to as bi-axial fastener holes in some embodiments. In some embodiments (not shown), the fastener holes **122** each may have more than two sets of threads with intersecting axes, depending on a specific surgical application. Where the axes cross is the intersect point or pivot point "P" which can be determined during manufacturing to be either within the fastener hole **122**, or within the fastener hole **122** and generally in the same plane as the upper surface **112** of the bone plate **100** as shown in FIG. **4**A, or within the fastener hole **122** and generally in the same plane as the bone-facing surface **114** of the bone plate **100** as illustrated in FIG. **4**B. The provision of these bi-axial fastener holes **122** in the bone plate **100**, particularly in the proximal or head portion of the bone plate **100**, offers the surgeon with choice of two different and opposed trajectories, such as superiorly and inferiorly as illustrated in FIGS. **2**A-E and FIGS. **3**A-E respectively, for locking the bone fasteners **140** relative to the bone plate **100**.

[0047] The two intersecting axes, axis **1** and axis **2**, as illustrated in FIGS. **4**A-B, may be configured to lie in a plane substantially parallel to a longitudinal plane dividing the bone plate into left and right halves, and form an angle a of about 5-45 degrees relative to one another. However, other angles are possible. In an alternative embodiment (not shown), the fastener holes **122** may include two sets of threads with intersecting axes lying on a plane substantially parallel to a transverse or cross-section plane dividing the bone plate into proximal and distal portions.

[0048] Additionally or alternatively, the bone plate **100** can be provided with one or more fastener holes, such as fastener hole **119** located in the distal portion of the bone plate **100**, formed with three sets of threads with intersecting axes, such as axis **1**, axis **2**, axis **3** as shown in FIG. **5**, wherein the intersect point or pivot point "P" of the axes is outside the fastener hole **119** and below the bone-facing surface **114** of the bone plate **100**. The fastener hole **119** may have more than three sets of threads with intersecting axes. These intersecting axes each form an angle o of about 5-45 degrees relative to one another. However, other angles are possible.

[0049] The bi-axial and tri-axial fastener holes **122**, **119** can be formed in one of two methods. Referring to FIGS. **4**A-B, the bi-axial hole **122** may be formed by drilling a hole along axis **1** at a predetermined angle relative to the bone plate **100** and another hole along axis **2** at a different predetermined angle relative to the bone plate **100** so that axis **1** and axis **2** intersect at a point "P" proximate the upper surface **112** of the bone plate **100**, or proximate the bone-facing surface **114** of the bone plate **100**. The countersinks **138**A, **138**B may be formed during or after drilling the holes. The threads **136**, **137** may be right-hand threads and cut out with a machine tap that follows the individual axes of the respective drilled holes. The bi-axial hole, such as fastener hole **122**, may have, but is not limited to, an oval or elongated shape from a top view of the fastener hole **122**. The shape and size of the bi-axial holes **122** may vary throughout the thickness of the bone plate **100**. Alternatively, the threads **136**, **137** of the bi-axial hole **122** may not extend all the way from the upper surface **112** to the bone-facing surface **114** of the bone plate **100**. A smooth, non-threaded, conical inward or outward taper may be

formed into the upper or lower region of the bi-axial hole **122** (not shown) to provide for a broader range of angles for angularly positioning a non-locking bone fastener.

[0050] The tri-axial hole **119** as illustrated in FIG. **5** can be formed by drilling three separate holes through the bone plate **100** such that the hole axes intersect at a point below the bone facing surface **114** of the bone plate **100**. The method of forming the countersinks and the threads may be similar to that of forming the bi-axial fastener hole **122**.

[0051] Different types of screws/pegs may be used with the bi-axial and tri-axial holes **122**, **119**, including non-locking, locking, unidirectional and omnidirectional or surgeon-directed screws. One type of screw may be a locking screw that has a conically-tapered or cylindrical threaded head such as bone screws **140**. The external threads of heads of the screws **140** may mate with the internal threads **136**, **137** of the holes **122**, **119** to angularly lock the screws/pegs **140** while the helical threads of the shaft of the screws/pegs **140** engage the bone.

[0052] The bone plate **100** further includes a non-threaded elongated slot **120** configured and dimensioned to engage a substantially spherical or hemi-spherical screw-head of a bone screw, such as bone screw **160**. Alternatively, a conically shaped screw head, with or without threads, may engage the elongated slot **120**. The elongated slot **120** may have a concave, substantially spherical portion or recess that opens toward the upper surface **112** of the bone plate **100**. When the shaft of a bone screw **160** having a spherical or semi-spherical head is located eccentrically in the elongated slot **120**, the spherical or semi-spherical head may engage the recess and bias the bone plate to provide compression of the bone fracture. The bone plate **100** may be provided with other non-locking, locking and/or combination holes for specific surgical applications.

[0053] The bone plate system of the present invention provides for any tissue repair and attachment of soft tissue to bone as part of fracture management repair. Although there have been described and illustrated herein various embodiments of a humeral fracture bone plate, it is not intended that the invention be limited thereto, as it is intended that the invention be as broad in scope as the art will allow and that the specification be read likewise. Thus, while the exemplary embodiment is described and illustrated as a humeral fracture bone plate system, it is appreciated that the system is well adapted to bone fractures of any bones with or without an articular convex-shape surface. Thus, the system of the invention could similarly be used to treat fracture of other bones, e.g., a fracture of the femoral head, a fracture of a radius. In addition to the use of the present bone plate system for treatment of fractures, it is appreciated that the present invention may also be used in the treatment of osteotomies and non-unions of the proximal humerus and other bones with or without an articular convex-shape surface.

[0054] The principles, preferred embodiments and modes of operation of the present invention have been made apparent in the foregoing description.

[0055] Although the embodiments are numbered with, for example, "first," "second," or "third," or "fourth," the ordinal numbers do not imply priorities of the embodiments.

[0056] Since many modifications, variations and changes in detail can be made to the described embodiments of the invention, it is intended that all matters in the foregoing description and shown in the accompanying drawings be interpreted as illustrative and not in a limiting sense. Thus, the scope of the invention should be determined by the appended claims and their legal equivalents.

What is claimed is:

1. A bone plate system for securing a bone plate to a bone, the system comprising:

a bone plate having a first upper surface and a first opposed bone-facing surface, a bone plate thickness, at least one fastener hole extending between the first upper surface and the first bone-facing surface;

a bone fastener adapted to couple the bone plate to the bone; and

a suture hole structure extending from at least a portion of a boundary of the bone plate and having a second upper surface and a second opposed bone-facing surface, a suture hole structure thickness, at least one suture hole extending between the second upper surface and the second bone-facing surface,

wherein at least a portion of the second bone-facing surface of the suture hole structure is elevated above the first bone-facing surface of the bone plate by a distance "d" greater than 0 mm.

2. The bone plate system of claim **1**, wherein the suture hole structure thickness is less than the bone plate thickness.

3. The bone plate system of claim **2**, wherein the suture hole structure includes a plurality of suture holes extending between the second upper surface and the second bone-facing surface.

4. The bone plate system of claim **2**, wherein the second bone-facing surface of the suture hole structure is elevated above the first bone-facing surface of the bone plate by a distance "d" less than about 4 mm.

5. The bone plate system of claim **2**, wherein the second upper surface of the suture hole structure is flush with the first upper surface of the bone plate.

6. The bone plate system of claim **5**, wherein the second upper surface of the suture hole structure has a similar contour to a contour of the portion of the boundary of the bone plate from which the suture hole structure extends.

7. The bone plate system of claim **6**, wherein the bone plate comprises a plurality of the suture hole structures.

8. The bone plate system of claim **7**, wherein the plurality of the suture hole structures are integral to the bone plate.

9. The bone plate system of claim **2**, wherein the second upper surface of the suture hole structure is set below the first upper surface of the bone plate by a distance less than about 1 mm.

10. The bone plate system of claim **2**, wherein the suture hole structure has a width "w" in the range of about 1-3 mm.

11. The bone plate system of claim **3**, wherein the suture hole structure is a continuous structure extending from and surrounding the boundary of the bone plate.

12. The bone plate system of claim **1**, wherein the second bone-facing surface of the suture hole structure is substantially parallel to or at an angle with respective to the first bone facing surface of the bone plate.

13. The bone plate system of claim **1**, wherein at least one of the bone plate, the suture hole structure and the fastener is constructed from titanium, titanium alloys, stainless steel, tantalum, composite materials, resorbable materials, biocompatible materials or combinations thereof.

14. The bone plate system of claim **2**, wherein the fastener hole includes a plurality of sets of threads with intersecting axes.

15. The bone plate system of claim **14**, wherein the intersecting axes of the plurality of sets of threads lie in a plane substantially parallel to at least one of a longitudinal plane which divides the plate into left and right portions and a transverse plane which divides the bone plate into proximal and distal portions.

16. The bone plate system of claim **14**, wherein the fastener hole comprises a countersunk region, a middle threaded region, and a lower smooth, non-threaded region.

17. The bone plate system of claim **14**, wherein the fastener comprises a head having a thread for forming a threaded connection with at least one of the sets of threads of the fastener hole.

18. The bone plate system of claim **14**, wherein at least one of the plurality of sets of threads is selected from a group consisting of left-hand threads and right-hand threads.

19. The bone plate system of claim **15**, wherein the bone plate further comprises a second fastener hole having three sets of threads with intersecting axes.

20. The bone plate system of claim **19**, wherein the bone plate further comprises an elongated slot having at least a portion of an inner wall surface being smooth for receiving a non-locking fastener.

21. The bone plate system of claim **19**, wherein the bone plate includes an opening defined by two adjacent threaded holes communicating with one another.

22. The bone plate system of claim **17**, wherein the threads of the fastener hole engage the bone fastener at a variable angle relative to the bone plate.

23. The bone plate system of claim **15**, wherein the intersecting axes form an angle of about 5 to 45 degrees relative to one another.

24. A bone plate system of claim **1**, wherein the bone is one of humerus, ulna, radius, clavicle, femur, tibia, fibula, tarsals, metatarsals, carpals, metacarpals and phalanges.

25. A bone plate system for securing a bone plate to a bone, the system comprising:

a bone plate having a first upper surface and a first opposed bone-facing surface, the first bone-facing surface shaped to generally conform to a plate-facing surface of the bone, a bone plate thickness, at least one fastener hole extending between the first upper surface and the first bone-facing surface;

a bone fastener adapted to couple the bone plate to the bone; and

a suture hole structure extending from at least a portion of a boundary of the bone plate and having a second upper surface and a second opposed bone-facing surface, a suture hole structure thickness, at least one suture hole extending between the second upper surface and the second bone-facing surface,

wherein at least a portion of the second bone-facing surface of the suture hole structure is elevated above the first bone-facing surface of the bone plate,

wherein the suture hole structure thickness is less than the bone plate thickness, and

wherein the second upper surface of the suture hole structure is flush with the first upper surface of the bone plate.

26. The bone plate system of claim **25**, wherein the fastener hole comprises two or more sets of threads with intersecting axes.

27. The bone plate system of claim **26**, wherein the bone plate further comprises a second fastener hole having two or more sets of threads with intersecting axes and a second bone fastener engageable with at least a portion of the threads of the second fastener hole.

28. The bone plate system of claim **27**, wherein at least one of the fastener holes is located in a proximal portion of the bone plate and comprises intersecting axes lying in a plane substantially parallel to at least one of a longitudinal plane which divides the plate into left and right portions and a transverse plane which divides the bone plate into proximal and distal portions.

29. A bone plate system for securing a bone plate to a bone, the system comprising:

a bone plate having an upper surface and an opposed bone-facing surface, the bone-facing surface shaped to generally conform to a plate-facing surface of the bone, at least a first fastener hole extending between the upper surface and the bone-facing surface; and

a first bone fastener having a head with external threads engageable with the bone plate in the first fastener hole,

wherein the first fastener hole comprises a plurality of sets of threads with intersecting axes, and

wherein the intersecting point of two or more of the axes is within the fastener hole and substantially in the same plane as one of the upper surface and the bone facing surface of the bone plate, or outside the fastener hole and below the bone-facing surface of the bone plate.

30. The bone plate system of claim **29**, wherein the two or more of the intersecting axes form an angle of about 5-45 degrees relative to one another.

31. The bone plate system of claim **30**, wherein the bone plate further comprises a second fastener hole having a plurality of sets of threads with intersecting axes and a second bone fastener having a head with external threads engageable with at least a portion of the threads of the second fastener hole.

32. The bone plate system of claim **31**, wherein the intersecting axes of the plurality of sets of threads of at least one of the first and second fastener holes lie in a plane substantially parallel to at least one of a longitudinal plane which divides the plate into left and right portions and a transverse plane which divides the bone plate into proximal and distal portions.

33. The bone plate system of claim **31**, wherein at least one of the first and second fastener holes comprises a countersunk region and an opposed non-threaded region located adjacent to the bone-facing surface, the non-threaded region is either conically shaped or partially spherically shaped with increasing diameter toward the bone-facing surface.

34. The bone plate system of claim **31**, wherein at least one of the first and second fastener holes is located in the proximal portion of the bone plate, and the bone plate further comprises an elongated slot having at least a portion of an inner wall surface being smooth for cooperating with a non-threaded head of a fastener.

35. A bone plate system for securing a bone plate to a bone, the system comprising:

a bone plate having a first upper surface and a first opposed bone-facing surface, a bone plate thickness, at least one fastener hole extending between the first upper surface and the first bone-facing surface;

a bone fastener adapted to couple the bone plate to the bone; and

a suture hole structure located proximate at least a portion of a boundary of the bone plate and having a second upper surface and a second opposed bone-facing surface, a suture hole structure thickness, at least one suture hole extending between the second upper surface and the second bone-facing surface,

wherein at least a portion of the second bone-facing surface of the suture hole structure is elevated above the first bone-facing surface of the bone plate by a distance "d" greater than 0 mm.

36. The bone plate system of claim **35**, wherein the suture hole structure thickness is less than the bone plate thickness.

37. The bone plate system of claim **36**, wherein the second bone-facing surface of the suture hole structure is elevated above the first bone-facing surface of the bone plate by a distance "d" less than about 4 mm.

38. The bone plate system of claim **36**, wherein the second upper surface of the suture hole structure is flush with the first upper surface of the bone plate.

39. The bone plate system of claim **38**, wherein the second upper surface of the suture hole structure has a similar contour to a contour of the portion of the boundary of the bone plate.

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