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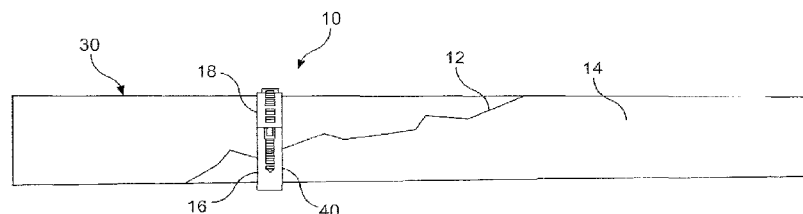


FIG. 1

(57) Abstract: A bone fixation clamp comprises a first arcuate clamp member conforming to a shape of a bone and extending between a first connection end and a first free end, a second arcuate clamp member conforming to a shape of the bone, a second connection end of the second clamp member being pivotally attached to the first clamp member, the second clamp member extending between the second connection end and a second free end and a driving member received in the first clamp member passing out of the first clamp member to abut an abutment portion of the second member so that, as the driving member is extended further out of the first member, the driving member pivots the second clamp member relative to the first clamp member to draw the first and second free ends toward one another to apply a radially compressive force to the bone.

BONE FRACTURE FIXATION CLAMP

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Priority Claim

[0001] The present application claims priority to and is a Continuation-in-Part of U.S. Application Serial No. 13/068,397 entitled "Bone Fracture Fixation Clamp" filed on May 10, 2011 to George J. Haidukewych, the entire disclosure of which is incorporated herein by reference.

Field of the Invention

[0002] The present invention relates to the fixation of fractured bones and, in particular, relates to a system and method for securing a bone fixation clamp over an outer periphery of a fractured bone.

Background

[0003] Fractures of long bones are sometimes treated by bone fixation devices that are positioned over an outer periphery of the bone. For example, the fixation of long oblique fractures in bones previously fitted with metal prostheses (e.g. intramedullary nails) precludes the use of bone fixation devices that extend into the bone. Such bone fixation procedures therefore use a combination of cables, clamps and metal compression plates which are employed with or without fixation screws that extend into the bone. A number of prior art examples are discussed below.

Summary of the Invention

[0004] The present invention is directed to a bone fixation clamp comprising a first arcuate clamp member conforming to a shape of a target portion of a bone and extending between a first

connection end and a first free end and a second arcuate clamp member conforming to a shape of the target portion of the bone, a second connection end of the second clamp member being pivotally attached to the first connection end of the first clamp member, the second clamp member extending between the second connection end and a second free end. The bone fixation clamp further comprises a driving member received in the first clamp member passing out of the first clamp member to abut an abutment portion of the second member so that, as the driving member is extended further out of the first member, the driving member pivots the second clamp member relative to the first clamp member to draw the first and second free ends toward one another to apply a radially compressive force to the bone.

Brief Description of the Drawings

[0005] Fig. 1 is a side view of the fixation clamp according to a first embodiment of the present invention secured in operative position on a fractured bone;

Fig. 2 is an exploded top view of the fixation clamp of the present invention;

Fig. 3 is a partial side view of the fixation clamp of the present invention;

Fig. 4 is a side view of a fractured bone with a plurality of fixation clamps of the present invention in combination with an elongated plate secured in operative position on the fractured bone;

Fig. 5 is a side view of a fractured bone with a plurality of fixation clamps embodying the present invention in combination with an elongated plate secured in operative position on a fractured bone;

Fig. 6 is a top view of a fixation clamp according to a first alternate embodiment of the invention;

Fig. 7 is a top view of the fixation clamp shown in Fig. 6 operatively affixed to the bone of a patient;

Fig. 8 depicts an isometric cutaway view of a bone fixation clamp according to a second alternate embodiment of the invention;

Fig. 9 depicts an isometric cutaway view of a bone fixation clamp according to a third

alternate embodiment of the invention;

Fig. 10 depicts an isometric cutaway view of a bone fixation clamp according to a fourth alternate embodiment of the invention;

Fig. 11 depicts an isometric cutaway view of a bone fixation clamp according to a fifth alternate embodiment of the invention; and

Fig. 12 depicts an isometric cutaway view of a bone fixation clamp according to a sixth alternate embodiment of the invention.

Detailed Description

[0006] The present invention may be further understood with reference to the following description and the appended drawings, wherein like elements are referred to with the same reference numerals. The present invention relates to the treatment of fractured bones and, in particular, relates to a system and method for stabilizing a fractured or otherwise damaged bone by securing a bone fixation device to an outer surface thereof. The exemplary system and method according to the invention may be used for the fixation of fractures in a long bone (e.g., oblique fractures, transverse fractures, etc.) or to add strength and stability to a weakened bone (e.g., due to osteoporosis). An exemplary bone stabilization device according to the invention includes first and second clamp members having an arcuate shape conforming to an outer surface of a bone to which the first and second clamp members are to be attached. In one embodiment of the invention, the first and second clamp members may be removably attachable to one another such that the first and second clamp members are individually insertable into the body and over the bone in a target orientation. In another embodiment, the first and second clamp members are permanently attached to one another and permitted to move relative to one another within a predetermined range of motion. The first and second clamp members include respective attachment portions configured to interlock one another. The first and second attachment portions include a provisional attachment mechanism configured to provisionally hold the first and second clamp members together and permit a limited movement of the first and second clamp members relative to one another such that little or no compression is applied to the bone.

As will be described in greater detail later on, the provisional attachment mechanism may be one of a pivot joint, a sliding joint, a ratcheted joint or a threaded joint. The first and second attachment portions further comprise a locking mechanism configured to draw the first and second clamp members radially inward to apply a compressive force to the bone. The locking mechanism may be a screw configured for threaded insertion through respective holes in the first and second clamp members. In an operative configuration, once the first and second clamp members have been provisionally secured to the bone, the screw may be inserted through the respective holes to draw the first and second clamp members to a tightened configuration over the bone, radially compressing the bone. In another embodiment of the invention, a bone plate may be inserted over the bone prior to or after insertion of the first and second clamp members so that the first and second clamp members also secure the bone plate to the bone, as will be described in greater detail later on. It will be understood by those of skill in the art that although the exemplary embodiments specifically describe a device for a stabilization of a fractured long bone, the device of the present invention may be used for any bone through which it is desirable to secure the exemplary stabilization device.

[0007] As shown in Figs. 1 and 2, the present invention relates to a fixation clamp generally indicated as 10 to stabilize a spiral bone fracture 12 in an elongated tubular bone 14. The fixation clamp 10 comprises a first arcuate clamp member 16 and a second arcuate clamp member 18 (a pair of clamp members) pivotally coupled or hinged to each other by a hinge or pivot pin 20 operatively disposed in channels or holes 21 formed in each of the clamp members 16 and 18. A bias or spring 22 is disposed adjacent the hinge or pivot pin 20 to normally bias the first arcuate clamp member 16 and the second clamp member 18 in an open position relative to each other.

[0008] Each arcuate clamp member 16 and 18 includes a concave inner surface 24 having at least one spike-like element or protrusion 26 extending outwardly from each concave inner surface 24 to engage the surface of the bone 14 to secure the fixation clamp 10 in place. In addition, a plurality of pressure relief recesses or indentations each indicated as 28 is formed in

the concave inner surface 24 of each clamp member 16 and 18 to preserve the blood flow in the patient's limb when the fixation clamp 10 is secured in position.

[0009] As shown in Figs. 2 and 3, the fixation clamp 10 further includes an adjustment device generally indicated as 30 to tighten the arcuate clamp members 16 and 18 around the bone 14 forcing the spike-like elements or protrusions 26 into the surface of the bone 14. The adjustment device 30 comprises an externally threaded member 32 configured to be threaded through an internally threaded channel or portion 34 formed in the first arcuate clamp member 16 adjacent the hinge or pivot pin 20 and into an internally threaded portion or recess 36 formed in the second arcuate clamp member 18 adjacent the hinge or pivot pin 20 to tighten and secure the fixation clamp 10 in place around the bone 14.

[00010] The second arcuate clamp member 18 includes an upper plate or flange 37 and a lower plate or flange 39 disposed in spaced relationship relative to each other to cooperatively form a slot or opening 41 therebetween to receive an extension or tongue 43 including the internally threaded channel or portion 34 formed on the first arcuate clamp member 16. The fixation clamp 10 may further include at least one internally threaded aperture or channel 38 formed through one or both arcuate clamp members 16 and 18 to receive an externally threaded anchoring screw or fastener 40 screwed into the bone 14 to anchor the fixation clamp 10 in place.

[00011] Figs. 4 and 5 show the fixation clamp 10 in use as part of a fixation assembly. Specifically, in addition to the fixation clamp 10, the fixation assembly includes a bone plate generally indicated as 210 comprising an elongated plate member 212 having a plurality of internally threaded apertures each indicated as 214 formed along the length thereof and a trochanteric grip portion 216 formed on the upper end portion of the elongated plate member 212 having at least one internally threaded aperture 218 to receive a corresponding plurality of externally threaded screws or fasteners 40 to secure the bone plate 210 to the patient's bone 14 including the femur adjacent the hip prosthesis 218. At least one fixation clamp 10 is then

placed around the bone 14 and over the elongated plate member 212 of the bone plate 210 aligning the internally threaded aperture 38 of one of the pair of clamp members 16 and 18 with corresponding internally threaded aperture 214 to insert a corresponding anchoring screw or fastener 40 therethrough and into the bone 14.

[00012] Fig. 6 shows an alternate embodiment of the present invention. Specifically, the fixation clamp 10 comprises a first arcuate clamp member 16 and a second arcuate clamp member 18 (a pair of separate clamp members).

[00013] Each arcuate clamp member 16 and 18 includes a concave inner surface 24 at least one of which has at least one spike-like element or protrusion 26 extending outwardly from the concave inner surface 24 to engage the surface of the bone 14 to secure the fixation clamp 10 in place. In addition, at least one pressure relief recess or indentation 28 is formed in the concave inner surface 24 of at least one of the clamp members to preserve the blood flow in the patient's limb when the fixation clamp 10 is secured in position.

[00014] The fixation clamp 10 further includes an adjustment device generally indicated as 30 to tighten the arcuate clamp members 16 and 18 together around the bone 14 forcing the spike-like element or protrusion 26 into the surface of the bone 14. The adjustment device 30 comprises an externally threaded member 32 configured to be threaded through an internally threaded portion or channel 34 formed in the first arcuate clamp member 16 and into an internally threaded portion or recess 36 formed in the second arcuate clamp member 18 to tighten and secure the fixation clamp 10 in place around the bone 14.

[00015] As best shown in Fig. 7, the first arcuate clamp member 16 and the second arcuate clamp member 18 do not fully encircle the bone 14 leaving a space between the free or distal ends to insure continued circulation.

[00016] Fig. 8 depicts a clamp assembly 300 according to another embodiment of the invention. The clamp assembly 300 includes first and second arcuate clamp members 302, 304 positionable over a bone 14. The first clamp member 302 extends from a first end 306 along a first arm 308 to an arcuate body 310 which terminates in a second end (not shown). The first arm 308 extends linearly away from the arcuate body 308 along an axis which, when the assembly 300 is positioned as desired over a target portion of bone, extends substantially parallel to a diameter of the bone 14 across which a clamping force is applied by the first and second clamp members 302, 304. The first arm 308 includes an elongated first channel 312 extending thereinto from the first end 306 along a longitudinal axis 3L. A length of the channel 312 is selected to conform to a length of a locking screw 350 to be inserted therein in an operative configuration, as will be described in greater detail later on. The first channel 312 according to this embodiment includes threading 314 threadedly engaging threading on a shaft 356 of the locking screw 350.

[00017] The second clamp member 304 extends from a first end 318 along a second arm 322 distally to an arcuate body 326 terminating in a second end 320 which, in this embodiment, is configured to engage a bone plate and hold it in contact with a target portion of the bone 14. The second arm 322 includes a first surface 328 contoured to correspond to a portion of bone it is to contact. In this embodiment, as the bone 14 is generally cylindrical, the surface 328 is similarly curved. An outer surface 330 of the second arm 322 opposite the surface 328 extends substantially parallel to the longitudinal axis 3L. The second arm 322 includes second and third channels 332, 334 extending therethrough from respective first ends 333, 335 to a common second end 340. The second channel 332 extends along the longitudinal axis 3L and is dimensioned to slidably receive a portion of the first arm 308 therein. The third channel 334 extends along an axis 30L angled with respect to and intersecting the longitudinal axis 3L such that a set screw 360 inserted therethrough extends into the second channel 332. As will be described in greater detail with respect to the exemplary method below, a conical tip 370 of the set screw 360 passes through the third channel 334 to frictionally engage the outer surface 316 of the first arm 308 to provisionally hold the first and second arms 308, 322 together prior to

insertion of the locking screw 350 into the second channel 332.

[00018] The arcuate body 326 of the second arm 322 further comprises a relief recess or indentation 336 substantially similar to the relief recess 28 and configured to permit insertion of a bone plate 210 therethrough to be held against the bone 14, as described in greater detail with respect to earlier embodiments. As would be understood by those skilled in the art, the shape and size of the relief recess 336 may be modified to conform to the dimensions of the bone plate 210. The bone plate 210 may be any bone plate known in the art and may be selected to conform to the requirements of a target bone stabilization procedure. A portion of the arcuate body 326 at the relief recess 336 may include an opening 338 extending therethrough and configured to align with an opening in the bone plate 210 to optionally permit insertion of a bone fixation element (e.g., a bone screw) therethrough and into the bone, as those skilled in the art will understand.

[00019] In accordance with an exemplary method according to the invention, the first and second clamp members 302, 304 are positioned over a target portion of the bone 14 employing a known minimally invasive insertion device. Specifically, the first clamp member 302 may be removably attached to a manipulation instrument (not shown) which allows introduction and aids in positioning of the first clamp member 302 over the bone 14. The manipulation instrument (not shown) also guides insertion of the second clamp member 304 into the body and over the bone 14 to assemble the first and second clamp members 302, 304 to one another in-situ. As will be described in greater detail later on, the set screw 360 is positioned in the third channel 334 prior to insertion of the second clamp member 304 over the bone. Specifically, the set screw 360 may be initially housed in the third channel 334 in an insertion configuration in which the distal conical tip 370 does not intersect the second channel 332. In an exemplary embodiment the bone plate 210 is placed and locked to the bone 14 prior to the insertion of the clamp assembly 300. In another embodiment, the bone plate 210 is positioned between the relief recess 336 and the bone 10 after the clamp assembly has been provisionally secured to the bone. The first arm 308 is then slidably inserted into the end 340 and into the second channel 332 until engagement of the

arcuate bodies 310, 326 with an outer surface of the bone 14 prevents further movement. Frictional engagement between the outer surface 316 of the first arm 308 and the second channel 332 prevents the first and second arms 302, 304 from inadvertently disengaging one another. The set screw 360 is then tightened into the first end 335 of the third channel 334 until the conical tip 370 frictionally engages the outer surface 316 of the first arm 308 to provisionally secure the first and second clamp members 302, 304 to the bone 14. The set screw 360 extends from a first end 362 having a head 364 and along a shaft 366 to a distal end 368 having the conical tip 370. A portion of the shaft 366 includes threading 365 engaging threading on an outer surface of the third channel 334. Engagement of the head 364 with a reduced diameter portion 335 of the third channel 334 prevents the set screw 360 from applying excessive force to the first arm 308. Once the first and second clamp members 302, 304 have been provisionally locked over the bone 14, the manipulation instrument is removed from the body.

[00020] The locking screw 350 is then inserted into the first end 333 of the second channel 332. The locking screw 350 extends from a first end 352 having a head 354 and along a threaded shaft 356 to a distal end 358. Threading of the shaft 356 is configured to engage the threads 314 of the first channel 312. The head 354 is dimensioned to prevent insertion thereof into the second channel 332. In an operative configuration, as the locking screw 350 is driven through the second channel 332 and into the first channel 312, the first and second clamp members 302, 302 are drawn toward one another to apply a radially compressive force to the bone 14.

[00021] Fig. 9 depicts a clamp assembly 400 according to another embodiment of the invention. The clamp assembly 400 is formed substantially similarly to the clamp assembly 300 of Fig. 8, wherein like elements have been referenced with like reference numerals. The clamp assembly 400 includes the first and second clamp members 302, 304 including first and second arms 408, 422 substantially similar to the first and second clamp arms 308, 322. The clamp assembly 400 includes a locking screw 350 and a set screw 460 substantially similar to the locking screw 350 and the set screw 360. The set screw 460 extends from the first end 362 having the head 364 and

along a threaded shaft 366 to a distal end 368 having a threaded tip 470. The threaded tip 470 includes threading 417 at a pitch corresponding to threading on an outer surface 416 of the first arm 408. The pitch of the threaded tip 470 may be greater than a pitch of the threaded shaft 366. It is noted, however, that the threaded tip 470 and the threaded shaft 366 may each be formed with any thread pitch without deviating from the scope of the invention.

[00022] In an exemplary embodiment, a portion of an outer surface 416 of the first arm 408 includes threading 417 threadedly engaging the threaded tip 470 of the set screw 460. The threading 417 extends along a length of the first arm 408 and may be formed on only a portion of the outer surface 416 which, in an operative configuration, is open to the third channel 334. An outlying portion of the outer surface 416 separate from the threading 417 may be substantially smooth. In another embodiment of the invention, the outer surface 416 may include one of teeth, a geared surface, or the like to engage a corresponding structure provided on either a surface of the second channel 432 or a distal end of a set screw to form a ratchet mechanism, as those skilled in the art will understand.

[00023] In accordance with an exemplary method of use of the clamp assembly 400, the first arm 408 is slidably inserted into the second channel 332 until the arcuate bodies 310, 326 contact an outer surface of the bone 14. The set screw 460 is then screwed into the first end 335 of the third channel 334 until the threaded tip 470 threadedly engages the threading 417 on the outer surface 416 of the first arm 408. Specifically, as described in greater detail earlier with respect to the clamp assembly 300, the set screw 460 may be partially inserted into the third channel 334 prior to insertion of the second clamp member 304 into the body. The set screw 460 may subsequently be driven further into the third channel 334 such that mechanical interaction of the threaded tip 470 with the threading 417 provisionally holds the first and second arms 302, 304 in position over the bone 14. The locking screw 350 is then driven through the second channel 332 and into the first channel 312, threaded engagement between the threaded shaft 356 and the threads of the first channel 312 drawing the first and second clamp members 302, 302 toward one

another and applying a radially compressive force to the bone 14. As those skilled in the art will understand, the set screw 460 and the locking screw 350 may each need to be adjusted any number of times to achieve a desired tightening of the first and second arms 302, 304 over the bone 14. In an alternate embodiment, the locking screw 350 may be removed from the assembly 400 such that only the set screw 460 applies a compressive force to the bone 14.

[00024] The clamp assembly 500 shown in Fig. 10 is substantially similar to the clamp assembly 300 of Fig. 8, with like elements referenced with like reference numerals. The clamp assembly 500 includes first and second clamp members 302, 304 including first and second arms 508, 522. The second arm 522 includes the second channel 532 and a third channel 534. The second channel 532 is substantially similar to the second channel 332 and extends through the second arm 522 from a first end 533 to a second end (not shown) open to an end of the second arm 522. The third channel 534 extends through the second arm 522 from a first end 535 and along a longitudinal axis 5L substantially parallel to the axis 3L to a second end 537 within the second arm 522. The third channel 534 is dimensioned to receive therethrough a set screw 560 substantially similar to the set screw 360 but having a substantially blunt, non-threaded distal tip 380. The third channel 534 may include threading configured to threadedly engage a threaded shaft of the set screw 560.

[00025] The second arm 522 further includes a tab 550 therein intersecting the second and third channels 532, 534. The tab 550 extends from a first end 552 connected to an outer wall of the second arm 522 adjacent the second channel 532 to a free end 554 within the third channel 534. In a region intersecting the second channel 532, the tab 550 includes an opening 556 having an opening axis substantially aligned with the axis 3L to permit insertion of the first arm 508 therethrough. In a region intersecting the third channel 534, the tab 550 is substantially planar and is dimensioned to prevent the set screw 560 from moving therepast, as will be described in greater detail with respect to the exemplary method below. The tab 550 is attached only to the outer wall of the second arm 522 at the first end 552 and is therefore substantially deflectable

within a range selected to permit the tab 550 to apply a predetermined pressure on the first arm 508 in an operative configuration, as will also be described in greater detail below. The tab 550 further comprises an extension 558 configured and dimensioned to separate the free end 554 from the second end 537 of the third channel 534 by a predetermined distance, a length of the extension conforming to a permitted range of deflection of the free end 554.

[00026] In accordance with an exemplary method of use of the clamp assembly 500, the set screw 560 is partially inserted into the third channel 534 such that the blunt tip 570 is separated from the tab 550. The first and second clamp members 302, 304 are then inserted into the body such that the first arm 508 is slidably inserted into the second channel 532 and the arcuate bodies 310, 326 contact an outer surface of the bone 14. The set screw 560 is then advanced further into the third channel 534 until the blunt tip 570 abuts the tab 550. Further driving of the set screw 560 causes a deflection of the tab 550 toward the second end 537. The deflection causes the opening 556 of the tab 550 to apply a frictional force on the first arm 508 inserted therethrough sufficient to prevent the first arm 508 from moving relative to the second arm 522. Engagement of the deflected tab 550 with the second end 537 prevents the tab 550 from deflecting out of a predetermined range (i.e. to prevent a fracture of the tab 550 or damage to the first arm 508). The locking screw 350 (not shown) is then inserted through the second channel 532 and into the first channel 312 to draw the first and second clamp members 302, 302 together and apply a radially compressive force to the bone 14.

[00027] The clamp assembly 600 shown in Fig. 11 is substantially similar to the clamp assembly 300 of Fig. 8, wherein like elements are referenced with like reference numerals. The clamp assembly 600 includes first and second clamp members 302, 304 including first and second arms 608, 622. The first arm 608 is substantially similar to the first arm 608 and includes the channel 312 having threading 614. A cross-bore 615 extends through the first arm 608 along an elongated cross-bore axis extending substantially orthogonal to the longitudinal axis 3L of the first channel 612 from a first end 616 to a second end 617. In an exemplary embodiment, the

cross-bore 615 extends through both outer walls of the first arm 608 so that a pin (not shown) inserted therethrough and through a pin bore 690 effectively locks the first and second clamp members 302, 304 to one another, as will be described in greater detail later on. In another embodiment, however, the cross-bore 615 may extend through only one wall of the first arm 608 without deviating from the scope of the invention. In an exemplary embodiment, the cross-bore 615 has a length of approximately 30 ± 4 mm to define a corresponding range of movement of the first and second clamp members 302, 304 toward and away from one another.

[00028] The second arm 622 includes a second channel 632 extending therethrough and substantially similar to the second channel 332 of Fig. 8. A screw 660 is housed completely within the second channel 632 in an operative configuration. The screw 660 extends from a first end including a driver-engaging recess 662 and along an elongated threaded shaft 664 to a second end 666. The second channel 632 further includes a longitudinal slot (not shown) permitting a wall 680 to extending therethrough and into the second channel 632 to substantially bisect the second channel 632. The wall 680 extends from a first end 682 and includes a first wall portion 684 having a first height. In an exemplary embodiment, the first height is selected to prevent the screw 660 from moving therepast out of the second channel 632 while also permitting a driving mechanism (not shown) to be inserted therepast to permit driving of the screw 660. A second wall portion 686 of the wall 680 extending away from the first wall portion 684 is formed with a height selected to prevent extension thereof into the second channel 632. A length of the second wall portion 686 is substantially equivalent to a length of the screw 660 to permit the screw 660 to be seated between the first wall portion 684 and a third wall portion 688. The third wall portion 688 extends into the second channel 632 by a distance selected to prevent movement of the screw 660 therepast such that a pin bore 690 extending therethrough along an axis 6L aligns with the cross-bore 615. A diameter of the pin bore 690 is substantially equivalent to a diameter of a pin (not shown) inserted therethrough in an assembled configuration. Specifically, the pin (not shown) extends through the cross-bore 615 and pin bore 690 along the axis 6L and is permanently secured to the clamp assembly 600 (i.e., during manufacturing). The pin (not

shown) is axially movable along a length of the cross-bore 615, which defines a desired range of movement of the first and second clamp members 302, 304 relative to one another in a direction substantially perpendicular to a longitudinal axis of the bone 14.

[00029] The second clamp member 304 also comprises a third channel 634 extending into the arcuate body portion 326 separate from the relief recess 336. The third channel 634 is threaded and configured to engage a positioning tool (not shown) to provisionally clamp the clamp assembly 600 to the bone 14.

[00030] In accordance with an exemplary method of use of the clamp assembly 600, the positioning tool (not shown) is inserted through the third channel 634 to provisionally hold the assembly 600 over the bone 14. In a first insertion configuration, the pin (not shown) and pin bore 690 are positioned toward the first end 616 of the cross-bore 615 so that the first and second clamp members are moved radially away from one another to permit insertion thereof over the bone 14. A driving mechanism (not shown) is then inserted into the recess 662 to drive the screw 660 forward, causing the pin (not shown) to advance toward the second end 617 of the cross-bore 615. As described above, positioning of the screw 660 between the first wall portion 684 and the third wall portion 688 prevents loss of the screw 660 in soft-tissue of the body. This movement causes the first and second clamp members 302, 304 to move radially inward to apply a radially compressive force to the bone 14.

[00031] The clamp assembly 700 shown in Fig. 12 is substantially similar to the clamp assembly 300 of Fig. 8, with like elements are referenced with like reference numerals. However, whereas the clamp assemblies 300-600 are slidably brought into engagement with one another, the exemplary embodiment of Fig. 12 includes first and second clamp members 702, 704 pivotally attached to one another about a pivot axis of a pivot pin 706. The first and second clamp members 702, 704 are each substantially arcuate conform generally to a contour of an outer surface of the bone 14. The second clamp member 704 includes a relief recess 336 to house the

bone plate 210, as described in greater detail earlier. The pivot pin 706 may be permanently attached to the first and second clamp members 702, 704 (e.g., via a laser weld, etc.) to permit pivotal movement of the first and second clamp members 702, 704 relative to one another within a predetermined angular range.

[00032] The second clamp member 704 includes a channel 708 extending therethrough from a first end 710 to a second end 712. A portion of the channel 708 is threaded to threadedly receive a screw 750 therethrough. The screw 750 extends from a first end including a head 752 and along a threaded shaft 754 to a non-threaded, substantially blunted second end 756. In an exemplary embodiment, the channel 708 includes a first channel portion 714 having a first diameter and a second channel portion 716 having a second diameter smaller than the first diameter. The second channel portion 716 is dimensioned to prevent movement of the head 752 thereinto to define a maximum insertion depth of the screw 750 within the channel 708. In a first exemplary embodiment, the channel 708 is positioned adjacent an outer surface 718 of the second clamp member 704 so that the screw 750 is positioned laterally of the pivot pin 706. Insertion of the screw 750 into the channel 708 thereby applies a compressive force to an outer surface of the first clamp member 702 having an abutment 703, as will be described in greater detail with respect to the exemplary method below. In another embodiment (not shown), the channel 708 may be positioned adjacent a surface 720 of the second clamp surface configured to lie adjacent an outer surface of the bone 14 in an operative configuration, at least a portion of the surface 720 coming into direct contact with the bone 14. In this embodiment, the screw 750 inserted through the channel 708 may come into contact with a first portion of bone-contacting surface of the first clamp member 702. The first portion of the bone-contacting surface may be angled and dimensioned such that the force applied thereto by the screw 750 forces the first clamp member 702 to a radially compressive configuration over the bone 14. Those skilled in the art will understand that, alternatively, the screw 750 may extend into a threaded opening in the second clamp member 704 so that interaction between a threaded surface of the opening and the screw 750 pivots the second clamp member 704 relative to the first clamp member 702.

[00033] In one embodiment of the invention, the first and second clamp members 702, 704 may have a substantially uniform width and thickness. In another embodiment, portions of the first and second clamp members 702, 704 configured to directly contact the bone 14 in the operative configuration may have an increased thickness to increase a contacting surface area thereof with the bone 14. A free end 705 of the second clamp member 704 further comprises one or more plate holes 707 extending therethrough, the plate holes 707 permitting passage of bone screws (not shown) therethrough and into the bone 14. As those skilled in the art will understand, these bone screws (not shown) provide an additional mechanism to secure the assembly 700 to the bone 14.

[00034] In accordance with an exemplary method according to the invention, the first and second clamp members 702, 704 are positioned over a target portion the bone 14. The screw 750 may be pre-loaded onto the clamp assembly 700 prior to insertion thereof into the body (i.e., in a retracted position in which the second end 756 does not extend out of the second end 712 of the channel 708 or is otherwise separated from an abutment 703). In another embodiment, the screw 750 may be inserted into the body after the clamp assembly 700 has been provisionally positioned over the bone 14. In an exemplary embodiment, the assembly 700 may include a biasing member (e.g., a spring-loaded element) biasing the first and second clamp members 702, 704 toward a radially expanded configuration to aid in positioning of the clamp assembly 700 over the bone 14. As those skilled in the art will understand, the first and second clamp members 702, 704 may be pivoted through a predetermined range of angles relative to one another prior to insertion of the screw 750 to permit insertion of the clamp assembly 700 over the bone 14, a maximum opening angle of the first and second clamp members 702, 704 being an angle at which the abutment 703 contacts the second end 712 of the opening 708. The screw 750 may then be advanced into the channel 708 until the distal end 756 contacts an abutment 703 extending from the first clamp member 702. As the screw 750 is advanced, engagement of the distal end 756 with the abutment 703 forces the first clamp member 702 to pivot about the pin

706 closing the first and second clamp members 702, 704, respectively, over the bone 14 and increasing a compressive hold of the clamp assembly 700 on the bone 14.

[00035] It will be apparent to those skilled in the art that various modifications and variations can be made in the structure and the methodology of the present invention, without departing from the spirit or the scope of the invention. Thus, it is intended that the present invention cover the modifications and the variations of this invention provided that they come within the scope of the appended claims and their equivalents.

What is claimed is:

1. A bone fixation clamp, comprising:

a first arcuate clamp member conforming to a shape of a target portion of a bone and extending between a first connection end and a first free end; and

a second arcuate clamp member conforming to a shape of the target portion of the bone, a second connection end of the second clamp member being pivotally attached to the first connection end of the first clamp member, the second clamp member extending between the second connection end and a second free end;

a driving member received in the first clamp member passing out of the first clamp member to abut an abutment portion of the second member so that, as the driving member is extended further out of the first member, the driving member pivots the second clamp member relative to the first clamp member to draw the first and second free ends toward one another to apply a radially compressive force to the bone.

2. The bone fixation clamp of claim 1, wherein the first and second clamp members are connected to one another by a pin and are pivotable about a pin axis of the pin.
3. The bone fixation clamp of claim 2, wherein the pin is laser welded to the first and second clamp members.
4. The bone fixation clamp of claim 1, wherein the driving member is received within a channel extending through the first clamp member along a channel axis extending substantially orthogonal to a longitudinal axis of the bone.

5. The bone fixation clamp of claim 4, wherein a portion of the channel is threaded to threadedly engage threads of the driving member.
6. The bone fixation clamp of claim 4, wherein the abutment portion extends out of the second clamp member to intersect the channel axis.
7. The bone fixation clamp of claim 6, wherein a free end of the driving member is substantially blunt.
8. The bone fixation clamp of claim 4, wherein a portion of the channel has a reduced diameter, the reduced diameter engaging an enlarged diameter portion of the driving member to prevent insertion of the driving member therebeyond.
9. The bone fixation clamp of claim 1, further comprising a relief recess formed on one of the first and second clamp members, the relief recess being configured to receive a bone plate therein such that, when the first and second clamp members are secured to the bone, the bone plate is fictionally held against the bone.
10. The bone fixation clamp of claim 9, wherein the relief recess includes an opening extending therethrough, the opening aligning with a bone plate hole extending through the bone plate to permit insertion of a bone fixation element therethrough and into the bone.
11. The bone fixation clamp of claim 1, wherein the first and second clamp members are biased to a radially expanded configuration.
12. A bone fixation clamp, comprising:

a first arcuate clamp member conforming to a shape of a target portion of a bone and extending between a first end having a first connection portion to a first free end, the first connection portion having a first channel extending therethrough; and

a second arcuate clamp member conforming to a shape of the target portion of the bone and extending between a second end having a second connection portion and a second free end, the second clamp member having a second channel extending therethrough, the first connection portion being slidably received within the second channel along an attachment axis; and

a first driving member received in the second channel and passing into the first channel so that, as the first driving member is inserted into the first channel, the first clamp member is drawn toward the second clamp member along the attachment axis to draw the first and second free ends toward one another to apply a radially compressive force to the bone.

13. The bone fixation device of claim 12, wherein the first connection portion engages the second channel with a friction fit.
14. The bone fixation clamp of claim 12, wherein the second clamp member includes a third channel extending therethrough along a third channel axis.
15. The bone fixation clamp of claim 14, wherein the third channel axis intersects a second channel axis of the second channel and wherein a set screw is insertable into the third channel such that a free end of the set screw engages an outer surface of the first connection portion to inhibit slidable movement thereof within the second channel.
16. The bone fixation clamp of claim 15, wherein the free end of the set screw is threaded to

receive corresponding threads on the outer surface of the first connection portion.

17. The bone fixation clamp of claim 15, wherein the free end of the set screw is contoured at an angle selected to permit engagement thereof with the outer surface of the first connection portion.
18. The bone fixation clamp of claim 14, wherein the third channel axis extends substantially parallel to a second channel axis of the second channel.
19. The bone fixation clamp of claim 18, wherein the second connection portion includes a deflectable tab extending from a base disposed within the second channel to a free end disposed within the third channel, the tab including an opening to permit insertion of the first connection portion therepast in the second channel and having a wall preventing insertion of a set screw therepast in the third channel, such that the set screw inserted into third channel contacts the wall of the tab to cause a deflection thereof, the deflection causing the tab to apply a frictional force to the first connection portion to provisionally lock a position of the first and second clamp members relative to one another.
20. The bone fixation clamp of claim 12, wherein the first clamp member is connected to the second clamp member by a pin.
21. The bone fixation clamp of claim 20, wherein the first connection portion includes an elongated slot configured to receive a wall of the second connection portion therethrough, the wall extending into the second channel by a predetermined distance selected such that a pin bore formed in the wall aligns with a pin slot formed in the first connection portion, wherein the pin extends through the pin slot and the pin bore to secure the first clamp member to the second clamp member and wherein the pin slot limits movement of the first and second clamp members relative to one another within a predetermined range

equivalent to a length of the pin slot.

22. The bone fixation clamp of claim 22, wherein the wall includes a recess configured to house the driving member therein and prevent disengagement thereof from the second channel.
23. The bone fixation clamp of claim 21, wherein the third channel axis intersects the bone, the third channel being dimensioned to permit insertion of a provisional locking tool thereinto to hold the clamp against the bone.
24. The bone fixation clamp of claim 12, further comprising a relief recess formed on one of the first and second clamp members, the relief recess being configured to receive a bone plate therein such that, when the first and second clamp members are secured to the bone, the bone plate is fictionally held against the bone.
25. The bone fixation clamp of claim 24, wherein the relief recess includes an opening extending therethrough, the opening aligning with a bone plate hole extending through the bone plate to permit insertion of a bone fixation element therethrough and into the bone.

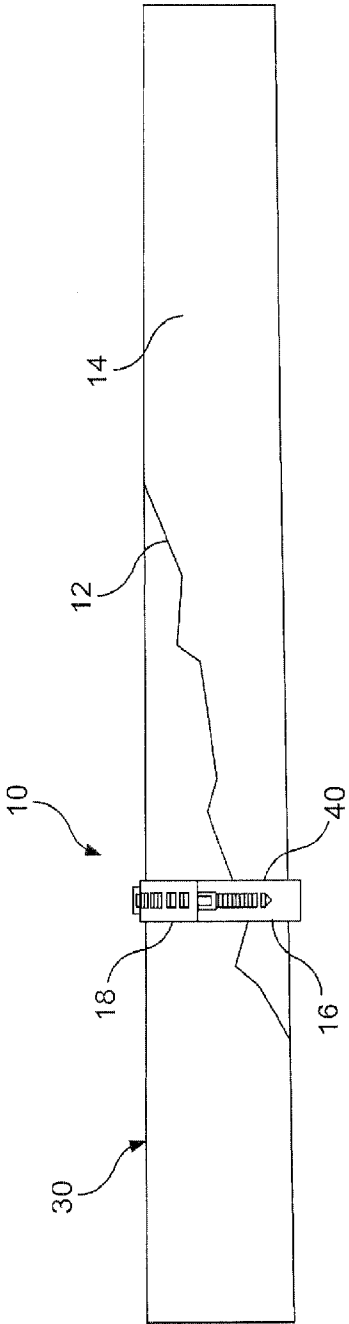
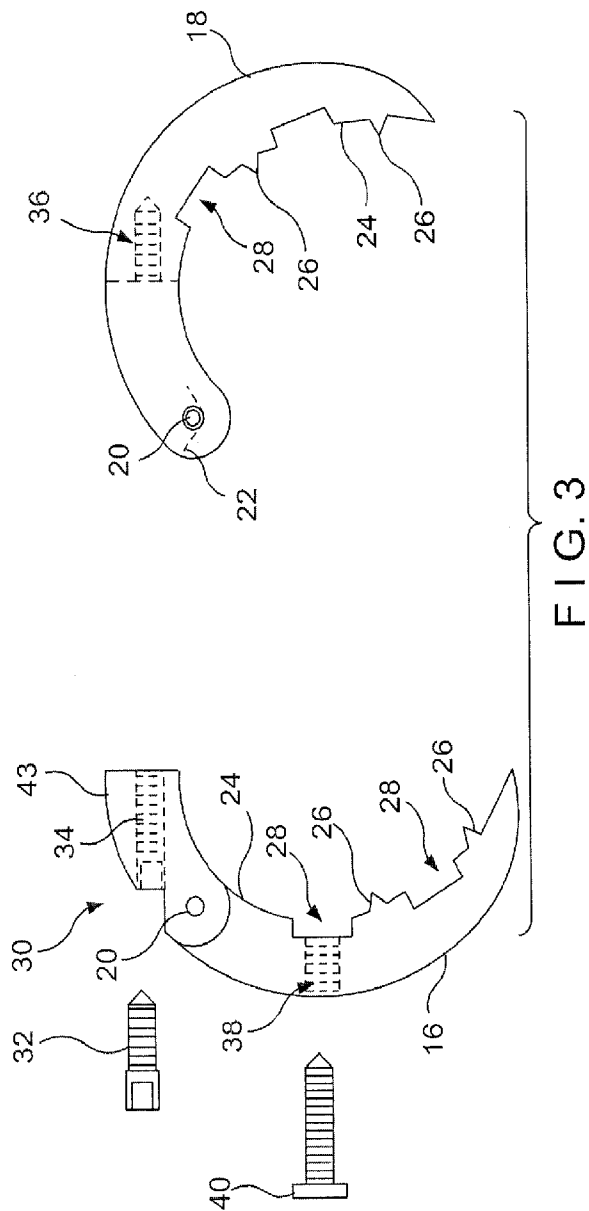
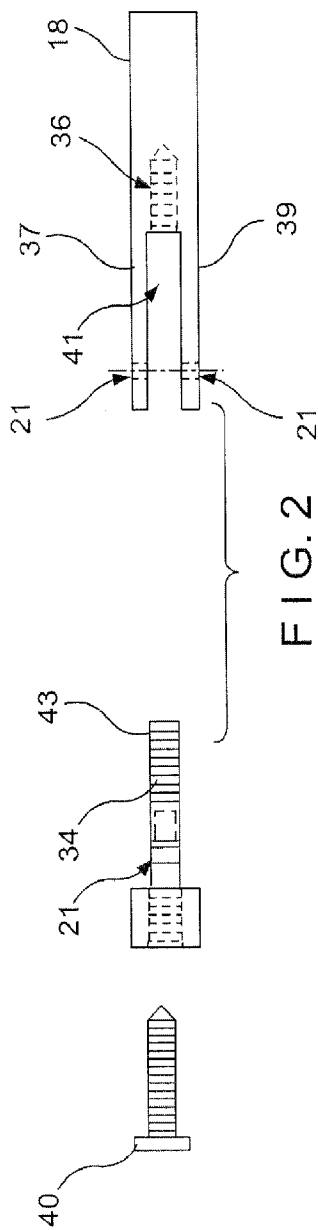


FIG. 1



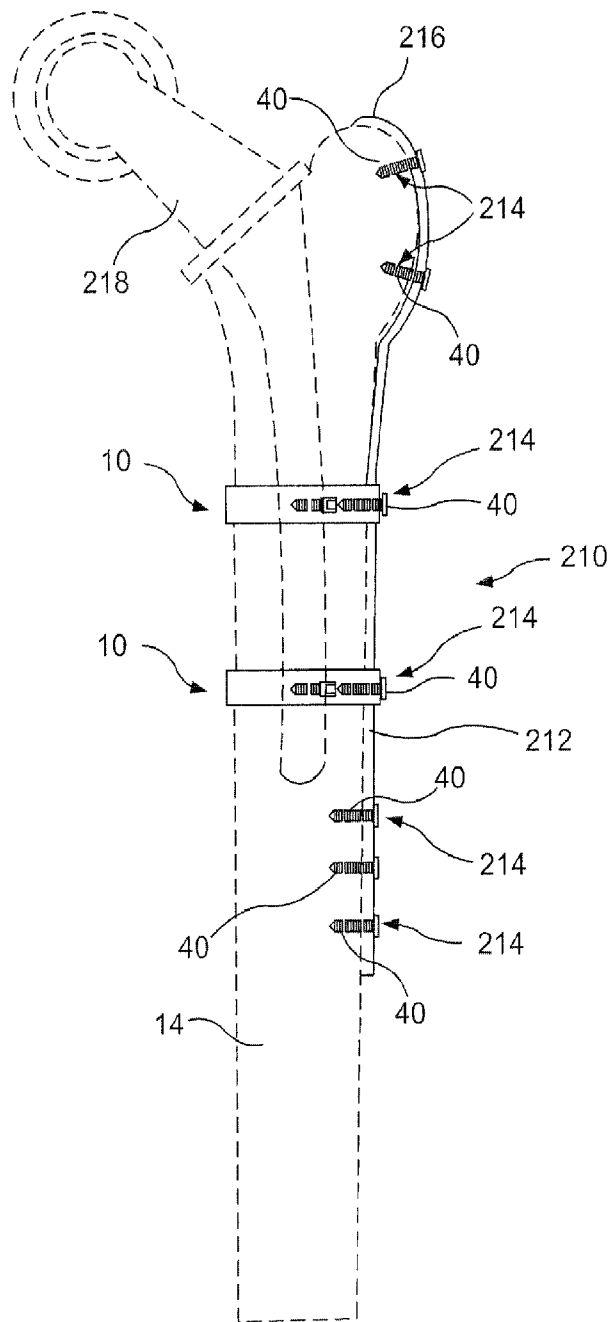


FIG. 4

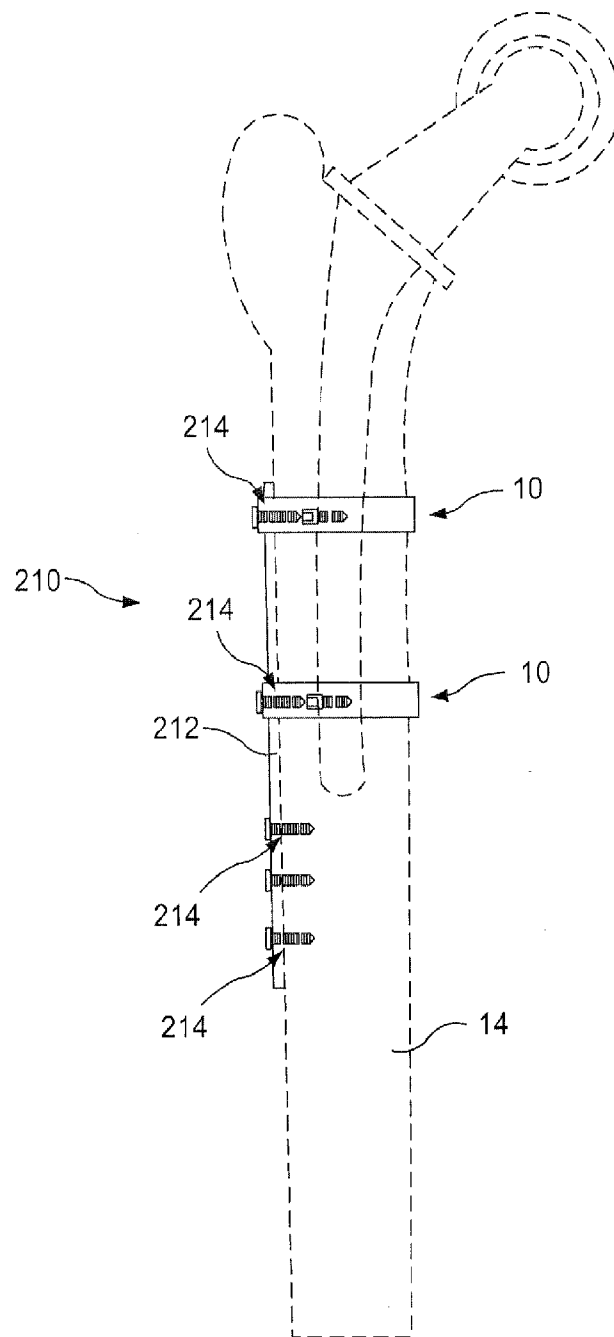


FIG. 5

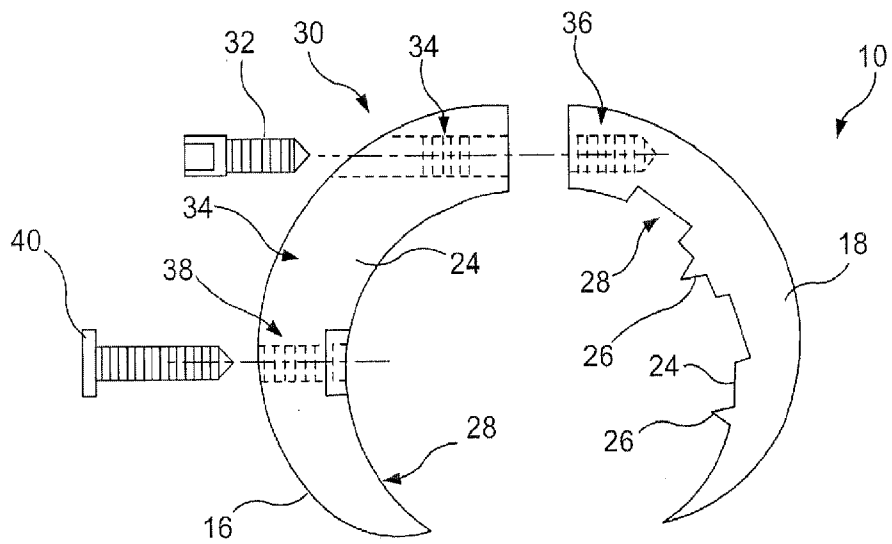


FIG. 6

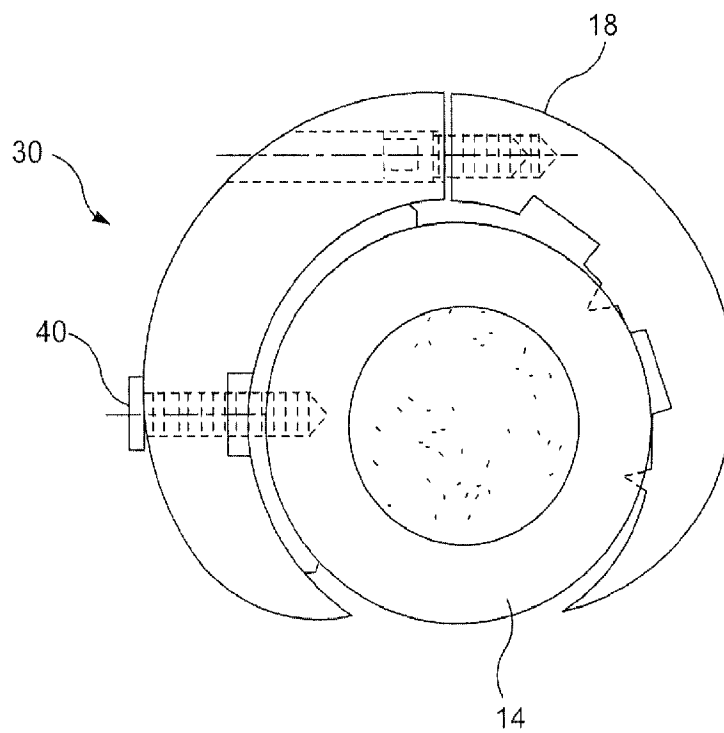


FIG. 7

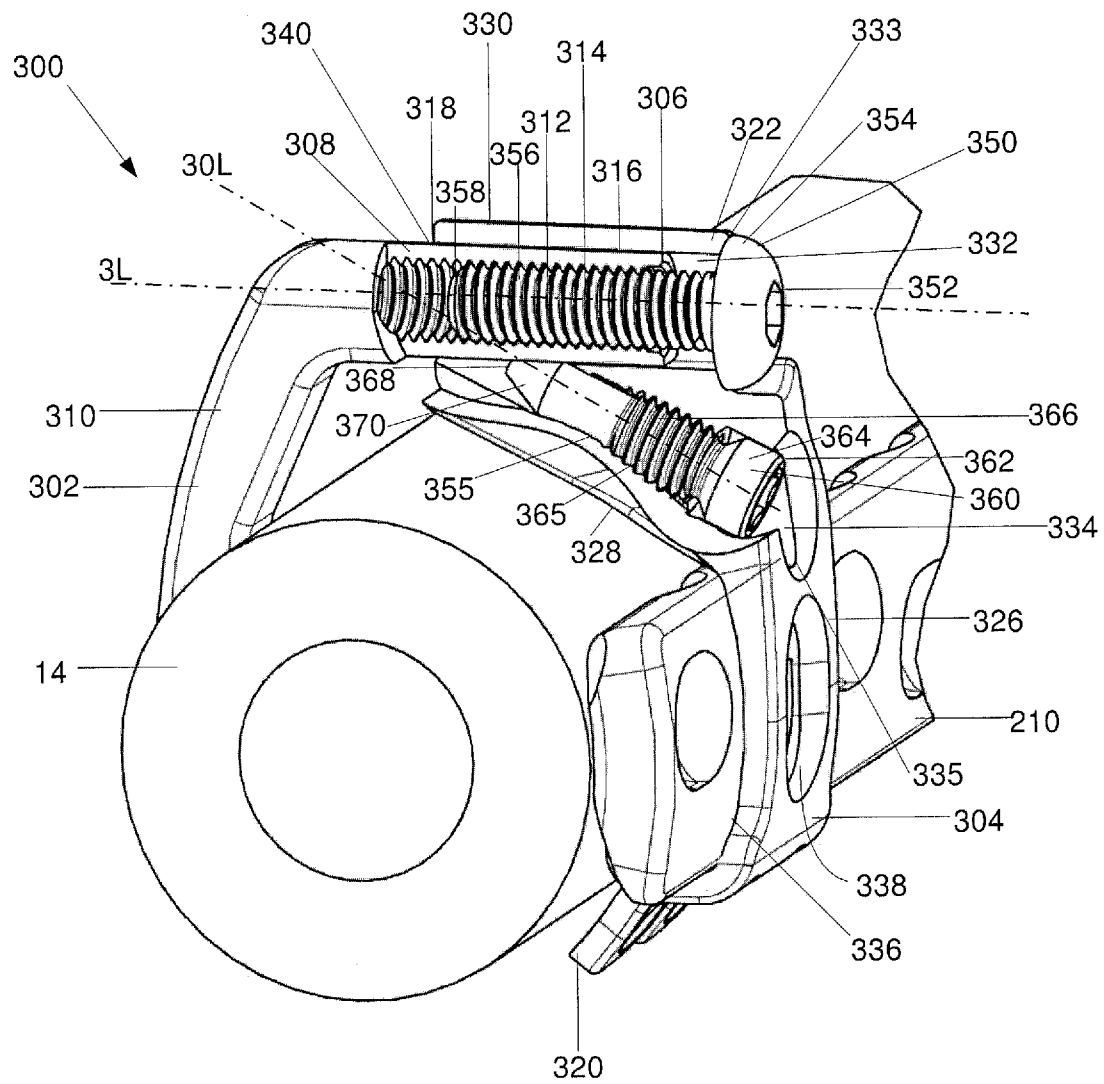


FIG. 8

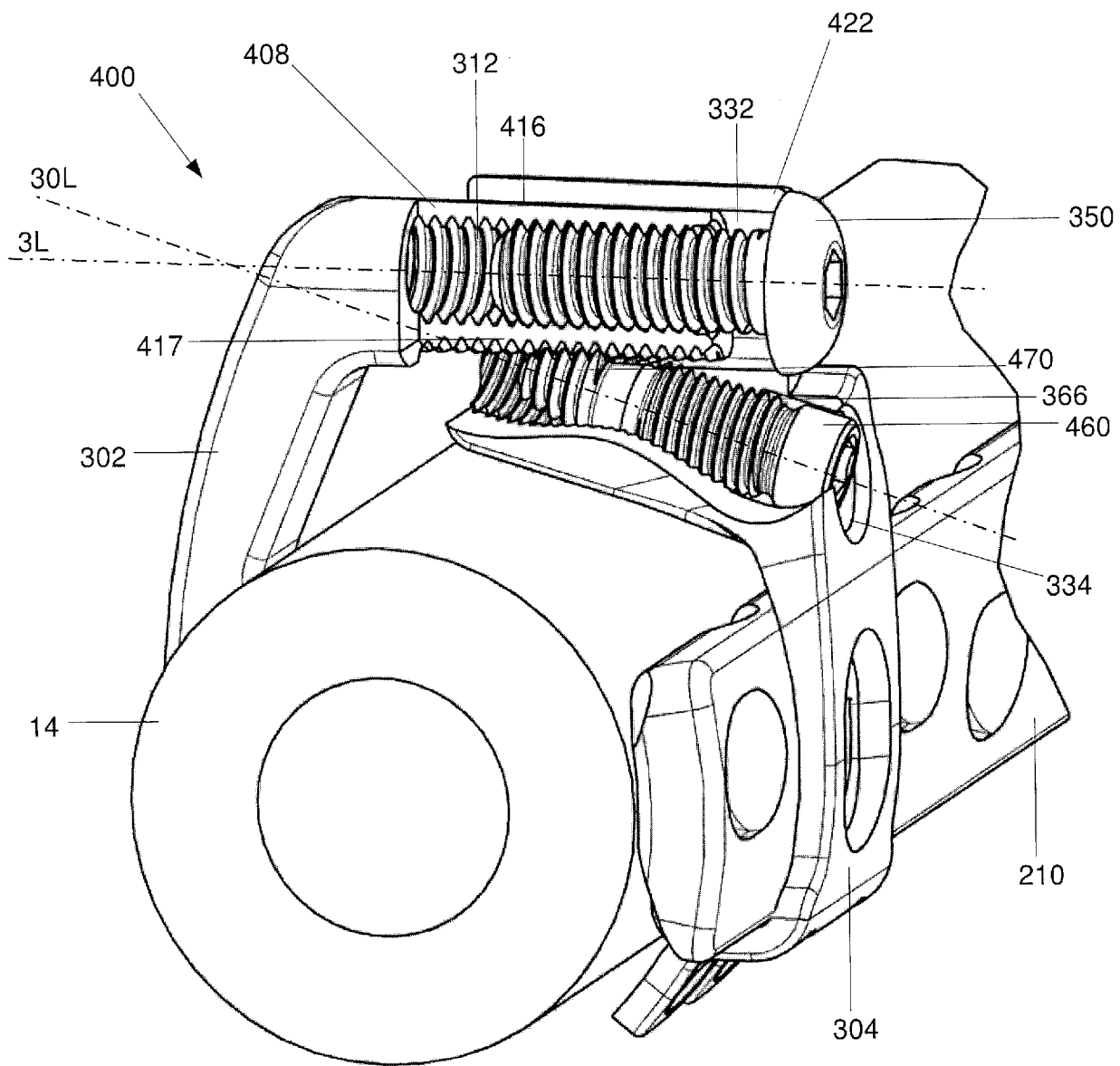


FIG. 9

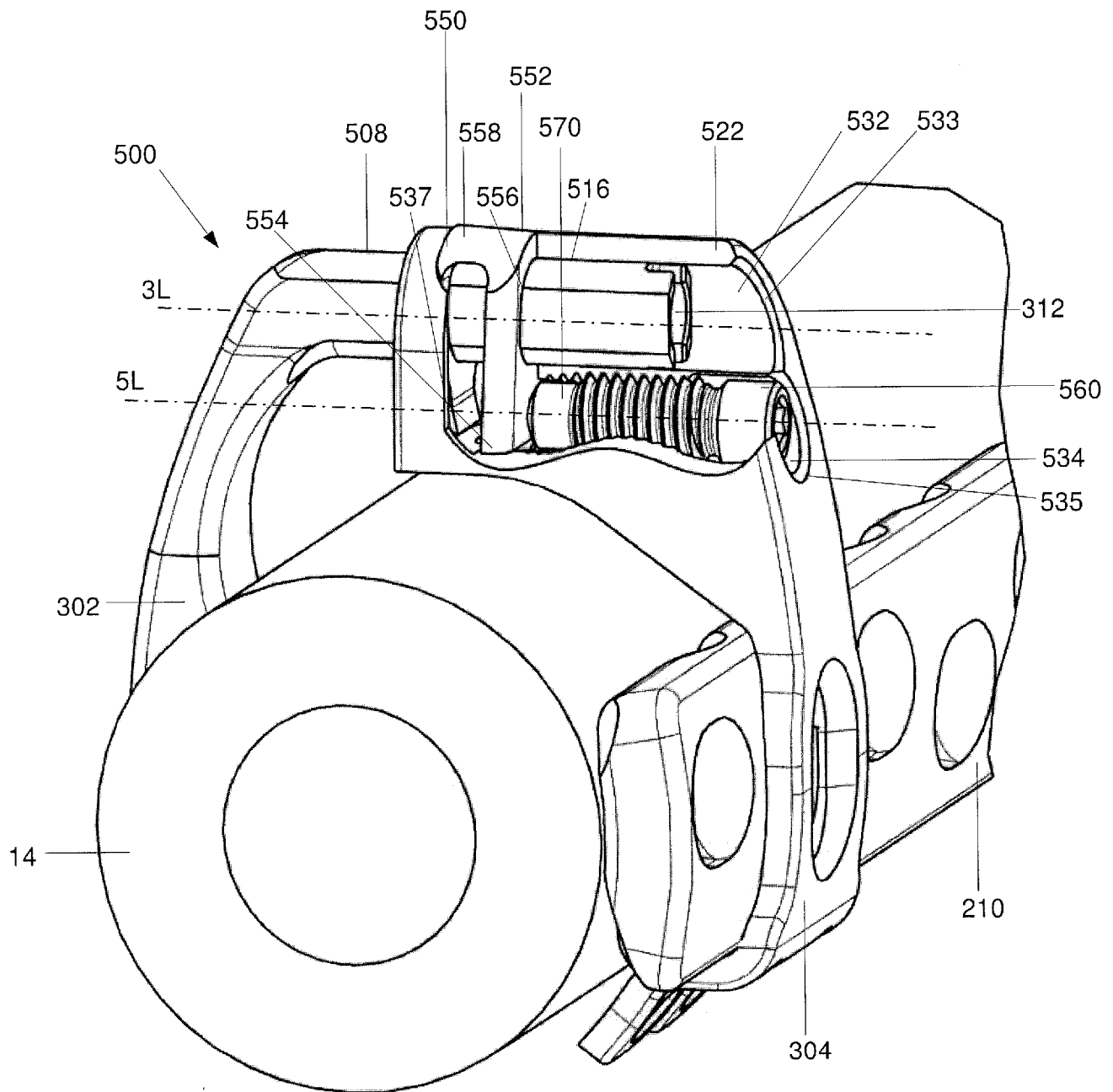


FIG. 10

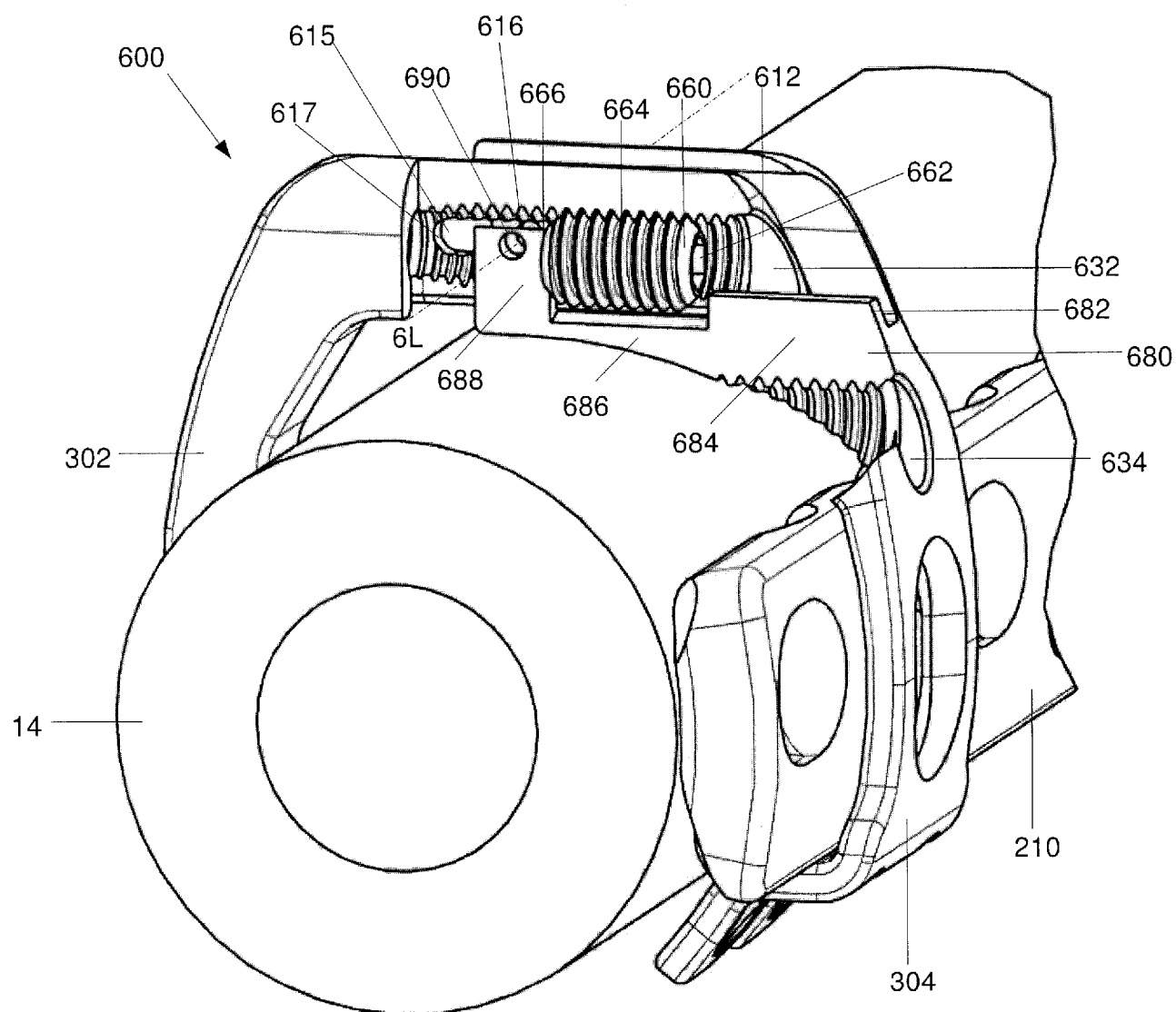


FIG. 11

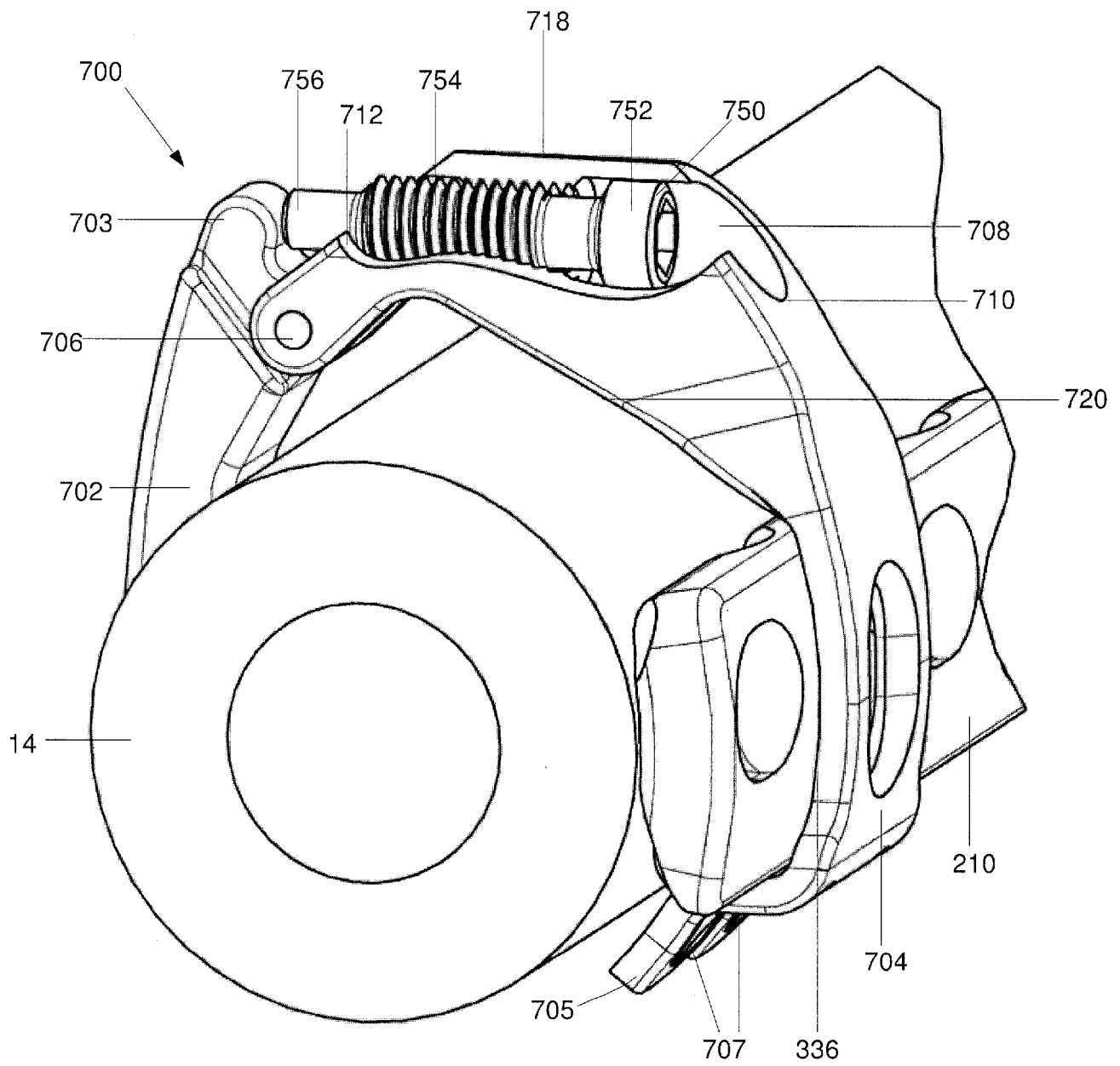


FIG. 12

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2012/037304

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B17/82 A61B17/68
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A61B

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6 051 007 A (HOGENDIJK MIKE [US] ET AL) 18 April 2000 (2000-04-18) figures 14, 14a	12
A	JP 11 347046 A (KOBE STEEL LTD) 21 December 1999 (1999-12-21) figure 1	1-11



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

2 August 2012

Date of mailing of the international search report

08/10/2012

Name and mailing address of the ISA/

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Authorized officer

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2012/037304

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

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

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

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

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

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-12

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-12

A bone fixation clamp having two arcuate clamp members pivotally attached to one another and a driving member adapted to pass out of the first clamp member to abut the second clamp member to apply a radially compressive force to the bone (claim 1), for solving the problem of providing a more secure attachment of the clamp on the bone.

2. claim: 13

A bone fixation clamp according to claim 12, wherein the first connection portion engages the second channel with a friction fit, for solving the problem of easily fixing the two clamp members with respect to each other before the driving member is driven and compression is applied to bone.

3. claims: 14-19

A bone fixation clamp according to claim 12, wherein the second clamp member includes a third channel (claim 14), thereby solving the problem of allowing the first connection portion to be more securely fixed within the second channel.

4. claims: 20-23

A bone fixation clamp according to claim 12, wherein the two clamp members are connected to each other by a pin (claim 20), thereby solving the problem of limiting the sliding movement of the first connection portion in the second channel (actually this effect is achieved in combination with the slot of claim 21, which has been understood as an essential feature of the clamp of claim 20, and therefore implicitly present therein).

5. claims: 24, 25

A bone fixation clamp according to claim 12, further comprising a relief recess (claim 24), thereby allowing a bone plate to be previously mounted onto the bone and thereby better repairing a bone fracture.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2012/037304

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 6051007	A	18-04-2000	NONE

JP 11347046	A	21-12-1999	JP 3608943 B2 12-01-2005
		JP 11347046 A	21-12-1999
