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(54) **BONE PLATE SUPPORTED BY A LEG MEMBER AND USED AS A LEVER**

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Related U.S. Application Data

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(51) **Int. Cl.**
A61B 17/56 (2006.01)
A61B 17/88 (2006.01)

(52) **U.S. Cl.**
USPC **606/281**; 606/70; 606/102; 606/105

(58) **Field of Classification Search** ..... 606/280–299, 606/86 B, 86 R, 88, 90, 99, 101, 102, 105, 606/905, 915–916
See application file for complete search history.

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(57) **ABSTRACT**

System, including apparatus and methods, for fixing bone with a bone plate supported temporarily at a slant on bone by a leg member before the bone plate is used as a lever to reposition a region of the bone. In some embodiments, the leg member may be a post member that attaches to the bone plate by threaded engagement with an aperture of the bone plate. In some embodiments, the bone plate and the leg member may be used near the end of a long bone, such as on a distal portion of a radial bone.

19 Claims, 4 Drawing Sheets

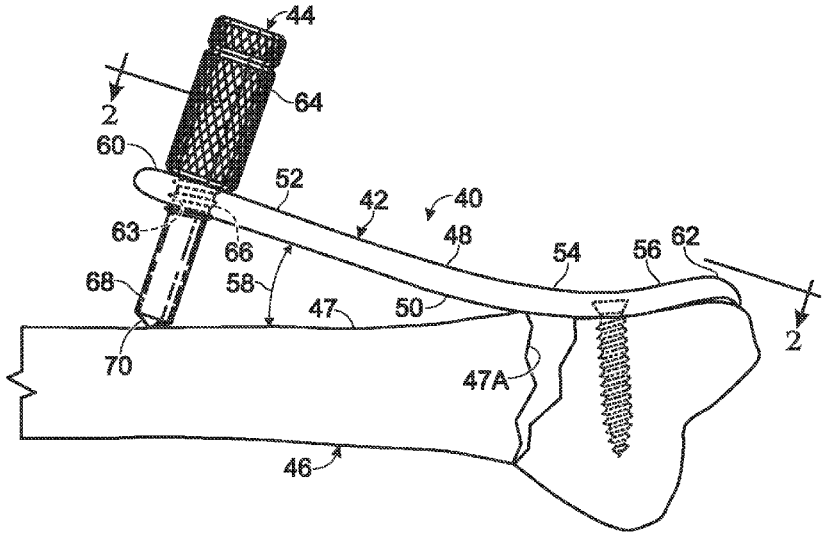
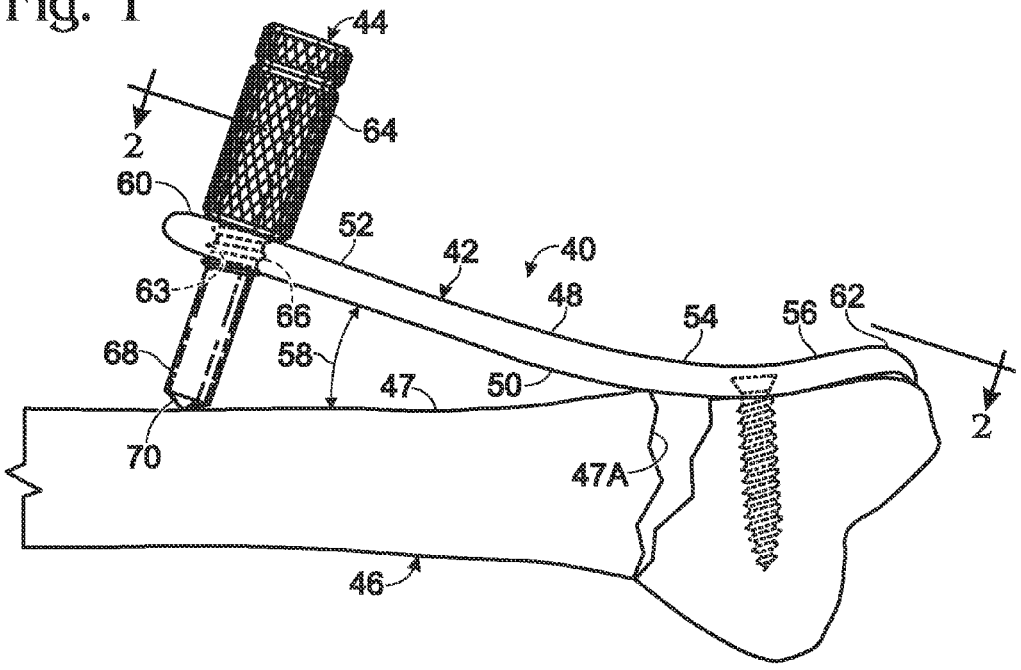


Fig. 1


44
64
2
60
52
42
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66
48
54
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62
68
58
47
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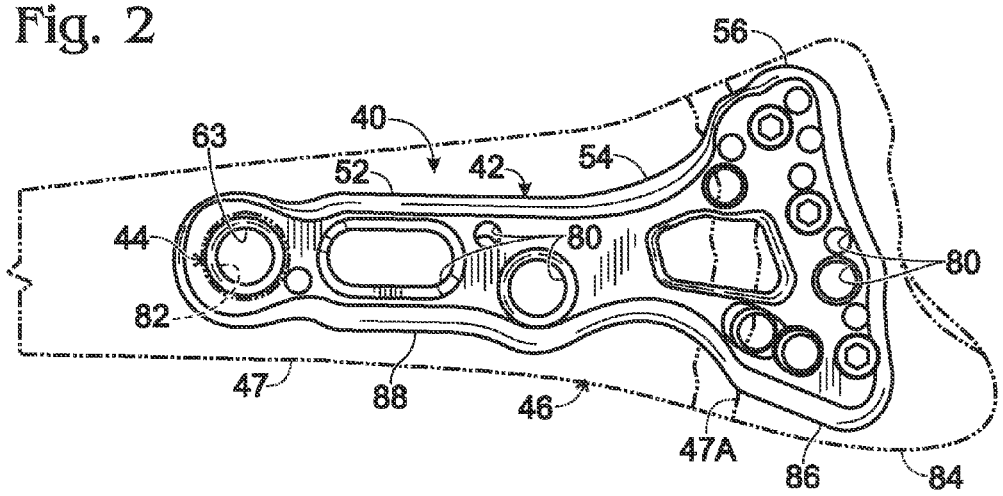
2
70
47A
46

Fig. 2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52
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80
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82
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88
46
47A
86
84

Fig. 3

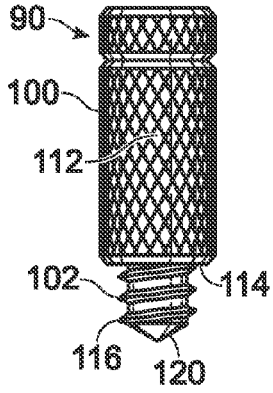


Fig. 4

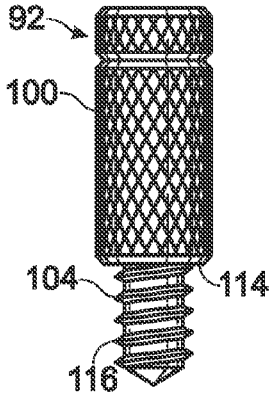


Fig. 5

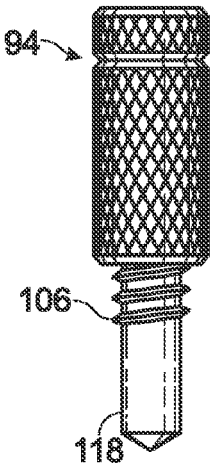


Fig. 6

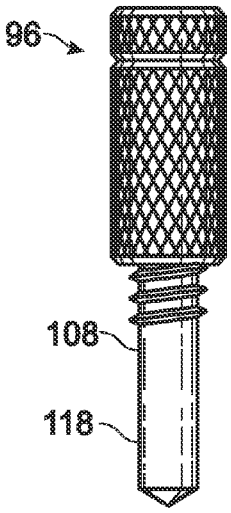


Fig. 7

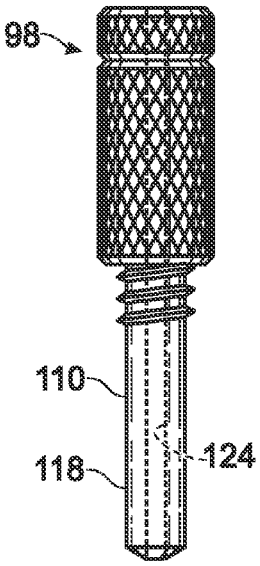


Fig. 8

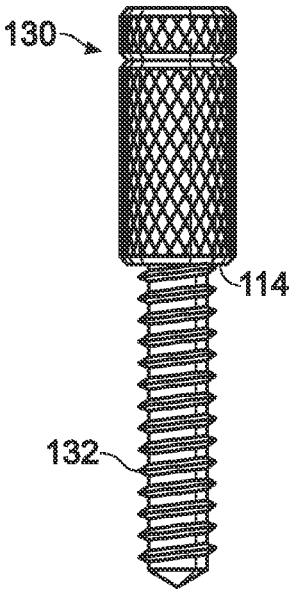


Fig. 9

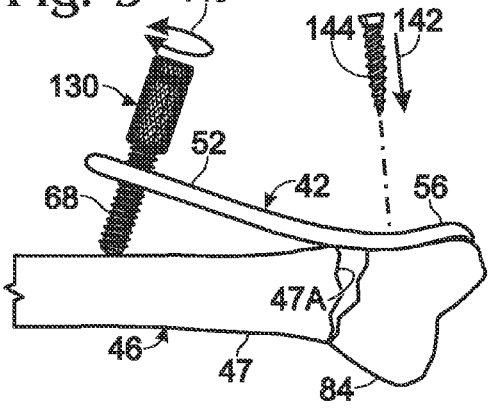


Fig. 10

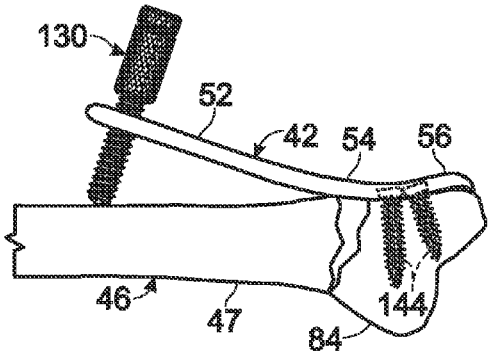


Fig. 11

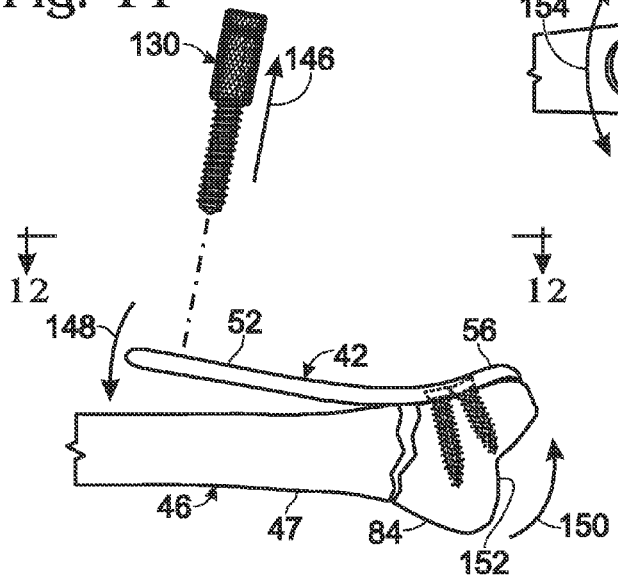


Fig. 12

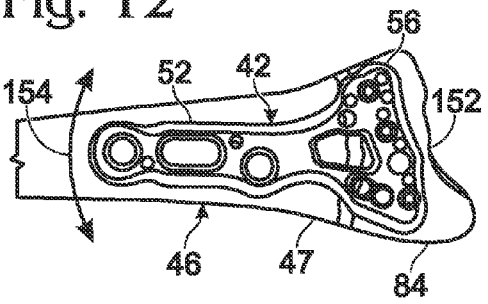


Fig. 13

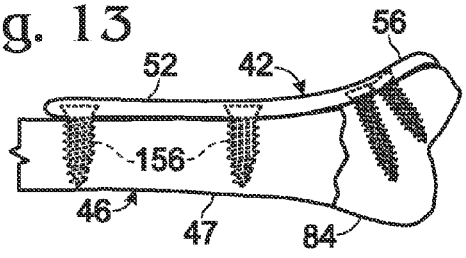


Fig. 14

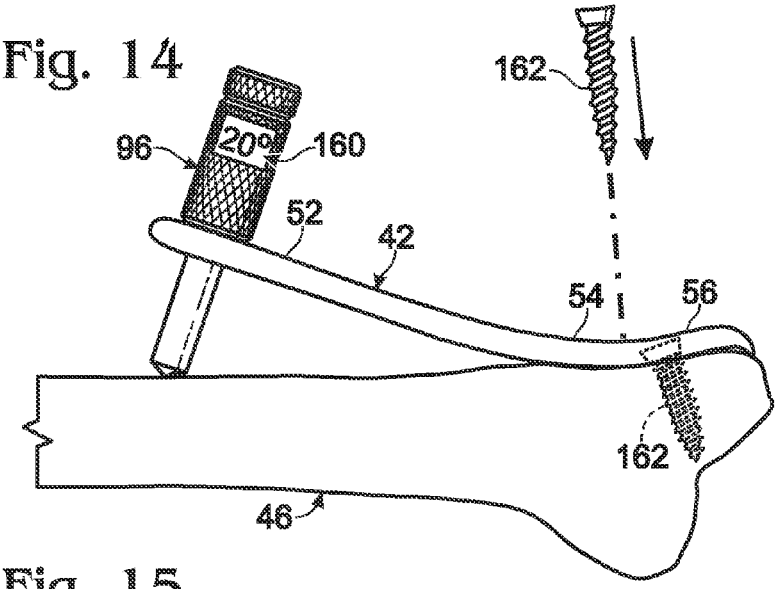


Fig. 15

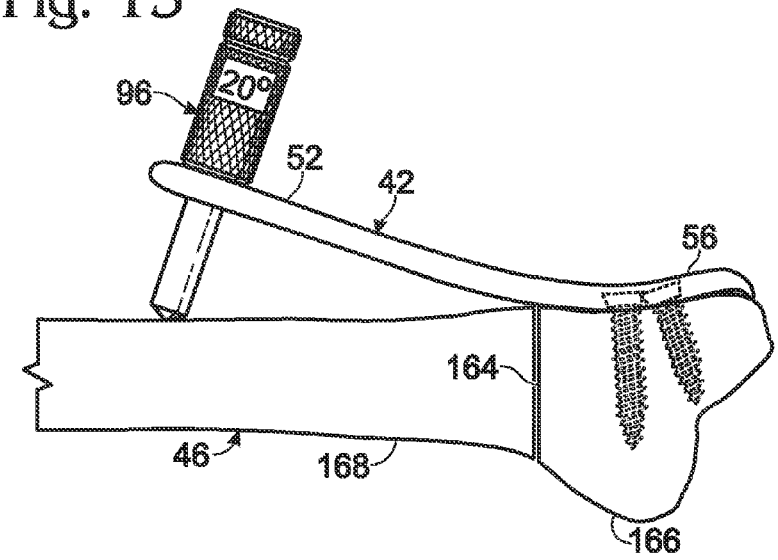
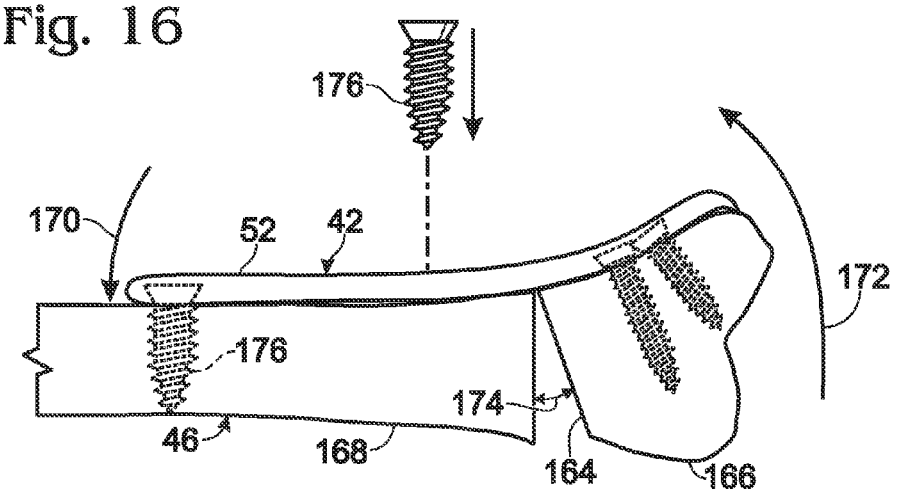


Fig. 16



BONE PLATE SUPPORTED BY A LEG MEMBER AND USED AS A LEVER

CROSS-REFERENCE TO PRIORITY APPLICATION

This application is based upon and claims the benefit under 35 U.S.C. §119(e) of U.S. Provisional Patent Application Ser. No. 61/386,925, filed Sep. 27, 2010, which is incorporated herein by reference in its entirety for all purposes.

INTRODUCTION

The radius or radial bone is one of two long bones found in the human forearm. The radius, like other bones, is susceptible to a variety of fractures and deformities. For example, distal fractures of the radius are a common result, particularly among the elderly, of forward falls with the palms facing downward. In such falls, force exerted on the distal radius at impact can produce dorsal displacement and rotation of one or more bone fragments created distally to the fracture site.

Fixation of the fractured radius may be performed by internal fixation with a bone plate. The bone plate may be secured on the volar (or dorsal) surface of the distal radius with fasteners, such as bone screws or K-wires, among others. The bone plate may be pre-bent to follow the longitudinal profile of the volar (or dorsal) surface of the radius.

A fractured distal radius, if not fixed properly, may heal in a misshaped configuration, such as with an incorrect amount of volar tilt at the distal articular surface. This deformity can cause arthritis and the inability to rotate the wrist. To restructure the bone, a surgeon may perform a corrective osteotomy. A distal portion of a bone plate may be attached near the end of the radius, with a proximal portion of the bone plate forming a projecting arm extending at a slant above the shaft of the bone. The surgeon then may cut the bone at a position proximal to the site of attachment to create a distal bone fragment. The distal bone fragment may be pivoted into a more anatomically correct position by moving the projecting arm into contact with the shaft of the bone, followed by attachment of the arm to the shaft. However, a surgeon generally must guess an orientation for attachment of the bone plate, to slant the arm of the bone plate above the shaft of the bone at an angle that will provide a suitable angular correction. Also, the bone plate tends to slip or shift during attachment of the distal portion of the bone plate near the end of the bone, which alters the orientation of the bone plate's arm.

Better approaches are needed to use a projecting arm of a bone plate effectively to reposition a bone fragment.

SUMMARY

The present disclosure provides a system, including apparatus and methods, for fixing bone with a bone plate supported temporarily at a slant on bone by a leg member before the bone plate is used as a lever to reposition a region of the bone. In some embodiments, the leg member may be a post member that attaches to the bone plate by threaded engagement with an aperture of the bone plate. In some embodiments, the bone plate and the leg member may be used near the end of a long bone, such as on a distal portion of a radial bone.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a side view of selected aspects of an exemplary embodiment of a bone fixation system including a bone plate and a detachable leg member temporarily supporting an arm portion of the bone plate at a slant above a shaft of a fractured radial bone, in accordance with aspects of the present disclosure.

FIG. **2** is a top view of the bone plate and bone of FIG. **1** taken generally along line **2-2** of FIG. **1** with the leg member removed.

FIGS. **3-7** are side views of exemplary leg members, structured as post members, for use in the system of FIG. **1**, with the leg members designed to support an arm portion of the bone plate at a predefined angle of about 5°, 10°, 15°, 20°, and 25°, respectively, above a shaft surface region of bone, in accordance with aspects of the present disclosure.

FIG. **8** is a side view of another exemplary leg member structured as a post member for use in the system of FIG. **1**, with the leg member designed to support an arm portion of the bone plate at a continuous range of angles from about 0° to 30° above a shaft surface region of bone, in accordance with aspects of the present disclosure.

FIGS. **9-13** are somewhat schematic configurations produced during performance of an exemplary method of fixing a fractured bone using the bone plate of FIG. **1** and the leg member of FIG. **8**, in accordance with aspects of the present disclosure.

FIGS. **14-16** are somewhat schematic configurations produced during performance of an exemplary method of fixing a cut bone using the bone plate and leg member of FIG. **1**, in accordance with aspects of the present disclosure.

DETAILED DESCRIPTION

The present disclosure provides a system, including apparatus and methods, for fixing bone with a bone plate supported temporarily at a slant on bone by a leg member before the bone plate is used as a lever to reposition a region of the bone. In some embodiments, the leg member may be a post member that attaches to the bone plate by threaded engagement with an aperture of the bone plate. In some embodiments, the bone plate and the leg member may be used near the end of a long bone, such as on a distal portion of a radial bone.

An exemplary method of bone fixation is provided. In the method, a bone plate including a first portion and a second portion may be selected. A leg member may be disposed on the bone with the leg member attached to and projecting from the first portion of the bone plate to a first region of the bone, such that the first portion of the bone plate is supported at a slant with respect to the first region and spaced from the bone. The second portion of the bone plate may be attached to a second region of the bone. The leg member may be disconnected from the bone plate. The first portion of the bone plate may be pivoted toward the first region of the bone such that the bone plate is used as a lever to change an orientation of the second region relative to the first region of the bone. The first portion of the bone plate may be attached to the first region of the bone.

Another exemplary method of bone fixation is provided. In the method, a bone plate may be selected. The bone plate may include an elongated body portion connected to a head portion that is wider than the body portion. A leg member may be disposed on the bone with the leg member attached to and projecting from the body portion of the bone plate to a shaft region of the bone, such that the body portion of the bone plate is supported at a slant above the shaft region. The head portion of the bone plate may be attached to an end region of the bone. The leg member may be disconnected from the bone plate. The body portion of the bone plate may be pivoted toward the

shaft region of the bone such that the bone plate is used as a lever to change an orientation of the end region relative to the shaft region of the bone. The body portion of the bone plate may be attached to the shaft region of the bone.

Yet another exemplary method of bone fixation is provided. In the method, a bone plate may be selected. The bone plate may include an arm portion, a fulcrum portion, and an anchor portion arranged in order along the bone plate. A post member may be disposed on the bone with the post member extending through an aperture of the arm portion to a first region of bone and attached to the arm portion at the aperture, such that the fulcrum portion and the post member collectively support the arm portion in a spaced relation to the bone and at a slant with respect to the first region of the bone. The anchor portion of the bone plate may be attached to a second region of the bone. The leg member may be disconnected from the bone plate. The arm portion of the bone plate may be pivoted toward the first region of the bone such that the bone plate is used as a lever to change an orientation of the second region relative to the first region of the bone. The arm portion of the bone plate may be attached to the first region of the bone.

An exemplary system for bone fixation is provided. The system may comprise a bone plate including an arm portion and an anchor portion separated from the arm portion by a fulcrum portion. Each of the arm portion and the anchor portion may define one or more apertures for receiving fasteners that attach the bone plate to bone. The system also may comprise a thumbscrew including a graspable handle portion affixed to a shaft portion having an external thread. The shaft portion may be configured to be disposed in threaded engagement with an aperture of the arm portion, such that the handle portion projects from an outer surface of the arm portion, and such that the shaft portion projects from an inner surface of the arm portion, to enable support of the arm portion at a slant above a bone surface by the thumbscrew and the fulcrum portion of the bone plate.

The system disclosed herein has substantial advantages over bone fixation systems lacking a leg member. For example, the leg member may reduce undesired plate movement while another portion of the bone plate is being attached to an end region of bone, permitting a surgeon to more accurately direct fasteners into bone, with less plate slippage. Also, the leg member may enable a surgeon to support an arm portion of a bone plate at a desired and/or predefined angle above a shaft region of a bone, to introduce a corresponding change in angular disposition of the end region of a bone when the arm portion is moved into alignment with the shaft region. Thus, the system may enable more accurate angular repositioning of bone fragments in corrective osteotomy or during reduction of a fractured bone.

Further aspects of the present disclosure are described in the following sections: (I) overview of an exemplary bone fixation system with a leg member, (II) exemplary method of fixing a fractured bone, (III) exemplary method of bone fixation with corrective osteotomy, (IV) bone plates, (V) leg members, and (VI) selected embodiments.

I. Overview of an Exemplary Bone Fixation System with a Leg Member

FIG. **1** shows selected aspects of an exemplary bone fixation system **40** including a bone plate **42** connected to a detachable leg member **44** that provisionally supports a portion of the bone plate in a spaced relation to a bone **46**, particularly a shaft region (and/or a shaft fragment) **47** of the bone. Here, bone **46** is a radial bone that has sustained a fracture **47**A, and fixation system **40** is disposed on a distal volar surface region of the radial bone.

The bone plate has opposing outer and inner surfaces **48**, **50** configured to face, respectively, away from and toward bone **46**. The plate bone is depicted here in profile, which reveals an upward longitudinal bend. However, in other embodiments, the bone plate may have a substantially linear profile or a downward longitudinal bend, among others.

The bone plate may include an arm portion **52** (interchangeably termed a lever portion), an intermediate or fulcrum portion **54**, and an anchor portion **56** arranged in order along the bone plate. The arm portion may be supported in a spaced relation to bone by a set of contacts provided collectively by leg member **44** and fulcrum portion **54** and/or anchor portion **56**. For example, fulcrum portion **54** (or anchor portion **56**), due to its width, may provide at least two points of contact with bone **46**, and leg member **44** may provide at least one more point of contact with the bone. In any event, leg member **44** may support arm portion **52** at a slant, in a spaced configuration from an adjacent surface area of bone **46** (and shaft region **47**), such that the bone plate and the bone diverge as arm portion **52** extends away from fulcrum portion **54**. Accordingly, an acute angle **58** may be formed between arm portion **52** and shaft region **47** and/or may be defined collectively by arm portion **52** and bone **46**.

Leg member **44** may be attached to the arm portion of the bone plate, such that at least part of the leg member projects below the bone plate, in a direction transverse (e.g., substantially orthogonally) to the arm portion. For example, the leg member may project from inner surface **50** (and, optionally, outer surface **48**) of the bone plate. The leg member may be attached by any suitable mechanism that allows subsequent detachment, such as threaded engagement with the arm portion, one or more clips, a sleeve, a mated snap-fit, etc. The leg member may be attached to the bone plate near one of the plate's opposing ends **60**, **62**, such as the proximal end in the depicted embodiment. The leg member, when attached to the bone plate, may extend through an aperture **63** of the bone plate. The leg member may provide an upper portion **64** projecting above outer surface **48** of the bone plate, an intermediate portion **66** locked to the bone plate in aperture **63**, and a lower or spacer portion **68** that projects below inner surface **50** of the bone plate. Spacer portion **68** may extend to a distal tip **70**, such as a pointed or blunt tip, that contacts bone. The length of spacer portion **68** and its distance of separation from fulcrum portion **54** (and/or anchor portion **56**) of the bone plate generally determine the magnitude of acute angle **58** at which arm portion **52** is supported relative to shaft region **47** and how far an end (e.g., proximal end **60**) of the bone plate is spaced from bone **46**.

FIG. **2** shows a top view of bone plate **42**, including arm portion **52**, fulcrum portion **54**, and anchor portion **56**, and with leg member **44** removed. (The perimeter of leg member **44** is shown in phantom outline.) Each of the arm portion and the anchor portion may define a plurality of apertures **80** (e.g., through-holes) to receive fasteners (e.g., bone screws, wires, a screw to attach a target guide or handle, etc.). Each of the apertures may be locking (e.g., having an internal thread) or nonlocking (e.g., lacking an internal thread). At least one aperture in arm portion **52**, such as aperture **63**, may include a locking structure, such as an internal thread **82**, adapted to provide locked engagement with an external thread of the leg member.

Bone plate **42** may be used to fix an end region **84** of bone **46** relative to shaft region **47**. The bone plate may include a relatively wider head portion **86** connected to a relatively narrower body portion **88**, which may be elongated. Head

portion **86** may be disposed closer to the end of the bone than body portion **88**, such as distally on the radial bone, and corresponds to anchor portion **56**. The body portion may be disposed more centrally along the bone, such as more proximally on the radial bone, and corresponds to arm portion **52**. Fulcrum portion **54** of the bone plate may be disposed generally between head portion **86** and body portion **88**.

FIGS. **3-7** show exemplary leg members **90-98** for use in fixation system **40** with bone plate **42**. Each leg member **90-98** is designed to support the arm portion of the bone plate at a predefined angle of about 5°, 10°, 15°, 20°, and 25°, respectively, with respect to an adjacent surface region of bone. Each leg member may be marked with one or more indicia, such as with one or more alphanumeric characters (e.g., a number, such as "15"), to identify the angle at which the leg member is configured to support the arm portion.

Each leg member **90-98** may be structured as a post member. The post member may include a graspable handle or head portion **100** connected to a respective shaft portion **102-110**, which may be of smaller width/diameter than the handle/head portion. The handle portion may include a knurled surface **112** with ridges formed on sides of the handle to facilitate manual engagement (e.g., with a gloved (or ungloved) hand of a surgeon). The post member (e.g., the head and/or shaft portion) may form a stop structure **114** (e.g., a shoulder) that blocks axial advancement of the post member through an aperture of the bone plate. In other words, the stop structure may form an abutment with the bone plate that determines a fully advanced position of the post member. In some embodiments, the post member may be described as a thumbscrew, which may be any screw configured to be turned by hand via an integral, graspable head.

Each shaft portion of the post member may include an external thread **116**, which may extend along any suitable portion, a majority, or at least substantially all of the length of the shaft portion. The shaft portion may (or may not) include a nonthreaded region **118** (e.g., see FIGS. **5-7**) and may extend to a distal tip **120** (see FIG. **3**). The distance of tip **120** from stop structure **114** is different for each post member of FIGS. **3-8**. This distance determines how much of the post member, and particularly the shaft portion thereof, projects below the bone plate when stop structure **114** is abutted with the bone plate, and thus the angle at which the arm portion of the bone plate is supported relative to bone.

The post member may have a through-bore **124** extending lengthwise through the post member (see FIG. **7**). The through-bore, which may be described as a cannulation, may be utilized to receive a wire (such as a K-wire) that extends through the post member and, optionally, into bone. The wire may help to hold the post member in place on the bone, may be used to guide the post member on the bone, and/or may be visualized under fluoroscopy to project the axis defined by the post member into bone, among others.

FIG. **8** shows another exemplary leg member **130** structured as a post member for use in system **40** with bone plate **42** (see FIG. **1**). Leg member **130** may be designed to support the arm portion of the bone plate at a continuous range of angles from about 0° to 30°, based on how far a threaded shaft **132** of the leg member is advanced through the bone plate. If leg member **130** is advanced fully, such that stop structure **114** engages the bone plate, the leg member may support the arm portion of the bone plate at about 30°.

The bone fixation system may be provided as a kit. The kit may include at least one bone plate, one or more leg members, fasteners (e.g., bone screws) to attach the bone plate to bone, a protractor, a saw for cutting bone, a guide device to guide a drill bit and/or fasteners through apertures of the bone plate and into bone, and/or the like. In some embodiments, the kit may include a bone plate and a set of two or more leg members that assemble interchangeably with the bone plate to support an arm portion of the bone plate at two or more predefined angles, such as two or more predefined angles that differ from each other by an increment of about 1, 2, 3, 4, or 5 degrees, or an integer multiple thereof, among others. The two or more leg members may be post members with shafts of different length. The components of a kit may be supplied in a sterile package. Some of the components may be configured to be re-used (e.g., the protractor, saw, and guide device) and others may be configured to be used only once (e.g., the bone plate and fasteners).

The bone plate and leg members disclosed herein may be formed of any suitable biocompatible material(s). Exemplary biocompatible materials include (1) metals (for example, titanium or titanium alloys, alloys with cobalt and chromium (cobalt-chrome), stainless steel, etc.); (2) plastics/polymers (for example, ultra-high molecular weight polyethylene (UHMWPE), polymethylmethacrylate (PMMA), polytetrafluoroethylene (PTFE), polyetheretherketone (PEEK), nylon, polypropylene, and/or PMMA/polyhydroxyethylmethacrylate (PHEMA)); (3) ceramics (for example, alumina, beryllia, and/or zirconia, among others); (4) composites (e.g., a polymer matrix (such as PEEK) containing carbon fibers and/or ceramic); (5) bioresorbable (bioabsorbable) materials or polymers (for example, polymers of α-hydroxy carboxylic acids (e.g., polylactic acid (such as PLLA, PDLLA, and/or PDLA), polyglycolic acid, lactide/glycolide copolymers, etc.), polydioxanones, polycaprolactones, polytrimethylene carbonate, polyethylene oxide, poly-β-hydroxybutyrate, poly-β-hydroxypropionate, poly-δ-valerolactone, other bioresorbable polyesters, etc.; and/or the like. In exemplary embodiments, both the bone plate and the leg members are formed of metal. For example, the bone plate may be formed of titanium (such as a titanium alloy) and the leg member of surgical grade stainless steel.

II. Exemplary Method of Fixing a Fractured Bone

FIGS. **9-13** show somewhat schematic configurations produced during performance of an exemplary method of fixing fractured bone **46** using bone plate **42** and leg member **130** (see FIGS. **1** and **8**). The method may include any suitable combination of the steps disclosed in this section or elsewhere in the present disclosure, performed in any suitable order. In some embodiments, the method may reduce and fix a bone, such as a radial bone fractured distally.

A bone may be selected for fixation. The bone may have any suitable discontinuity or may be a candidate for an osteotomy. Exemplary bones that may be selected are long bones, such as a femur, tibia, fibula, ulna, radius, humerus, or the like.

In some embodiments, the bone may include an end region that has an undesired angular disposition relative to a shaft region of the bone. The undesired angular disposition may be the result of displacement caused by fracture, a malunion, a growth deformity, or the like.

A bone plate and a leg member may be selected. The leg member may be continuously adjustable (e.g., leg member **130** of FIG. **8**) and/or may provide a predefined angle of support. The leg member may be selected from a set of two or more leg members that provide different predefined angles of support and/or have spacer portions **68** (and/or shafts) of different length (see FIGS. **1** and **3-8**). In some cases, a continuously adjustable leg member may be more suitable for fracture fixation.

Bone plate **42** and leg member **130** may be disposed on the bone such that the leg member is attached to the bone plate and spaces arm portion **52** from the bone. The leg member may be attached to the bone plate before or after the bone plate is disposed on the bone. Accordingly, the bone plate and leg member may be assembled with each other off bone (e.g., by a manufacturer or peri-operatively) or on bone. The bone plate may be positioned to span a discontinuity in the bone (such as fracture **47**A) and/or a prospective osteotomy site.

FIG. **9** shows bone plate **42** and leg member **130** assembled with each other and disposed on fractured bone **46**. The leg member, which may be described as a jackscrew, is locked to the bone plate. The leg member may support arm portion **52** of the bone plate at a predefined slant relative to shaft region **47** of bone **46**.

End region **84** of the bone has been displaced at least in part by rotation out of alignment with shaft region **47** as a consequence of fracture **47**A. The bone plate may have an inner surface region (e.g., provided by anchor portion **56**) that is contoured to be complementary to an end surface region of bone **46** (e.g., on end region **84**). The inner surface region of the bone plate thus may serve as a template for reconstruction of the bone. Accordingly, in some embodiments, leg member **130** may be turned at this stage of the procedure, indicated at **140**, to change the acute angle formed between shaft region **47** and arm portion **52**, to adjust the fit of the inner surface region of anchor portion **56** on end region **84**. In other words, arm portion **52** may be raised or lowered, to pivot anchor portion **56** in order to improve the abutment of anchor portion **56** and end region **84**, at least in part by matching the angular disposition of end region **84** with that of anchor portion **56**. Adjustment of the length of spacer portion **68** of leg member **130** that projects below the bone plate, while the leg member is supporting arm portion **52**, may produce coincident pivotal motion of arm portion **52** and anchor portion **56**.

FIG. **10** shows an attached configuration of bone plate **42**. Anchor portion **56** may be attached to end region **84** of the bone while arm portion **52** is supported by leg member **130** and fulcrum portion **54**. Attachment may include placement of fasteners, indicated at **142** in FIG. **9**, such as one or more bone screws **144**, through one or more apertures of the anchor portion and into end region **84** of the bone. During this procedure, the leg member may stabilize the position of the bone plate by restricting pivotal and translational motion thereof. In some embodiments, anchor portion **56** may be attached to end region **84** before leg member **130** engages shaft region **47** of bone **46**.

FIG. **11** shows an adjustable configuration of the fractured bone in which bone plate **42** is poised to function as a lever. Leg member **130** may be manipulated, indicated at **146**, to remove the support previously provided to the bone plate by the leg member. For example, in the present illustration, the leg member has been disconnected from the bone plate and removed by unthreading the leg member from arm portion **52**. As a result, arm portion **52** can be urged toward shaft region **47** by pivoting the arm portion, indicated by a motion arrow at **148**. A fulcrum for pivotal movement may be formed by contact of the fulcrum portion of the bone plate with shaft region **47** near the fracture, with adjacent soft tissue, and/or with one or more intermediate bone fragments, among others.

Motion of the arm portion adjusts an orientation of end region **84**, as indicated by a motion arrow at **150**. The motion may set the palmar inclination (also called the palmar tilt) of a distal articular surface **152** of the radial bone. (The term "palmar" may be used as a synonym for "volar.") The palmar inclination is defined as the angle between a first line drawn perpendicular to the long axis of the radius and a second line drawn between the dorsal and palmar lips of the distal radial articular surface. An exemplary palmar inclination is about 12 degrees (with the dorsal lip disposed more distally than the palmar lip).

FIG. **12** shows a volar view of bone **46** with plate **42** attached to end region **84**, taken generally along line **12-12** of FIG. **11**. Arm portion **52** also may be moved pivotally, indicated by a motion arrow at **154**, to set a radial inclination of distal articular surface **152** of bone **46**. The radial inclination is defined as the angle between a first line drawn perpendicular to the long axis of the radius at the outer corner of the lunate fossa of surface **152** and a second line drawn between the outer corner of the lunate fossa and the tip of the radial styloid. An exemplary radial inclination is about 23 degrees.

FIG. **13** shows arm portion **52** attached to shaft region **47** to stabilize the adjusted orientation of end region **84**. The arm portion has been pivoted into alignment with shaft region **47**, such that the arm portion is no longer spaced and slanted with respect to the shaft region. End region **84** has been pivoted by a corresponding amount to an adjusted orientation that reduces the fractured bone by improving the alignment of the shaft and end regions of the bone. Attachment may include placement of fasteners, such as one or more bone screws **156**, through one or more apertures of the arm portion and into the shaft region of the bone.

III. Exemplary Method of Bone Fixation with Corrective Osteotomy

FIGS. **14-16** show somewhat schematic configurations produced during performance of an exemplary method of fixing a cut bone using bone plate **42** (FIGS. **1** and **2**) and leg member **96** (FIG. **6**). The method may include any combination of the steps disclosed in this section or elsewhere in the present disclosure, performed in any suitable order. In some embodiments, the method may be performed as part of a corrective osteotomy. In an osteotomy, a bone is cut and then realigned, shortened, or lengthened to correct a defect. The method may be performed on any of the bones listed above in the preceding section. In the present illustration, radial bone **46** is cut, realigned, and fixed.

A surgeon may estimate the amount of angular correction needed, and choose the appropriate leg member from a set of leg members offering different angular corrections. In this example, leg member **96** is selected to provide a 20-degree correction. The leg member may be marked with indicia **160** to facilitate identification of the leg member.

FIG. **14** shows bone plate **42** supported by leg member **96** proximally and being attached distally on the volar surface of radius **46** distally with bone screws **162**. Bone plate **42** may be supported distally, prior to attachment with bone screws **162**, by contact of radius **160** with fulcrum portion **54** and/or anchor portion **56** of the bone plate.

FIG. **15** shows a cut **164** placed through radius **46** proximal to secured anchor portion **56** of the bone plate. The cut may be formed with a saw and may create a distal bone fragment (an end fragment) **166** and a main, proximal bone fragment (a shaft fragment) **168**.

FIG. **16** shows bone plate **42** and radius **46** after removal of leg member **96** and pivotal movement, indicated at **170** of arm portion **52** of the bone plate into alignment with shaft fragment **168**. Pivotal movement of arm portion **52** may also produce a corresponding pivotal movement of end fragment **166**, indicated at **172**. The leg member is designed to support arm portion **52** at an angle of 20 degrees with respect to a shaft surface region of radius **46**. Accordingly, pivoting arm portion **52** through an angle of 20 degrees, to place the arm portion

against proximal bone fragment **168**, causes a corresponding rotation of 20 degrees of distal bone fragment **166**, which may create a 20-degree gap **174**. The arm portion then may be secured to proximal fragment **168** of the radius with fasteners, such as bone screws **176**, to fix the bone. The 20-degree gap may be filled, for example, via natural healing and/or a bone graft, so that the bone ends up with the desired shape.

IV. Bone Plates

A bone plate generally refers to any structure or piece having a plate geometry and being configured to be attached to bone with the bone plate at least mostly or completely under skin (and, generally, other soft tissue). The bone plate may be configured to reduce irritation to the bone and surrounding soft tissue. For example, the bone plate may have a low and/or feathered profile to reduce its protrusion into overlying soft tissue and rounded, burr-free surfaces to reduce the effects of such protrusion.

The bone plates of the present disclosure may have any shape suitable for use on their intended target bones. The bone plate may be shaped for use on any suitable bone or bones to be fixed, including a bone of the arms (such as a humerus, a radius, and/or an ulna), a bone of the legs (such as a femur, a tibia, and/or a fibula), a bone of the hands (such as a carpal, metacarpal, and/or phalange), a bone of the feet (such as a tarsal, metatarsal, and/or phalange), a clavicle, a rib, a scapula, a pelvic bone, a vertebra, a skull, a mandible, or the like.

Each bone plate may be configured for use on any suitable side or sides of the body. For example, the bone plate may be configured for use on both the left side and right side of the body/skeleton, such as when the bone plate is bilaterally symmetrical. Alternatively, each bone plate may be configured for use on either the left side or right side of the body/skeleton, but not both.

Each bone plate may have any suitable contour. In some examples, the bone plate may be supplied in a pre-contoured configuration produced during plate manufacture (e.g., by bending, molding, and/or machining, among others) to include an inner surface region that is complementary to a nonplanar surface region of a target bone. The bone plate thus may be pre-contoured according to an average or representative surface geometry of a target bone. Alternatively, or in addition, the bone plate may be contoured peri-operatively (e.g., by bending the bone plate), to adjust its shape before and/or during its installation on bone, to improve, for example, the fit of the bone plate on a target bone for particular individuals and/or on distinct regions of the target bone.

Each bone plate may be generally elongate, with length L>width W>thickness T. In use, the long axis of the bone plate may be aligned with the long axis of a target bone and/or may extend obliquely and/or transversely relative to the long axis. In some embodiments, the bone plate may have a length and a width that are about the same.

Each bone plate may be of continuous structure (e.g., monolithic) or may include two or more discrete pieces. The two or more discrete pieces may be fixed to one another or may be connected through a mechanical joint that enables translational and/or pivotal movement to adjust the shape and/or size of the bone plate.

The bone plate may include a first portion and a second portion, which may be arranged along the bone plate from each other. Each of the first portion and the second portion may be anchor portion (i.e., an attachment portion) defining one or more apertures for receiving fasteners that secure the anchor portion to bone. At least one of the anchor portions also may be described as an arm portion, a head portion, and/or a body portion, among others. An arm portion is any part of a bone plate that is supportable in a spaced relation to bone and then can be pivoted toward the bone.

V. Leg Members

The bone fixation systems disclosed herein utilize a leg member to temporarily support part of a bone plate in a spaced relation to bone, such as at a slant above a shaft region of a bone. A leg member generally comprises any detachable support that can prop up an end region of a bone plate while the opposing end region is being attached to bone. A leg member projects below an inner surface of the bone plate by any suitable distance. The leg member may project orthogonally or obliquely from the inner surface. In some cases, the leg member or a portion thereof may be described as a jackscrew, a stand, a bolt, a post, a kickstand, or a combination thereof.

The leg member may have any suitable shape. The leg member may be elongate. The leg member or regions thereof may or may not be at least generally cylindrical. For example, the leg member may include a cylindrical head/handle portion, a cylindrical shaft portion that extends through the bone plate and/or projects below the bone plate, or a combination thereof, among others.

Any suitable connection may be formed between the leg member and a bone plate. The leg member may be locked to the bone plate, such that axial motion of the leg member is restricted in both axial directions of the leg member. Alternatively, the leg member may support part of the bone plate without locked engagement. For example, the leg member may provide a post with a flange on which the bone plate rests, such that the flange restricts separation of the leg member from the bone plate in only one of two axial directions of the leg member. In other embodiments, the leg member may slide onto the bone plate from an end thereof, may clip onto the bone plate, or the like.

VI. Selected Embodiments

This section describes selected embodiments of the present disclosure, presented as a series of indexed paragraphs. These embodiments are intended for illustration and should not limit the entire scope of the present disclosure.

1. A method of bone fixation, comprising: (A) supporting an arm portion of a bone plate in a spaced relation to a shaft region of a bone with a leg member connected to the arm portion and engaged with the shaft region; (B) attaching an anchor portion of the bone plate to an end region of the bone; (C) manipulating the leg member to remove the leg member's support of the arm portion; (D) moving the arm portion toward the shaft region of the bone to adjust an orientation of the end region of the bone; and (E) attaching the arm portion to the shaft region to stabilize the adjusted orientation.

2. The method of paragraph 1, further comprising a step of disposing the leg member in threaded engagement with the arm portion.

3. The method of paragraph 2, wherein the leg member includes a handle portion, and wherein the step of disposing the leg member in threaded engagement includes a step of turning the handle portion with the handle portion grasped manually.

4. The method of paragraph 1, wherein the step of supporting includes a step of supporting the arm portion with the leg member at a predefined angle with respect to the shaft region.

5. The method of paragraph 4, further comprising a step of selecting the leg member from a set of two or more leg members providing different predefined angles of support for the arm portion.

6. The method of paragraph 4, wherein the leg member has a position where advancement through an aperture of the bone plate is stopped, and wherein the position provides the predefined angle.

7. The method of paragraph 6, wherein the leg member includes a head and a shaft, and wherein the position is achieved when the head engages the arm portion.

8. The method of paragraph 1, wherein the step of supporting includes a step of supporting the arm portion at a slant with respect to the shaft region, and wherein the leg member is configured to be adjustable to provide a continuous range of angles for the slant.

9. The method of paragraph 8, further comprising a step of adjusting the slant to provide a better fit of the anchor portion on the end region of the bone.

10. The method of paragraph 1, further comprising a step of cutting the bone to separate the shaft region from the end region before the step of moving.

11. The method of paragraph 1, wherein the shaft region and the end region of the bone are separated by a fracture in the bone.

12. The method of paragraph 1, wherein the step of manipulating includes a step of unthreading the leg member from the arm portion.

13. The method of paragraph 1, wherein the step of moving includes a step of pivoting the arm portion of the bone plate.

14. A system for bone fixation, comprising: (A) a bone plate including an anchor portion and an arm portion each defining one or more apertures; and (B) a leg member including a graspable handle portion connected to a shaft portion, the shaft portion being configured to be disposed in threaded engagement with an aperture of the arm portion of the bone plate, with the handle portion projecting above the bone plate, such that part of the shaft portion extends below the bone plate to permit support of the arm portion of the bone plate in a spaced relation to a shaft region of a bone.

15. A system for bone fixation, comprising: (A) a bone plate including an anchor portion and an arm portion each defining one or more apertures and also including a fulcrum; and (B) a post member including a handle portion connected to a shaft portion, the shaft portion being configured to be disposed in threaded engagement with an aperture of the arm portion of the bone plate such that part of the shaft portion extends below the bone plate to provide support of the arm portion of the bone plate at a predefined angle and such that the handle portion projects above the bone plate.

16. A system for bone fixation, comprising: (A) a bone plate including an anchor portion and an arm portion each defining one or more apertures; and (B) at least two posts each including a head portion connected to a shaft portion, each shaft portion being configured to be disposed in threaded engagement with an aperture of the arm portion of the bone plate such that part of the shaft portion extends below the bone plate to provide support of the arm portion of the bone plate at a predefined angle, wherein the leg members are configured to provide different predefined angles of support.

17. A method of fixing bone, comprising: (A) selecting a bone plate including a first portion and a second portion; (B) disposing the bone plate and a discrete leg member on the bone such that the leg member is attached to and projects from the first portion of the bone plate to a first region of the bone, to position the first portion of the bone plate at a slant with respect to the first region and spaced from the bone; (C) attaching the second portion of the bone plate to a second region of the bone; (D) pivoting the first portion of the bone plate toward the first region of the bone such that the bone plate is used as a lever to change an orientation of the second region relative to the first region of the bone; and (E) attaching the first portion of the bone plate to the first region of the bone.

18. The method of paragraph 17, wherein the step of disposing positions the first portion at a predefined angle with respect to the first region of the bone.

19. The method of paragraph 18, wherein the leg member has a stop structure that blocks advancement through an aperture of the first portion of the bone plate at a position of the leg member.

20. The method of paragraph 19, wherein stop structure is a shoulder formed by the leg member.

21. The method of paragraph 17, further comprising a step of selecting the leg member from a set of two or more leg members each extending a different predefined distance from the first portion when attached to the bone plate.

22. The method of paragraph 17, wherein the leg member is configured to be adjustably advanced with respect to the arm portion to provide a continuous range of angles for the slant of the first portion of the bone plate.

23. The method of paragraph 17, wherein the first region is a shaft region and the second region is an end region of the bone,

24. The method of paragraph 23, further comprising a step of cutting the bone to separate the shaft region from the end region before the step of pivoting.

25. The method of paragraph 23, wherein the shaft region and the end region of the bone are separated by a fracture in the bone.

26. A system for bone fixation, comprising: (A) a bone plate including an arm portion and an anchor portion separated from the arm portion by a fulcrum portion, each of the arm portion and the anchor portion defining one or more apertures for receiving fasteners that attach the bone plate to bone; and (B) a thumbscrew including a graspable handle portion affixed to a shaft portion having an external thread, the shaft portion being configured to be disposed in threaded engagement with an aperture of the arm portion, such that the handle portion projects from an outer surface of the arm portion, and such that the shaft portion projects from an inner surface of the arm portion, to enable support of the arm portion at a slant above a bone surface by the thumbscrew and the fulcrum portion of the bone plate before use of the bone plate as a lever.

27. The system of paragraph 26, wherein the thumbscrew is in threaded engagement with the aperture and restricted from further advancement into the aperture, and wherein a projecting region of the shaft portion projects into air from the inner surface of the arm portion to a distal tip of the shaft portion.

28. The system of paragraph 26, wherein the graspable handle portion of the thumbscrew is substantially permanently affixed to the shaft portion.

29. The system of paragraph 26, wherein the graspable handle portion is cylindrical.

30. The system of paragraph 26, wherein the graspable handle portion includes a knurled surface region.

31. The system of paragraph 26, wherein the thumbscrew defines a long axis, and wherein the graspable handle portion is elongated in a direction parallel to the long axis.

32. The system of paragraph 26, wherein the thumbscrew is a first thumbscrew, further comprising a second thumbscrew configured to be disposed in threaded engagement with the aperture of the arm portion of the bone plate, and wherein each of the first and second thumbscrews is configured to

support the arm portion at a respective different predefined angle of slant when fully advanced into the aperture.

33. The system of paragraph 32, wherein the predefined angle of slant for the first thumbscrew and the second thumbscrew differ from each other by about five or ten degrees.

34. The system of paragraph 32, wherein each of the first and second thumbscrews is marked with at least one indicium identifying an angle of slant at which the thumbscrew supports the arm portion.

35. The system of paragraph 26, wherein the anchor portion is wider than the arm portion.

36. The system of paragraph 26, wherein the anchor portion has an inner surface that is contoured to match a surface region near an end of a bone, such that the anchor portion fits onto the surface region.

37. The system of paragraph 36, wherein the anchor portion has an inner surface that is contoured to match a surface region near a distal end of a radial bone.

38. The system of paragraph 37, wherein the bone plate has a longitudinal bend that renders an outer surface of the bone plate at least substantially concave in profile.

The disclosure set forth above may encompass multiple distinct inventions with independent utility. Although each of these inventions has been disclosed in its preferred form(s), the specific embodiments thereof as disclosed and illustrated herein are not to be considered in a limiting sense, because numerous variations are possible. The subject matter of the inventions includes all novel and nonobvious combinations and subcombinations of the various elements, features, functions, and/or properties disclosed herein. The following claims particularly point out certain combinations and subcombinations regarded as novel and nonobvious. Inventions embodied in other combinations and subcombinations of features, functions, elements, and/or properties may be claimed in applications claiming priority from this or a related application. Such claims, whether directed to a different invention or to the same invention, and whether broader, narrower, equal, or different in scope to the original claims, also are regarded as included within the subject matter of the inventions of the present disclosure. Further, ordinal indicators, such as first, second, or third, for identified elements are used to distinguish between the elements, and do not indicate a particular position or order of such elements, unless otherwise specifically stated.

We claim:

1. A method of fixing bone, comprising:

selecting a bone plate including a first portion and a second portion;

disposing a leg member on the bone with the leg member attached to and projecting from the first portion of the bone plate to a first region of the bone, such that the first portion of the bone plate is supported at a slant with respect to the first region and spaced from the bone;

attaching the second portion of the bone plate to a second region of the bone;

disconnecting the leg member from the bone plate;

pivoting the first portion of the bone plate toward the first region of the bone such that the bone plate is used as a lever to change an orientation of the second region relative to the first region of the bone; wherein the step of disconnecting the leg member is performed before the step of pivoting; and

attaching the first portion of the bone plate to the first region of the bone.

2. The method of claim **1**, wherein the bone plate includes a third portion disposed along the bone plate between the first portion and the second portion, and wherein the step of disposing results in collective support of the first portion of the bone plate above the first region of the bone by the leg member and the third portion of the bone plate.

3. The method of claim **1**, wherein the leg member is a post member, further comprising a step of disposing the post member in threaded engagement with an aperture defined by the first portion of the bone plate.

4. The method of claim **3**, wherein the post member is a thumbscrew.

5. The method of claim **1**, wherein the first region includes at least one fragment containing a majority of a shaft of a bone and the second region includes at least one end fragment of the bone.

6. The method of claim **1**, wherein the step of pivoting includes a step of placing the first portion of the bone plate against a bone and at least generally parallel to a long axis defined by the bone.

7. A method of fixing bone, comprising:

selecting a bone plate including an elongated body portion connected to a head portion that is wider than the body portion;

disposing a leg member on the bone with the leg member attached to and projecting from the body portion of the bone plate to a shaft region of the bone, such that the body portion of the bone plate is supported at a slant above the shaft region;

attaching the head portion of the bone plate to an end region of the bone;

disconnecting the leg member from the bone plate;

pivoting the body portion of the bone plate toward the shaft region of the bone such that the bone plate is used as a lever to change an orientation of the end region relative to the shaft region of the bone; wherein the step of disconnecting the leg member is performed before the step of pivoting; and

attaching the body portion of the bone plate to the shaft region of the bone.

8. The method of claim **7**, wherein the bone is a radial bone, and wherein the step of pivoting adjusts a palmar inclination of a distal articular surface region of the radial bone.

9. The method of claim **8**, further comprising a step of adjusting a radial inclination of the distal articular surface region by moving the body portion.

10. The method of claim **7**, wherein the head portion has an inner surface that is contoured to match a surface region on the end region of the bone.

11. The method of claim **10**, further comprising a step of adjusting an angle of slant of the body portion to provide a better fit of the head portion of the bone plate on the end region of the bone.

12. The method of claim **11**, wherein the step of adjusting an angle of slant of the body portion includes a step of turning the leg member, a step of replacing the leg member with a different leg member, or a combination thereof.

13. A method of fixing bone, comprising:

selecting a bone plate including an arm portion, a fulcrum portion, and an anchor portion arranged in order along the bone plate;

disposing a post member on the bone with the post member extending through an aperture of the arm portion to a first region of bone and attached to the arm portion at the aperture, such that the fulcrum portion and the post member collectively support the arm portion in a spaced relation to the bone and at a slant with respect to the first region of the bone;

attaching the anchor portion of the bone plate to a second region of the bone;

disconnecting the post member from the bone plate;

pivoting the arm portion of the bone plate toward the first region of the bone such that the bone plate is used as a lever to change an orientation of the second region relative to the first region of the bone; wherein the step of disconnecting the post member is performed before the step of pivoting; and

attaching the arm portion of the bone plate to the first region of the bone.

14. The method of claim **13**, wherein the post member is attached to the aperture of the arm portion by threaded engagement.

15. The method of claim **13**, wherein the post member includes a head connected to a shaft including an external thread, wherein the aperture of the arm portion is configured to receive the shaft but not the head, and wherein the head projects from an outer surface of the arm portion when the post member is fully advanced into the aperture.

16. The method of claim **15**, wherein the head is a handle portion configured to be grasped by hand.

17. The method of claim **16**, wherein the handle portion is cylindrical and has a knurled surface region.

18. The method of claim **13**, wherein the post member is a thumbscrew.

19. The method of claim **13**, wherein the post member has a stop structure that blocks advancement of the post member through the aperture of the arm portion.

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