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(54) **SCREW LOCKING SYSTEMS FOR BONE PLATES**

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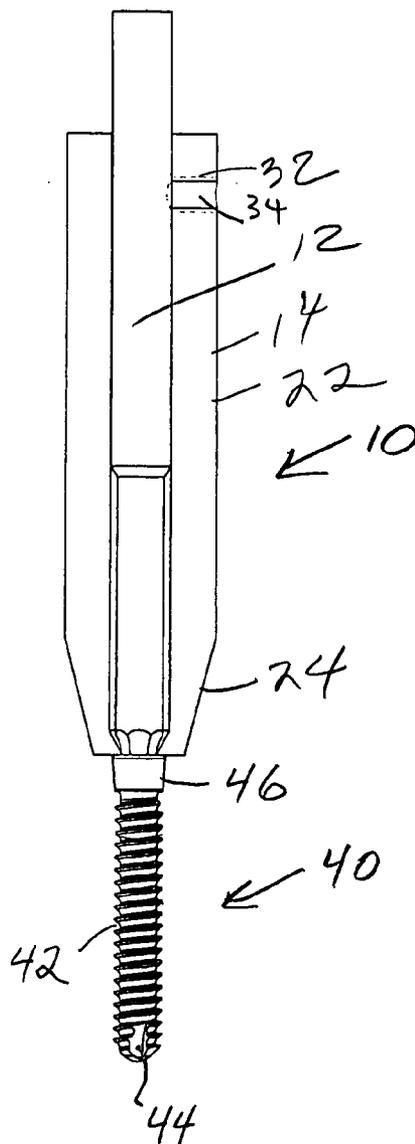
(57) **ABSTRACT**

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Bone screws have heads which are provided with a hex socket as well as a threaded portion. A screw driver system includes a hex driver and a threaded driver. The screw driver system permits driving the screw through a plate system into a bone until desired compression is obtained. Then the screw is locked to the plate while maintaining the imparted compression.

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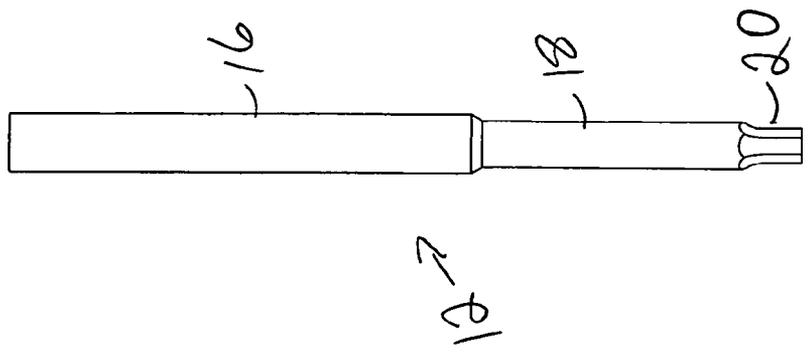


FIG. 1

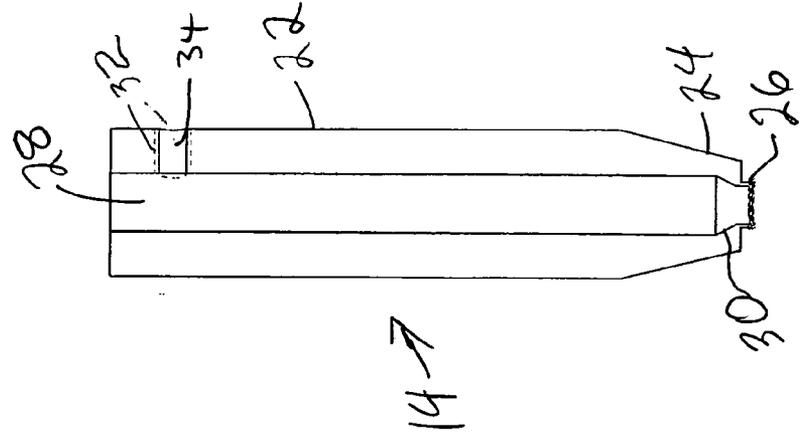


FIG. 2

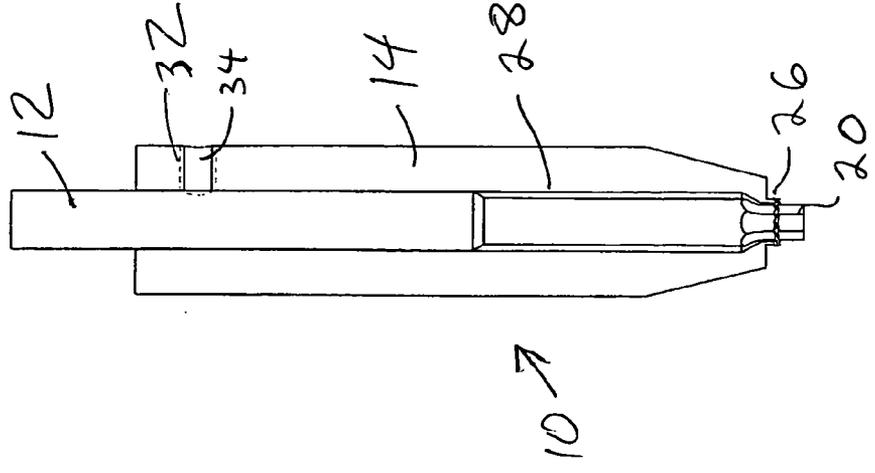


FIG. 3

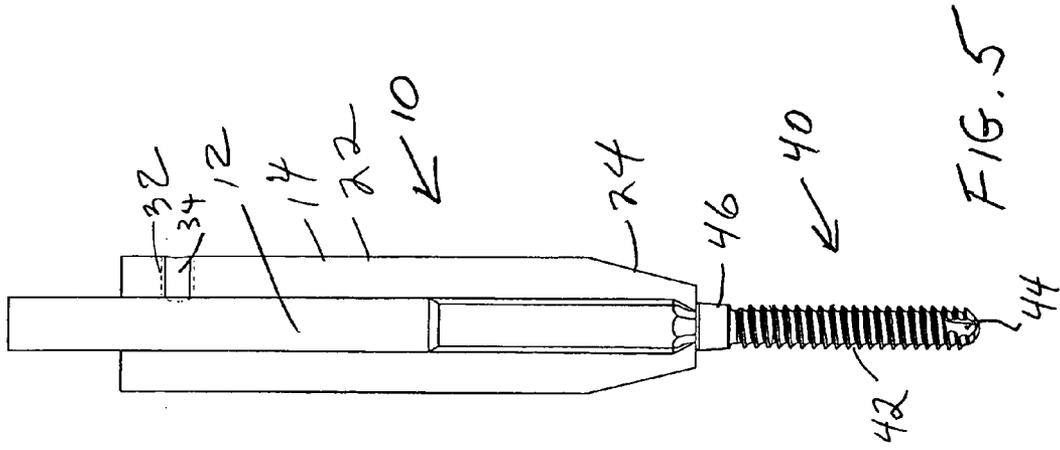


FIG. 5

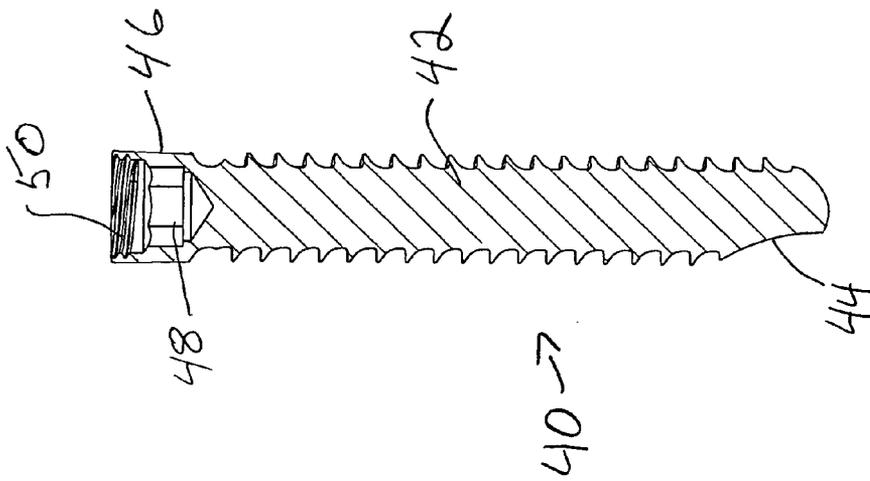


FIG. 4

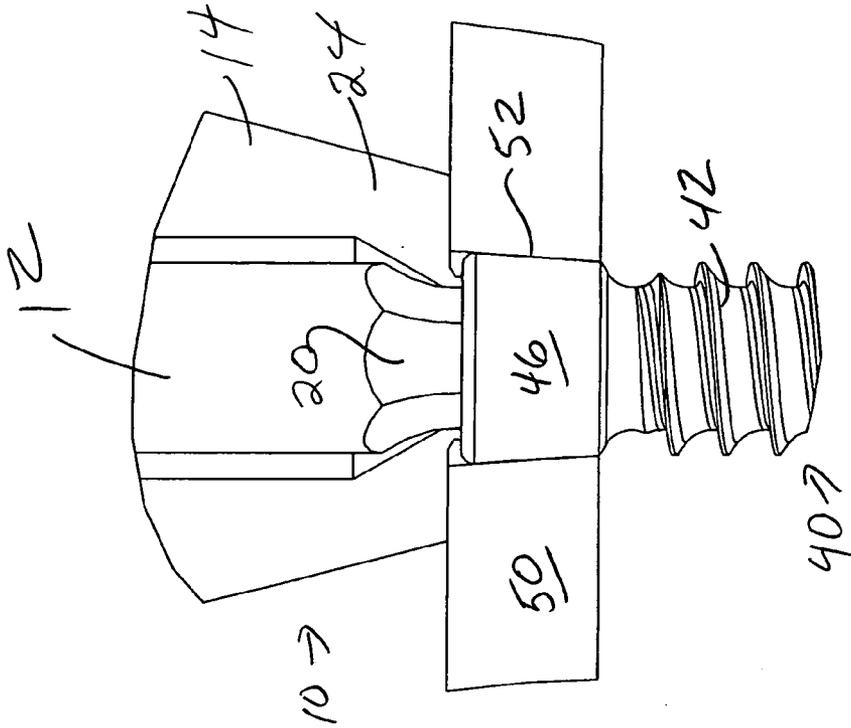


FIG. 6

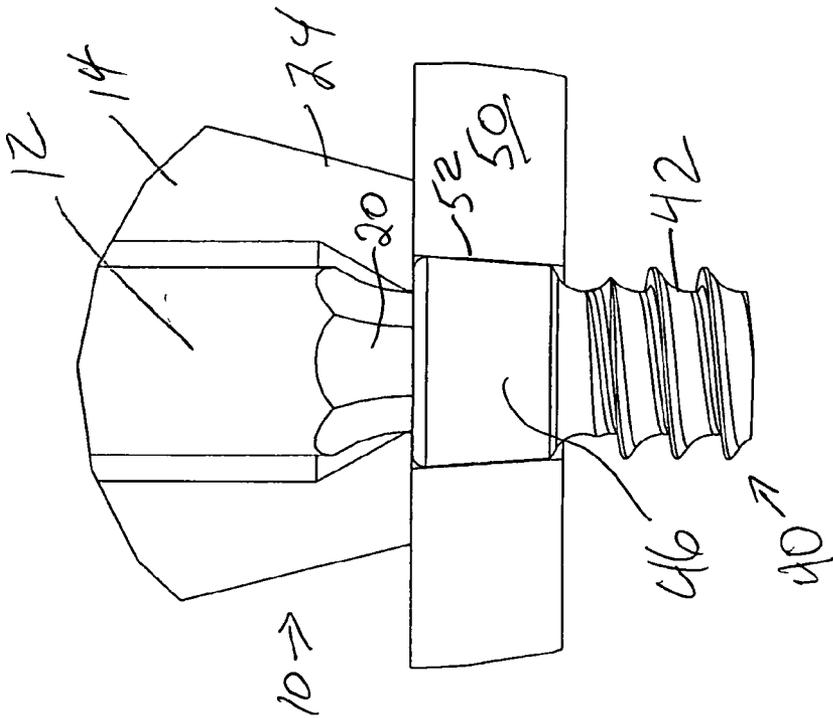


FIG. 7

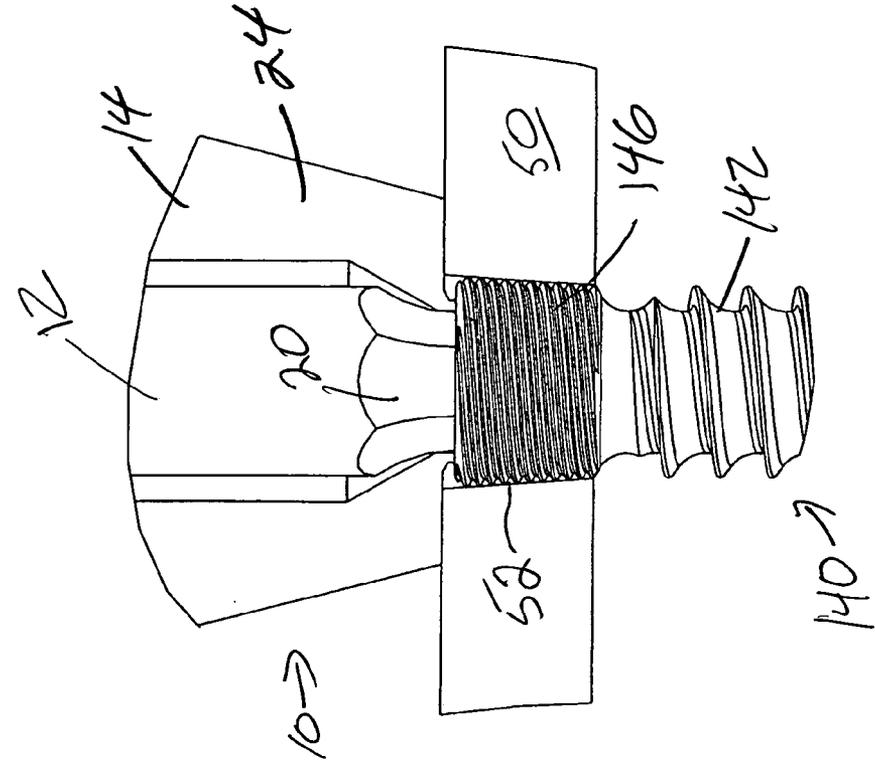


FIG. 8

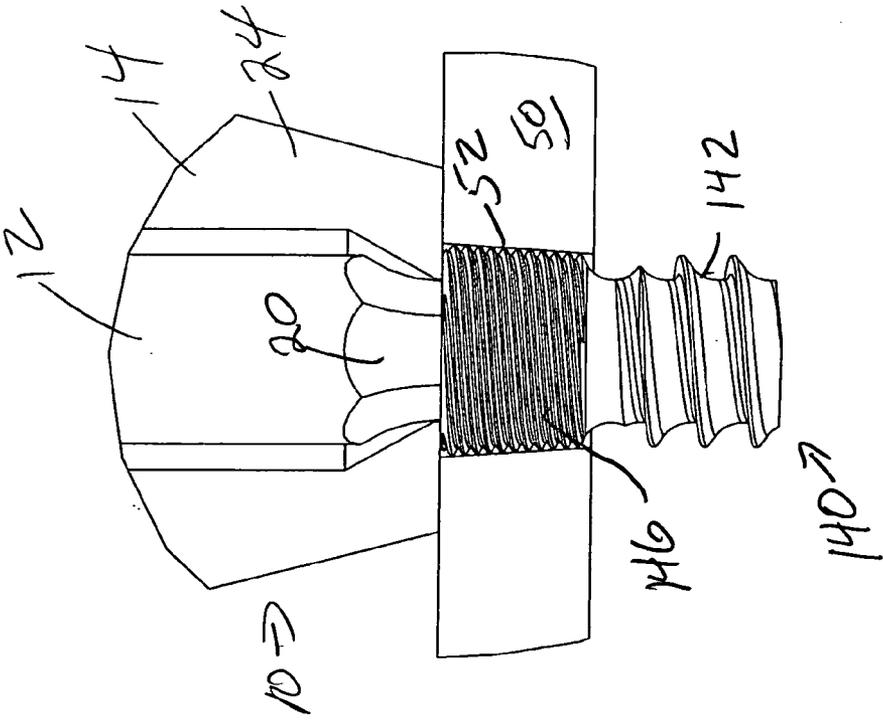


FIG. 9

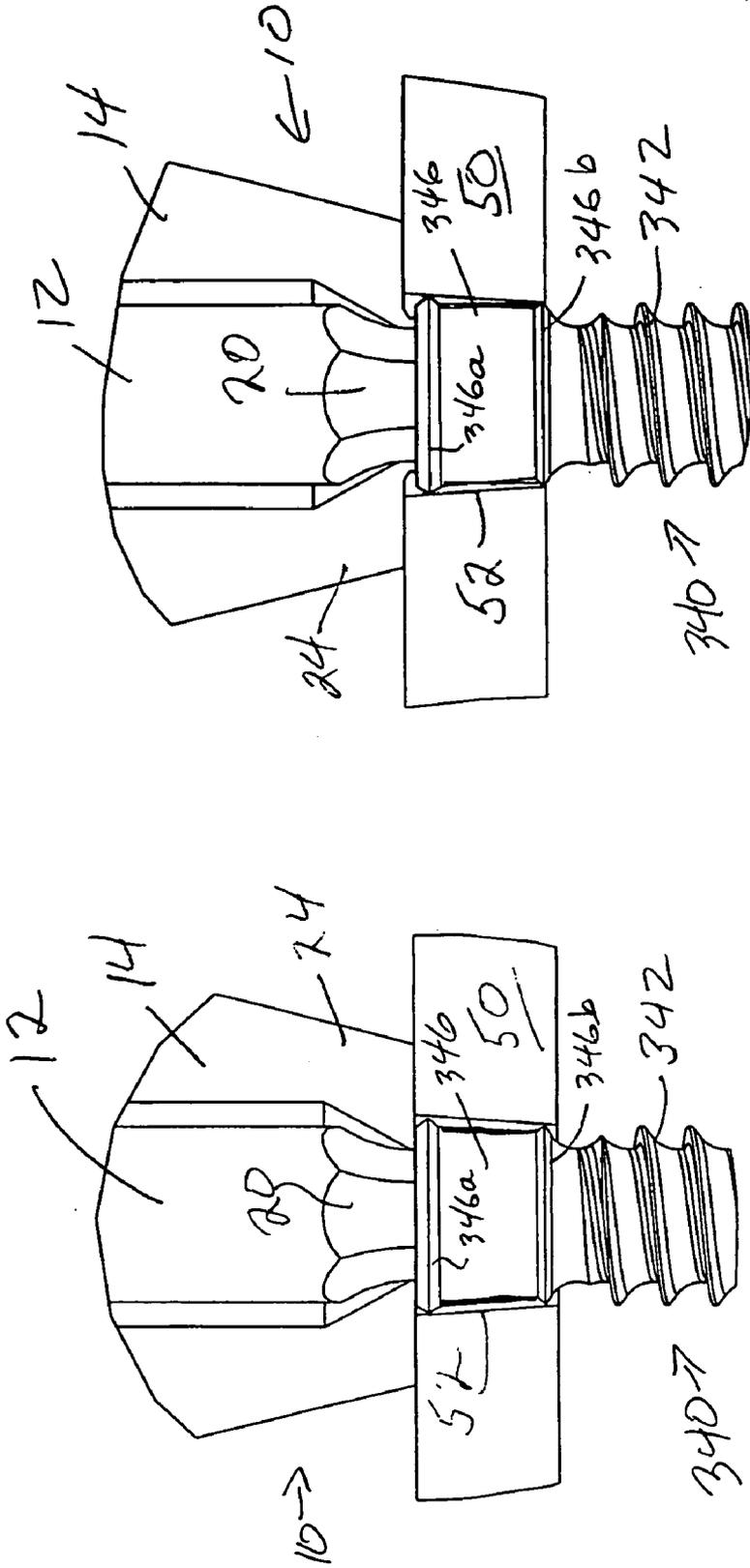


FIG. 11

FIG. 10

SCREW LOCKING SYSTEMS FOR BONE PLATES

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] This invention relates broadly to orthopedic devices. More particularly, this invention relates to systems for locking bone screws relative to bone plates.

[0003] 2. State of the Art

[0004] For various fractures of bones of the body, plating is a well known technique to impart the stabilization desirable for proper healing. In plating, a rigid, typically metal plate is placed on the outer surface of the bone across the fracture, and screws are secured through the plate and into the bone on either side of the fracture in a manner which permits the rigid plate to offer support to the bone during healing.

[0005] The screws include threads along a shaft adapted to engage cortical bone. Most commonly, the head portion of the screw is generally a standard screw head which provides a compressive force about a corresponding round screw hole of the plate as the screw is thread into the bone, thereby causing compression of the plate against the bone.

[0006] U.S. Pat. No. Re. 28,841 to Allgower describes a plate that is used with generally standard screws having heads with a convex undersurface. The plate includes oblong screw holes which each define at one end an upper ramped portion and a generally smaller radius of curvature about the ramped portion. In use, a hole is drilled into the bone through the screw hole adjacent the ramp and a screw is inserted through the screw hole adjacent the ramp into the drilled hole and rotated until the head of the screw contacts the ramp. Upon such engagement, there is displacement of the bone plate in a direction to move the ramped portion away from the screw and the cause the plate to apply pressure to maintain the bone parts together about the fracture in tight engagement.

[0007] More recently, particularly at the metaphysis of long bones though not limited thereto, there have been desirable results with screws having exteriorly threaded heads which threadably engage threads in the plate to lock the screws relative to the plate and thereby limit compression of the plate relative to the bone. However, such systems do not provide the necessary control of compression between the plate and bone. Control over compressive forces is lost as soon as the threads of the head of the screw lock relative to the plate. Therefore, such a system provides sub-optimal stability.

[0008] Certain plates sold by Synthes are designed with a hole called a COMBI-HOLE™. The COMBI-HOLE™ is an elongated screw hole including two joined circular sections, each extending through approximately 250°. One of the circular sections is threaded and thus adapted to received a screw with a threaded head at a fixed angle. When used as such, the system has the same lack of control over compression as discussed above.

SUMMARY OF THE INVENTION

[0009] It is therefore an object of the invention to provide a plate and screw system whereby the amount of compression between the plate and bone can be controlled completely by the surgeon.

[0010] It is an additional object of the invention to provide a plate and screw system which permits complete control over compression prior to and during locking the screw to the plate.

[0011] In accord with these objects, which will be discussed in detail below, bone screws according to the invention have heads which are provided with a hex socket as well as a threaded portion. A screw driver system according to the invention includes a hex driver and a threaded driver. The threaded driver is provided with an axial through bore which is dimensioned to receive the hex driver. The screw driver system is coupled to a screw by threadably engaging the threaded driver with the threaded portion of the screw head, and delivering the hex driver through the bore in the threaded driver to engage the hex socket in the screw head. Optionally, a set screw is used to secure the hex driver to the threaded driver. The end of the threaded driver is dimensioned to have a diameter larger than the diameter of the head of the screw with which it is used. According to a first embodiment, the screw head is frustoconical with a smooth side surface and the screw head includes internal threads coaxial with the hex socket. The first embodiment is used with a bone plate having a frustoconical screw hole.

[0012] When the screw is attached to the driver system and is passed through the hole in the bone plate, the threaded driver alone is used (or both drivers coupled together are used) to rotate the screw to engage the bone. After the screw is advanced into the bone, the frustoconical screw head enters the frustoconical screw hole in the bone plate, but is prevented by the threaded driver from contacting the inner wall of the screw hole. The larger diameter end of the threaded driver prevents the screw head from advancing further. Moreover, the end of the threaded driver contacts the area of the bone plate surrounding the screw hole and exerts compression on the plate as the screw is further advanced into the bone. When the desired compression is reached, turning of the threaded driver is stopped (and if the drivers were engaged, they are now disengaged) and the hex driver is used to further advance the screw. Turning the hex driver while holding the threaded driver advances the screw while starting to decouple the threaded portion of the screw head from the threaded driver. In order to maintain compression until the screw head is locked in the screw hole of the bone plate, the length of the threads on the screw head and the threaded driver prevent the screw head from being decoupled before the screw head is locked. When the frustoconical screw head lockingly engages the frustoconical screw hole, the threaded driver is backed off the screw head by turning it in the direction opposite to driving.

[0013] A second embodiment of a bone screw according to the invention is identical to the first embodiment but has a threaded exterior surface on the wall of the frustoconical head. The threaded surface creates high localized pressure between the thread crests and the tapered screw hole wall of the plate. It also causes some scoring and a better mechanical hold.

[0014] A third embodiment of a bone screw has a cylindrical head with two unequal diameter circumferential edges, one near the top and one near the bottom of the head, that make simultaneous contact with the tapered screw hole wall of the plate when the head is locked to the plate.

[0015] A fourth embodiment of a bone screw has a cylindrical head with external threads and an internal hex socket.

This embodiment of the screw is used with the second embodiment of the threaded driver which has internal threads which engage the exterior of the screw head and is also used with a bone plate that has a cylindrical threaded screw hole. The threads on the head of the screw preferably advance at a similar rate to the threads on the shaft so as to maintain the compression achieved while the head is being locked to the plate. Alternatively, the pitch of the screw head threads may be decreased slightly with respect to the screw shaft threads so as to increase compression slightly as the screw is locked to the plate.

[0016] Additional objects and advantages of the invention will become apparent to those skilled in the art upon reference to the detailed description taken in conjunction with the provided figures.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] FIG. 1 is a side elevational view of a hex screw driver according to the invention;

[0018] FIG. 2 is a transparent side elevational view of a threaded screw driver according to the invention;

[0019] FIG. 3 is a transparent side elevational view of the hex screw driver coaxially inserted through the threaded screw driver;

[0020] FIG. 4 is a longitudinal sectional view of a first embodiment of a bone screw according to the invention;

[0021] FIG. 5 is a partially transparent side elevational view of the screw drivers of FIGS. 1 and 2 coupled to the screw of FIG. 4;

[0022] FIG. 6 is a broken partially transparent side elevational view of the screw drivers and screw of FIGS. 1-5 and a bone plate showing the screw unlocked from the plate during plate compression;

[0023] FIG. 7 is a view similar to FIG. 6 but showing the screw locked to the plate;

[0024] FIG. 8 is a view similar to FIG. 6 but showing a second embodiment of a screw according to the invention;

[0025] FIG. 9 is a view similar to FIG. 7 but showing the second embodiment of the screw;

[0026] FIG. 10 is a view similar to FIG. 8 but showing a second embodiment of a threaded screw driver according to the invention and a bone plate having a threaded screw hole;

[0027] FIG. 11 is a view similar to FIG. 9 but showing the second embodiment of a threaded screw driver and the bone plate having a threaded screw hole;

[0028] FIG. 12 is a view similar to FIG. 8 but showing another embodiment of a bone screw according to the invention; and

[0029] FIG. 13 is a view similar to FIG. 9 but showing another embodiment of a bone screw according to the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0030] Turning now to FIGS. 1-3 a first embodiment of a screw driver system 10 according to the invention includes a hex driver 12 and a threaded driver 14. The hex driver 12

includes a cylindrical handle 16, a smaller diameter shank 18, and a male hex end 20. The threaded driver 14 includes a cylindrical handle 22 with a tapered end 24. An exteriorly threaded cylinder 26 extends from the tapered end 24. An axial through bore 28 extends through the handle 22 and through the cylinder 26. The through bore 28 exhibits a tapered wall 30 just prior to the cylinder 26. Optionally, a set screw hole 32 is arranged orthogonal to the bore 28. The hex driver 12 is dimensioned to fit through the bore 28 as shown in FIG. 3 with the male hex end 20 extending beyond the threaded cylinder 26. The tapered wall 30 in the bore 28 prevents the hex driver 12 from passing through the bore. The screw driver system 10 is designed for use with a bone screw of the type shown in FIG. 4.

[0031] Turning now to FIG. 4, a bone screw 40 includes a threaded shaft 42 having a cutting flute 44 at one end and a screw head 46 at the other end. The head 46 is substantially frustoconical and houses a hex socket 48 and a threaded inner wall 50 which is coaxial with the hex socket. Referring now to FIGS. 3-5, those skilled in the art will appreciate that, when assembled, the threaded cylinder 26 of the driver 14 engages the threaded inner wall 50 of the screw head 46 and the male hex end 20 of the driver 12 engages the hex socket 48. The screw and driver assembly is shown in FIG. 5. When the screw and drivers are assembled as shown, the screw is ready to be inserted through a bone plate and threaded into bone.

[0032] FIGS. 6 and 7 show two stages of applying the screw 40 to a bone plate 50 having a frustoconical screw hole 52. After the screw and drivers are assembled as shown in FIG. 5 and the drivers are optionally fastened to each other with a set screw 34 through the set screw hole 32, the handle 22 of the driver 14 is turned while the screw 40 is inserted through the plate 50 and into a pre-drilled hole in the bone (not shown). As the screw advances into the bone, the head 46 of the screw advances toward the plate 50 and ultimately enters the frustoconical hole 52 as shown in FIG. 6. Before the head 46 can frictionally engage the hole 53, the tapered end 24 of the driver 14 abuts the plate 50. Since the head 46 of the screw 40 is threadably coupled to the end of the driver 14, it is prevented from advancing away from the driver 14 into the hole 52. When the screw, driver and plate are arranged as shown in FIG. 6, rotating the driver 14 advances the screw into the bone while the tapered end 24 of the driver 14 compresses the plate 50 against the bone. When the surgeon feels that the proper amount of compression has been achieved, rotation of the driver 14 is stopped. If necessary, the set screw is 34 released from the hole 32 (FIG. 5) and the hex driver 12 is rotated further in the same direction while the threaded driver 14 is held stationary. This causes the screw 40 to advance while the head 46 rotates out of engagement with the driver 14 until the head 46 frictionally engages the hole 52 as shown in FIG. 7. The driver 12 may then be removed by lifting it out of the socket in the screw head and the bore in the driver 14. The driver 14, if not decoupled from the screw by the advancement, can then be uncoupled by reverse rotation.

[0033] From the foregoing, those skilled in the art will appreciate that the system of the invention allows the surgeon to carefully apply a controlled amount of compression to the plate prior to locking the screw to the plate. It also maintains the selected compression while the screw is being locked to the plate. The tapered end of the threaded driver

serves two functions, it reduces friction between the driver and the plate, making it easier to rotate the driver under compression. It also provides a clearer view of the screw and screw hole during insertion of the screw into the hole. However, it is not necessary that the driver be tapered.

[0034] **FIGS. 8 and 9** illustrate an alternate embodiment of a screw **140** which is substantially identical to the screw **40** having a threaded shaft **142**, a cutting flute at one end (not shown) and a frustoconical head **146** at the other end. The difference between this screw **140** and the screw **40** is that the outer surface of the head **146** is threaded. The screw **140** works with the same driver assembly **10** and bone plate **50** as the screw **40** in the same manner as described above but the threaded surface **146** creates high localized pressure between the thread crests and the tapered screw hole wall **52** of the plate. It also causes some scoring and a better mechanical hold. The pitch of the threads **146** should be the same as the pitch of the threads **142** to help maintain the same level of compression and create one scoring track.

[0035] **FIGS. 10 and 11** illustrate another embodiment of a bone screw according to the invention. The screw **340** has a threaded shaft **342** and a cylindrical head **346** with two unequal diameter circumferential edges **346a**, **346b**. The interior of the head **346** is the same as the head **46** of the screw **40** (**FIG. 4**) and the screw is used with the driver assembly **10** (**FIG. 3**) and the bone plate **50** described above. When the screw **340** is locked into the tapered hole **52** as shown in **FIG. 13**, the two circumferential edges **346a**, **346b** make simultaneous contact with the tapered hole, one near the top and one near the bottom. Such circumferential ridges can also be used on screws with frustoconical heads or any shaped head which will rotate within the screw hole.

[0036] **FIGS. 12 and 13** illustrate another embodiment of a bone screw **240**, a second embodiment of a bone plate **150**, and a second embodiment of a driver system **110**. The driver system **110** uses the same hex driver **12** as the driver system **10** but uses a different threaded driver **114**. The driver **114** has an interiorly threaded cylindrical recess inside its tapered end **124** as opposed to the exteriorly threaded cylinder **26** of the driver **14** (**FIGS. 2 and 3**). The screw **240** has a cylindrical head **246** which is provided with threads that match the threads in the recess **126** of the driver **114**. The screw head **246** also has an interior hex socket like the hex socket **48** in the screw **40** (**FIG. 4**) but it does not have interior threads like the threads **50** in the screw **40**. The threads on the shank **242** of the screw **240** have generally the same pitch as the threads on the head **246**. The plate **150** has a screw hole **152** with interior threads which match the threads of the screw head **126**. As can be seen in **FIGS. 10 and 11**, the threads **152** terminate before reaching the bottom of the plate **150**. The screw, driver, and plate of this arrangement operate in a manner similar to the systems described above. The screw **240** is attached to the driver **114** by threading its head **246** into the threaded recess **126** of the driver. The driver **114** drives the screw into the bone and advances the head **246** to the top of the plate **150**, but prevents it from entering the threaded hole **152**. The tapered end **124** of the driver abuts the top of the plate and compresses it. When the surgeon feels the appropriate amount of compression, the hex driver **12** is rotated while keeping the threaded driver **114** stationary. This rotates the screw head **246** out of engagement with the threaded recess **126** and into engagement with the threaded hole **152**. The

screw head bottoms out on the threads in the hole **152** before passing through the plate **150**. It is desirable that multiple thread starts be provided on the screw head **246** to avoid compression when the plate threads start to engage and to avoid cross-threading. It is important to note that the external threads on the head **246** are free to engage both the driver and the plate and are not blocked from engaging either by any other part of the head.

[0037] There have been described and illustrated herein embodiments of a bone plating system and methods of using the same. While particular embodiments of the invention have been described, it is not intended that the invention be as limited thereto, as it is intended that the invention be as broad in scope as the art will allow and that the specification be read likewise. For example, while the screws have been described as having a hex socket which is driven by a hex driver, it will be appreciated that other types of sockets and drivers can obtain substantially the same results as a hex socket and driver. It will therefore be appreciated by those skilled in the art that yet other modifications could be made to the provided invention without deviating from its scope as claimed.

What is claimed is:

1. A screw driver system, comprising:

a first driver having an elongate body having a first end and a second end with a throughbore extending through said body from said first end to said second end and first screw engagement means for engaging a first portion of a screw located at said second end; and

a second driver having an elongate body having a first end and a second end and dimensioned to fit through said through bore of said first driver and second screw engagement means for engaging a second portion of a screw located at said second end of said second driver.

2. The screw driver system according to claim 1, wherein:

said first screw engagement means includes means for locking the screw to the first driver and said second screw engagement means includes means for unlocking the screw from the first driver.

3. The screw driver system according to claim 1, wherein:

said first screw engagement means is threaded and adapted to engage a threaded portion of a screw head.

4. The screw driver system according to claim 3, wherein:

said first screw engagement means is an exteriorly threaded cylinder adapted to engage an interior threaded portion of the screw head.

5. The screw driver system according to claim 3, wherein:

said first screw engagement means is an interiorly threaded cylinder adapted to engage an exterior threaded portion of the screw head.

6. The screw driver system according to claim 1, wherein:

said second screw engagement means is a socket driver adapted to engage a socket in a screw head.

7. The screw driver system according to claim 6, wherein:

said socket driver is a hex driver.

8. The screw driver system according to claim 1, further comprising:

means for releasably locking said first and second drivers relative to each other.

9. A bone screw, comprising:
 a threaded shank having a first end, a second end, and an overall diameter;
 a screw head having a portion of larger diameter than said overall diameter, said screw head defining two separate driver engagement means for engaging two separate screw drivers.

10. The bone screw according to claim 9, wherein:
 said two separate driver engagement means includes a threaded portion of said screw head and a socket portion of said screw head.

11. The bone screw according to claim 10, wherein:
 said threaded portion includes threads located inside said screw head.

12. The bone screw according to claim 10, wherein:
 said screw head has an outer surface and said threaded portion includes threads on said outer surface.

13. The bone screw according to claim 10, wherein:
 said threaded portion is coaxial with said socket portion.

14. The bone screw according to claim 10, wherein:
 said socket portion is a hex socket.

15. The bone screw according to claim 9, wherein:
 said screw head has a frustoconical surface.

16. The bone screw according to claim 15, wherein:
 wherein said frustoconical surface is substantially smooth.

17. The bone screw according to claim 15, wherein:
 said frustoconical surface is threaded.

18. The bone screw according to claim 9, wherein:
 said screw head has a cylindrical surface.

19. The bone screw according to claim 18, wherein:
 said cylindrical surface is threaded.

20. The bone screw according to claim 18, wherein:
 said screw head has a pair of spaced apart circumferential edges.

21. The bone screw according to claim 20, wherein:
 said edges have different diameters.

22. A bone plating kit, comprising:
 a bone screw having
 a threaded shank with a first end, a second end, and an overall diameter, and
 a screw head having a portion of larger diameter than said overall diameter, said screw head defining two separate driver engagement means for engaging two separate screw drivers;

a screw driver system having
 a first driver having an elongate body having a first end and a second end with a throughbore extending through said body from said first end to said second end and first screw engagement means located at said second end for engaging a first one of said driver engagement means, and
 a second driver having an elongate body having a first end and a second end and dimensioned to fit through said throughbore of said first driver and second screw engagement means located at said second end of said second driver for engaging a second one of said driver engagement means; and

a bone plate having
 at least one screw hole adapted to receive said screw and lockingly engage said screw head.

23. The kit according to claim 22, wherein:
 said screw hole is tapered.

24. The kit according to claim 22, wherein:
 said plate has a top and a bottom and said screw hole is threaded from said top to a location between said top and bottom.

25. The kit according to claim 22, wherein:
 said first and second drivers are releasably lockable to each other.

26. The kit according to claim 22, wherein:
 said first screw engagement means is threads and said second screw engagement means is a hex driver.

27. The kit according to claim 26, wherein:
 said threads are internal to said first driver.

28. The kit according to claim 26, wherein:
 said threads are external to said first driver.

29. A method for attaching a plate to a bone with a screw through a hole in the plate, said method comprising:
 attaching the screw to a driver;
 inserting the screw through the hole in the plate;
 driving the screw into a bone while biasing the plate against the bone with the driver but not the screw; and
 releasing the screw from the driver while locking it to the plate.

* * * * *