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Forsythe et al.

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[54] **BONE FRACTURE COMPRESSION DEVICE AND METHOD OF USAGE**

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[52] **U.S. Cl.** .... **128/92 R,** 128/92 D

[51] **Int. Cl.** **A61f 5/04**

[58] **Field of Search**.. 128/92 R, 92 D, 92 B, 92 EC, 128/92 BC, 83

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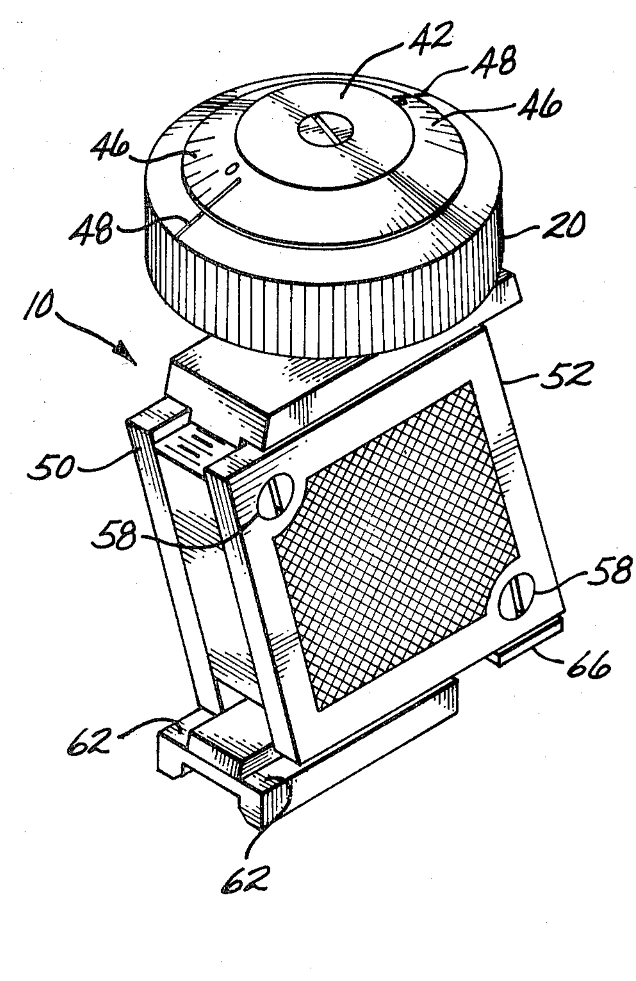
[57] **ABSTRACT**

Apparatus and method for applying controlled compressive forces to a bone fracture via a bone fracture plate is described. Means are provided for applying a predetermined compressive force to the fracture situs. The method comprises the steps of firmly fastening one end of a bone plate to one segment of a fractured bone adjacent the fracture, placing a bone engaging screw through a longitudinal slot in the bone plate adjacent the second bone fragment, drawing the bone segments firmly together by use of the compression device of this invention to exert a predetermined compression force across the bone fracture, inserting a second bone engaging screw through the bone plate to firmly attach the bone plate to the second bone segment and finally tightening the first placed bone engaging screw in the second bone.

7 Claims, 7 Drawing Figures



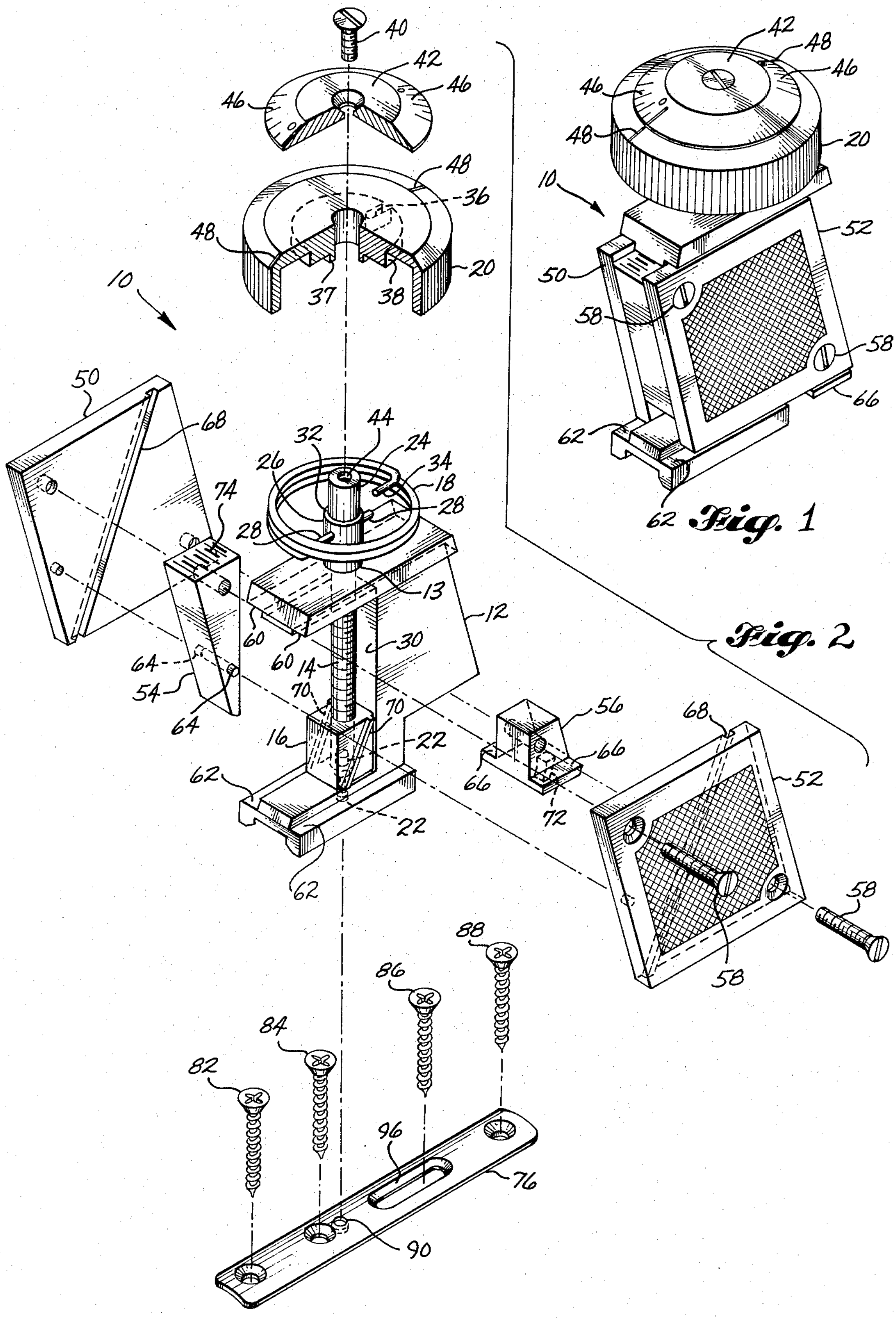

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Fig. 1

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Fig. 2

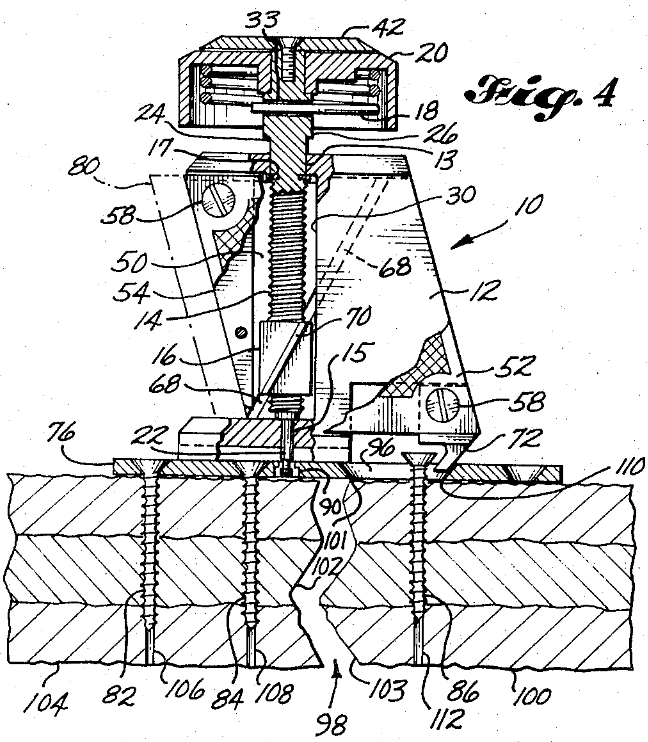


Fig. 4

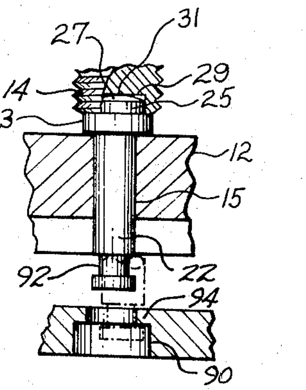


Fig. 5

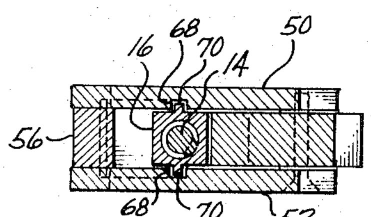


Fig. 3

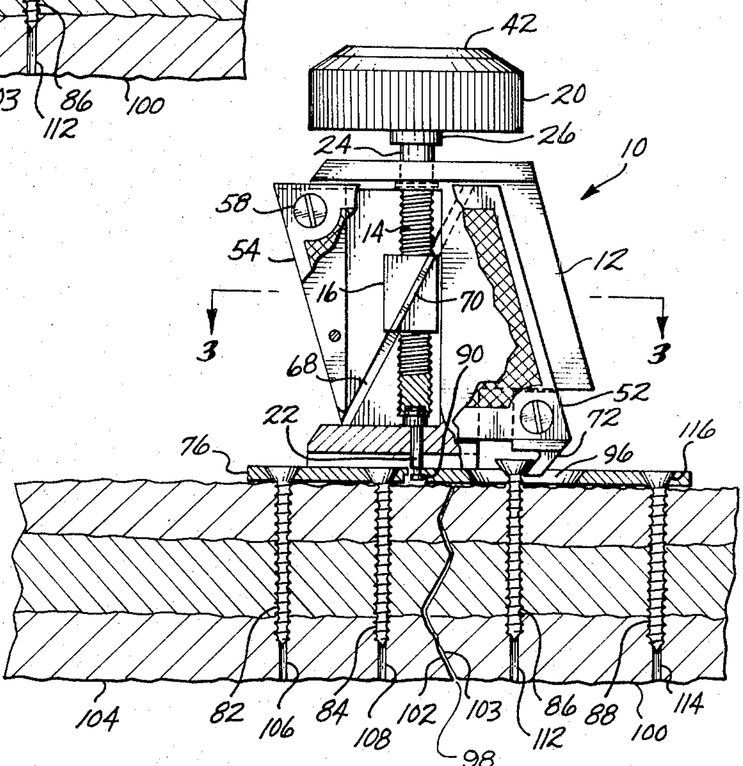
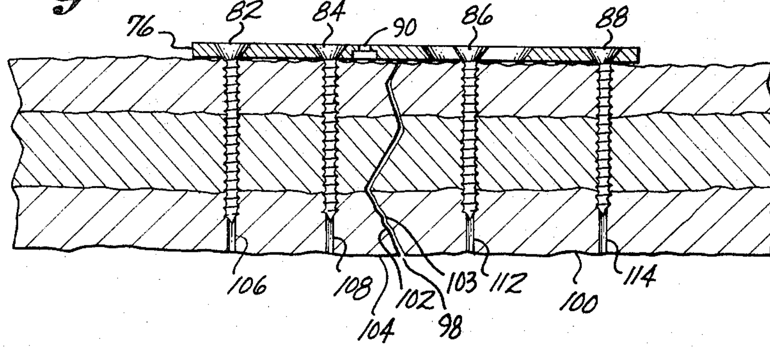


Fig. 6

Fig. 7



BONE FRACTURE COMPRESSION DEVICE AND METHOD OF USAGE

BACKGROUND OF THE INVENTION

This invention relates to apparatus and method for emplacing a bone fracture compression plate and further relates to a novel method of applying a predetermined compression to a bone fracture site spanned by a bone plate.

PRIOR ART

In the treatment of bone fractures a bone engaging plate is frequently used, especially in the veterinary medicine practice in which a plurality of bone screws are inserted through apertures in the plate after the plate has been placed adjacent the bone spanning the fracture area. The plate serves to rigidly hold the proximal and distal bone segments in the appropriate position for healing by natural body process. In one device long-known to the prior art the bone plate has an elongated slot for slidably receiving the shank of one of several bone screws. A compression unit is utilized to draw the proximal and distal bone segments together and is utilized by inserting one of the bone screws positioned in the proximal segment of the fractured bone through a first element of the compression device, thus, anchoring it with respect to the bone plate and to the proximal segment of the fractured bone. A moveable portion of the compression device is inserted into a special countersunk head end of a specially designed bone screw inserted into the slotted screw-receiving aperture in the distal bone segment engaging portion of the bone plate. The compression device is then drawn together by rotation of a threaded shaft member standing between the two above-mentioned portions of the compression device, thus drawing together the distal and proximal segments of bone. The structure of this device requires the usage of a separate wrench to accomplish a sufficient compression across the fracture interface.

After the distal and proximal segments of bone are drawn together, several additional screws are then placed in the distal portion of the fractured bone through the bone plate and tightened into place. The compression unit is removed by removing the bone screw holding it in place and then returning the bone screw to its operative position. The special screw utilized in the elongate slot screw aperture is removed and replaced by an ordinary bone screw. A substantial amount of the surgeon's time is thus consumed by the need to emplace and remove special screws during the attachment and removal of the compression device. The need to use a separate wrench to operate the compression device has been found to be a source of delay during a bone setting operation since the wrench is easily misplaced.

Another well-known compression device and method requires the usage of a longer special type of anchor screw inserted through the bottom of the compression device through the slotted aperture of the bone plate and then into the bone segment opposite the segment to which the plate is attached. This special screw must be replaced by an ordinary bone screw after compression of the fracture site. This system utilizes a hook means which engages one of the bone screw apertures adjacent the end of the proximal segment of the fractured bone. When the tightening is completed, additional screws are inserted into the distal portion of bone to hold the plate in place for removal of the compression device. This system, in addition to suffering from the need to emplace and replace specialized anchor screws and requiring the use of a wrench element to tighten the compression device, additionally requires the usage of a bone plate having preferably six or more bone screw apertures therein so that the proximal and distal elements of the bone may be held in alignment during the compression of the fracture.

Still another compression device, similar to that just described, is mounted directly on the bone with an anchor screw. This type of device is utilized in a method in which the bone plate, positioned to span the fracture, is secured to the distal bone segment with several screws. The device is then anchored with a bone screw on the proximal bone segment a predetermined distance from the end of the bone plate. The hook means of the device is then made to engage the end screw hole in the plate. The screw jack mechanism of the device is then made to apply compressive force at the fracture site by drawing the plate and attached distal bone segment toward the proximal segment. When desired compression is achieved, a screw is installed through the plate into the proximal bone segment to maintain compression while the device is disengaged from the plate. A screw is then installed in the end screw hole to complete the installation. The anchor screw securing the device is then removed and the assembly is removed from the bone. The obvious drawback to this method is the additional bone damage inflicted by the temporarily installed device anchoring screw.

The need in each of the known prior art bone plate compression systems and devices to use specially formed bone screws in the bone for the purpose of compressing the fracture and then replacement by ordinary bone screws is a time consuming operation. In addition the holding power of the screws is decreased due to the repeated insertion and removal of the screws in the bone structure. The prior art devices also require the usage of a special wrench separate from the compression device. The wrench, being separable from the compression unit, is inconvenient and may become misplaced resulting in valuable time lost in finding the wrench or seeking a replacement.

Further, no compression device of the prior art has any means other than experience or natural feel for determining the amount of force actually applied to the fracture site, even though compression force has a significant effect on rapidity and effectiveness of healing. Excessive force can cause pressure necrosis and prevent healing while too little force will retard healing and may permit refracture.

It is therefore an object of this invention to provide a bone fracture compression device and method which eliminates the need for special bone screws for operation but rather uses only the ordinary bone screws which remain at the fracture site upon completion of the emplacement of the bone compression plate.

It is a second object of this invention to provide a bone fracture compression device for use with bone compression plates which is self-contained and does not require use of a separate wrench or other adjusting means.

It is another object of this invention to provide a bone compression device which provides the surgeon with a direct indication of compression applied to the fracture.

SUMMARY OF THE INVENTION

A bone fracture compression method which permits the surgeon to accurately control the amount of compression placed upon the fracture line between the distal and proximal bone segments of a bone fracture is described herein. The device is utilized with a bone compression plate having means to engage a first portion of the device and having a longitudinal elongate slot adapted to slidably receive a bone engaging screw. Additional bone screw receiving apertures are positioned in the bone plate for emplacement of bone engaging screws in distal and proximal bone fracture segments. A depending hook means attached to a second portion of the compression device is adapted to engage the bone-engaging screw positioned in the elongate slot. The device includes means to cause relative motion between the first and second portions including means to measure the amount of force exerted in such movement. The above-described bone compression plate attached by two or more bone engaging screws to a distal segment of a fractured bone and by a single screw through the elongate slot into a proximal segment of the fractured bone may be used to draw the bone segments together into compressive contact with the above-described bone compression device. Force measuring means to indicate the force applied between the two portions of the bone compression device provides the surgeon with a direct indication of the amount of compressive force applied to the fracture site. Upon achieving the desired compressive force at the fracture site, at least one additional bone engaging screw is inserted through a bone screw receiving aperture in the compression plate and into the proximal end segment of the bone fracture. The bone compression device is then removed from the bone plate simply by releasing the pressure applied between the protruding portion and the hook means and lifting the device out of engagement with the bone plate. The bone plate remains in place with the applied compressive force across the fracture site remaining for proper healing of the bone. The bone screw residing in the elongate slot in the bone compression plate is then tightened and the incision repaired by well known surgical techniques. By using the bone compression device and the method taught herein it is unnecessary to use bone screws having a specially formed head or other special bone-engaging means but rather the ordinary typical bone screws widely utilized by surgeons are suitable for use with this invention.

BRIEF DESCRIPTION OF THE DRAWINGS

Further objects and advantages of this invention will become evident with a reading of the ensuing description of the preferred embodiment which makes reference to the accompanying drawings in which:

FIG. 1 is an isometric view of a compression device used in orthopedic surgery for repair of bone fractures by internal fixation.

FIG. 2 is an exploded isometric view of the device illustrated in FIG. 1 and includes an illustration of a typical bone plate with which the device is used.

FIG. 3 is a cross-sectional view of the device taken along lines 3—3 of FIG. 6, illustrating the interface between the drive portion and the slidable output portion.

FIG. 4 is a side elevation view of a compression device positioned on a bone compression plate prior to fracture compression.

FIG. 5 is a partial cross-section illustrating the manner in which the drive shaft pin extension engages the bone plate.

FIG. 6 is a side elevation view partly in section, of the compression device positioned on a bone compression plate after fracture compression on the bone ends of the fracture.

FIG. 7 is a cross-sectional view of a completed bone compression plate installation prepared according to the teachings of this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The Figures illustrate a compression device **10** used during orthopedic surgery in the repair of bone fractures by internal fixation and the method in which the compression device **10** in conjunction with a bone plate **76** is used. The compression device **10** functions to draw bone segments **100** and **104** into engagement at fracture site **98** and permanently fasten the bone segments together in compression to promote repair and healing of the fracture. The device applies a measurable compressive force at the fracture and holds the fracture under the desired compressive force until bone plate installation can be completed by the surgeon. The compression of the bone segments at the fracture is then maintained by the bone plate **76** to promote healing. The device is reliably simple and is reusable. Its simplicity allows easy assembly and disassembly for cleaning and sterilization purposes.

The main structural feature of the device **10**, as shown in FIGS. **2**, **4**, and **5** includes the frame **12** which provides the fixture upon which function components are mounted, spaced and otherwise interrelated. The adjustment linkage through which the device **10** is operated includes a threaded shaft **14**, slide block **16**, torque spring **18**, and knurled knob **20**. A cam means such as the slide block **16** is internally threaded and receives the threaded shaft **14**. The shaft **14** is rotatably mounted in the frame **12** at the upper shaft bearing **13** with the lower shaft bearing provided at the interface with pin extension **22**. The pin extension **22** is press fit into an opening **15** in the base portion of the frame **12** and has on the uppermost end a radial flange **23** which seats against the frame **12** and a bearing segment **25** which is crowned by a convex bearing surface **27**. A recess **29** in the lower end of the threaded shaft **14** rotatably seats over the bearing segment **25** such that the flat innermost face of the recess rests on the convex bearing surface **27** thereby providing a low-friction bearing interface at the point of tangency. The shaft **14** is restrained from longitudinal movement by a snap ring **17** on the upper end and the statically mounted pin extention **22** engaging the recess **29** in the shaft on the lower end. An unthreaded segment **24** of shaft **14** protrudes from the top of the frame. An enlarged portion **26** of segment **24** provides a bearing surface **32** engaging a corresponding bearing surface **37** on the underside of knurled knob **20**. The mounting tang **28** of the torque spring **18** is inserted through a hole **33** situated in shaft **14**. The slide block **16** is threaded on the shaft **14** and slidably engages a face **30** of the frame **12** which prevents the block from rotating as the shaft is turned. Thus, as the shaft **14** is rotated clockwise the block **16** is forced to progress upwardly along the shaft threads in sliding engagement with face **30**. Conversely, as the shaft 14 is rotated counterclockwise, the block 16 is forced to recede along the threads of the shaft.

Rotation is imparted to the threaded shaft by the knurled knob 20 via the torque spring 18 which is statically affixed to the shaft as previously described. The knob 20 is mounted for relative rotation on shaft 14 such that bearing surface 37 rests in sliding engagement upon bearing surface 32. The end tang 34 of the torque spring 18 engages a notch 36 in flange 38 inside the knob 20. A screw 40 inserted through Torque index plate 42 is positioned at the extreme upper end of shaft 14 and is held in place by screw 40 inserted into threaded hole 44 in the end of shaft 14. The screw 14, utilizing plate 42 as a washer, retains the knob 20 on the shaft 14 while allowing the knob 20 to rotate freely on the unthreaded shaft segment 24 within the limitations imposed by the torque spring 18. The torque index plate 42, on the other hand, is statically mounted on the end of the shaft 14 by the screw 40. Thus, torque applied to shaft 14 is shown by the relative angular deflection between knurled knob 20 and torque index plate 42. Indicia 46 on the torque index plate and scribe 48 on knurled knob 20 permit observation of the torque applied to shaft 14.

A subassembly formed by two slide plates 50 and 52, a spacer block 54, a hook fixture 56 and fasteners 58 is slidably mounted on the frame 12. The slide plates 50 and 52 reside on either side of the frame 12 between flange surfaces 60 and 62 at the top and bottom of the frame. Fasteners 58 secure plates 50 and 52 to each other with the spacer block 54 and hook fixture 56 between them. Note that pins 64 on the spacer block 54 and the flanges 66 on the hook fixture 56 fix the positions of the respective pieces relative to the slide plates 50 and 52 when assembled. The cardinal features of the slidable subassembly are the diagonal grooves 68 in the interior surfaces of the slide plates 50 and 52. As is best shown in FIG. 3, the external guiding cam surfaces in the form of ridges 70 on the sides of the slide block 16 slidably engage and reside in the grooves 68 and provide the interface through which the drive force is transmitted from the threaded shaft 14 to the slidable subassembly.

As previously described, turning the knurled knob 20 as shown in FIG. 4 drives the threaded shaft 14 via the torque spring 18 causing the rotationally captive slide block 16 to move upwardly or downwardly along the threads of the shaft 14. This movement of the slide block 16 along the threaded shaft 14 causes the side surfaces of the ridges 70 on the block 16 to bear against the sides of the grooves 68 in the slide plates 50 and 52. As the block 16 is elevated or lowered by rotation of the shaft 14, the ridges 70 impart a force to the surfaces of the grooves 68 at an angle causing the slidable subassembly to be laterally displaced relative to the frame 12 as indicated by the dotted line 80 in FIG. 4. This movement subsequently changes the spacing between pin extension 22 and hook 72 which is the essential mechanical output of the device as will be described in detail later in this text.

The type of drive arrangement just described is specifically advantageous in this application since counterforces exerted about pin extension 22 and hook 72 cannot displace the slidable subassembly once the desired positioning of the pin and hook has been achieved. It should be noted that an incremented scale 74 is provided on the top surface of the spacer block 54 allowing the surgeon to visually monitor the exact relative position of the pin 22 and hook 72.

Operation of the device 10 by clockwise rotation of the knurled knob 20 causes relative movement between the pin extension 22 and the hook 72 of the hook fixture 56. This mechanical arrangement is advantageously applied to a bone plate 76 and its bone engaging fasteners 82, 84, 86 and 88 as are shown in FIGS. 2, 4 and 6. The bone plate 76 is a common device used in orthopedic surgery and is well-known to those skilled in the art. The bone plate is designed to span a bone fracture 98 and hold the bone ends 102 and 103 rigidly together for healing by installation of screws through the plate and bone. The bone plate used with the preferred embodiment of the invention is substantially of standard design; however, it bears one modification. A double diameter hole 90 has been added to the plate 76 to receive the pin extension 22. The hole 90 and annularly grooved pin extension 22 are shown in cross-section in FIGS. 4, 5, and 6. The groove 92 on the pin engages the collar 94 formed by the small diameter portion of the hole 90 effectively locking the pin in the hole when the device is in use.

During orthopedic surgery, after the incision is made and the site of the bone fracture is exposed, a bone plate 76 of appropriate size and type is selected. Although the bone plate illustrated in FIG. 4 indicates four screw holes including the elongated slot 96, bone plates containing more than four holes are commonly used in situations in which a longer span of bone is desired to insure rigid and secure bone engagement. The present invention is designed to operate with any plate selected that has been modified by addition of the double diameter hole 90. FIG. 4 also illustrates a fracture 98 in an essentially rectilinear bone section; however, the compression device may be used in plate instalations on curvilinear bone sections requiring the bone plate to be moderately altered longitudinally to conform to the curvature of the bone. Screws to be employed with the bone plate are selected using a depth gauge and exercising care to insure that the screw length is just sufficient to traverse both cortices. In compression plating of bone fractures, bone screws employed are preferably of the precision type, consisting of buttress threads to obtain maximum holding power. The screws can be self-tapping with radially fluted points or the holes can be prethreaded with a bone tapper to minimize bone destruction around the threads during insertion of the screws.

Once the bone plate 76 and required screws have been selected, the plate is positioned over the site of the fracture 98 such that the end of the plate upon which the elongated screw slot 96 is situated is positioned toward the distal bone section 100. The plate is positioned longitudinally with the fracture 98 approximately centered between the inboard end of the elongated hole 96 and the next adjacent screw hold toward the proximal end. Thus positioned, holes 106 and 108 are drilled in the proximal bone section 104 through the openings in the plate 76 using a drill and drill guide. The screws 82 and 84 are installed and tightened in the holes, thereby securing the plate 76 to the proximal bone section 104. The fractured end 103 of the distal bone section 100 is then positioned adjacent the fractured end 102 of the proximal bone section 104. Using the drill and drill guide, a pilot hole 112 is drilled in the distal bone section 100 through the elongated screw hole 96 in the plate 76 at a point near the outboard end 110 of the hole. A screw 86 is then installed in the pilot hole 112 and tightened down so that it is snug but not tight in the elongated hole 96 of the plate 76. At this point, the compression device 10 is positioned on the plate 76 such that the annularly grooved pin extension 22, protruding from the underside of the frame 12, engages the hole 90 in the plate. The knob 20 is then rotated clockwise until the hook 72 engages the countersunk head of the screw 86 on the side away from the fracture 98. A slight clockwise turn of the knob 20 positively engages the hook 72 with the screw head.

Upon further rotation of knob 20 the device applies compressive force between the hole 90 in the bone plate 76 which is integrally attached to the proximal bone section 104 and the head of the screw 86 which is embedded into the distal bone section 100. The hook 72 engaging the screw 86 is physically moved closer to the pin 22 engaging the hole 90 in the plate 76 by further turning the knob 20 in a clockwise direction. Thus, the bone ends are drawn together. As the bone ends 102 and 103 meet, as shown in FIG. 6, a compressive force is applied at the fracture 98 through the action of the device. The compressive force is proportional to the torsional force applied to the threaded drive shaft 14 by knob 20 via the torque spring 18. This force is translated via the torque meter mechanism into a measurable value expressed on the incremented scale on plate 42 as related to the scribe on the knob 20. The surgeon may fine adjust the force at the fracture by monitoring the torque meter. It should be noted that compression of the bone fragments is helpful since it allows the fracture to heal by direct bone formation and obviates the slower cartilaginous phase of callus formation.

As noted above, the drive mechanism of the device is so designed that it effectively nullifies counter-compressive forces at the fracture during installation. The tendency of the bone ends to pull apart and relax the compressive force set by the surgeon, as would be translated into counter-compressive forces at the pin extension 22 and hook 72, are not readily translatable into a torsional force which could rotate the threaded shaft 14 and knob 20. Once the device has been set to a particular compressive force level at the fracture by the surgeon, the device will maintain that level unattended.

With the device maintaining the desired compressive force at the fracture 98, a hole 114 is drilled in the distal bone segment 100 through the remaining screw hole 116 in the bone plate 76. A screw 88 is installed in the hole 114 and firmly tightened. This screw will maintain the compressive force at the fracture while the device 10 is released and removed from the bone plate. The device is removed from the bone plate 76 by turning the knob 20 in a counterclockwise direction until the hook 72 is free of the head of screw 86. At this point the device can be lifted to allow pin extension 22 to be disengaged from the hole 90 in the plate. With the compression device removed, the screw 86 in the elongated hole 96 in the plate is tightened to complete the fixation of the bone ends. The completed bone plate installation is illustrated in FIG. 7. The incision is then sutured to complete the operation.

It will be appreciated by those skilled in the art that an improved bone fracture compression device and method of usage achieving the above-mentioned and related objectives may be embodied in variant forms within the framework of the inventive concepts. However, the illustrated embodiment is considered to be of optimum form and design so as to achieve these various objectives in a degree which is unique. Thus, while the invention broadly embraces the concept of applying a measured force to the fracture site of a bone fracture by applying compressive forces between a bone plate attached to one segment of the fractured bone and to a bone screw loosely inserted into a slotted aperture in the bone plate and thence into the second bone segment with subsequent insertion and tightening of a sufficient number of bone screws adjacent the fracture site so as to apply and maintain the desired compressive force across the fracture, it will be recognized that the application of forces across the fracture site may be accomplished by variant forms of the applicant's invention within the scope and intent of the disclosure set forth above. It should be noted that various means of attachment for the bone compression device to the bone compression plate may be utilized and that while compression has been applied across the fracture site by drawing a bone screw positioned in the elongate slot of the compression plate toward a fixed point located across the fracture situs, the concepts of this invention may be accomplished by apparatus in which the bone screw positioned in the elongate slot is forced away from the adjacent end of the compression plate by a suitably configured bone compression device having means to indicate applied force. It should also be noted that while the knurled knob carrying the torque indicating means is positioned on a shaft oriented perpendicular to the bone compression plate, the apparatus would work equally well with the shaft means oriented parallel to the plate, in threaded engagement with the frame and slidable subassembly. Thus, while a specific preferred embodiment has been described in detail, it will be apparent to one skilled in the art that various modifications may be made to the apparatus and method disclosed above while remaining well within the scope and spirit of the invention.

We claim:

1. An orthopedic apparatus for compression of a bone fracture and extramedulary fixation of a rigid bone plate thereon said bone plate adapted to be positioned in contact with the surface of a fractured bone, aligned parallel to the axis of said bone and overlapping a fracture therein, said plate having at least two bone screw receiving apertures positioned in each overlapping portion thereof whereby at least two bone screws may enter each segment of said fractured bone, one of said apertures comprising an elongate slot adapted for situation adjacent a fracture in said bone and having means to receive a plate engaging pin means adjacent said slot; said apparatus comprising:

a frame means including a bone plate engaging flange means having a depending pin means adapted for engagement with said bone plate;

a threaded member extending upwardly from said flange means and journalled into said frame means, the end of said threaded member opposite said flange means extending beyond said frame means and carrying means for indicating torque applied thereto;

cam means having external guiding cam surfaces thereon in threaded engagement with said threaded member and adapted to translate along said threaded member in response to rotation thereof; and,

a movable subassembly carried by said frame having cam follower means drivingly interengaged with said guiding cam surfaces and adapted for translation substantially parallel to said flange means upon movement of said cam means, said movable subassembly including hook means for engaging a bone screw positioned in said elongate slot whereby rotation of said threaded member causes said pin and said hook means to move with respect to each other, the force necessary to effect such movement being shown by said means for indicating torque.

2. The apparatus of claim **1** wherein said cam follower means comprises a groove angled with respect to said threaded member.

3. The apparatus of claim **1** wherein said pin means and said threaded member are coaxial.

4. The apparatus of claim **1** wherein said frame means and said movable subassembly carry indicia to indicate the relative position therebetween.

5. The apparatus of claim **1** wherein said pin means and said hook means are operatively positioned on said bone plate with the bone fracture site therebetween.

6. The apparatus of claim **1** wherein said pin means and said hook means are urged together in applying pressure to a bone fracture site.

7. The apparatus of claim **1** where said pin means and said plate have cooperating interlocking means restraining disengagement thereof whenever force is applied between said pin means and said hook means.

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