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**Bray**

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(54) **BONE PLATE AND BONE SCREW GUIDE MECHANISM**

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(52) **U.S. Cl.** ..... **606/71; 606/61; 606/70**

(58) **Field of Search** ..... **606/69, 70, 71, 606/61; 623/17**

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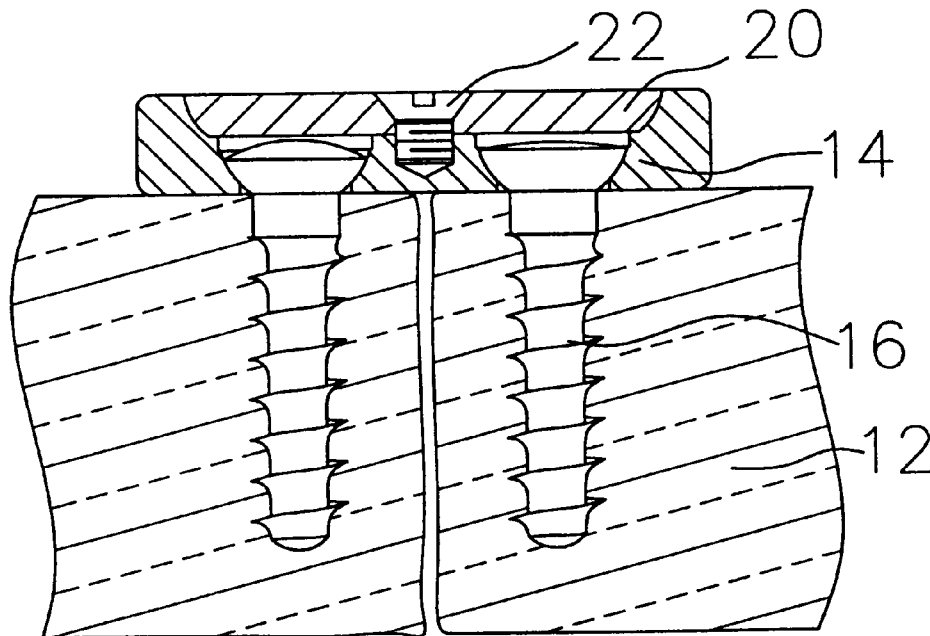
*Assistant Examiner*—Julian W. Woo

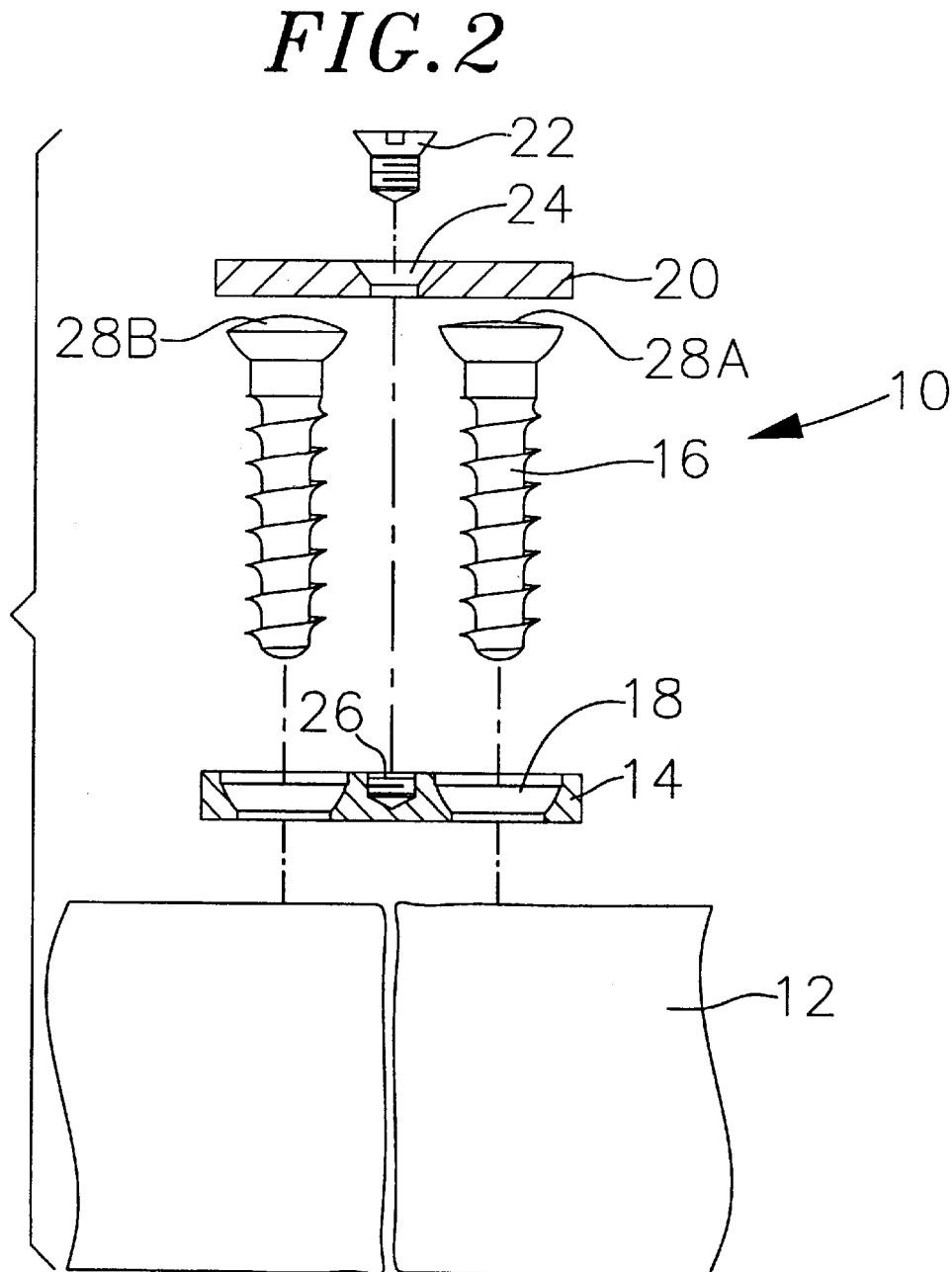
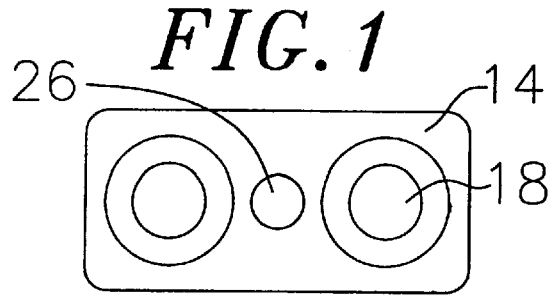
(74) *Attorney, Agent, or Firm*—Christie, Parker & Hale, LLP

(57) **ABSTRACT**

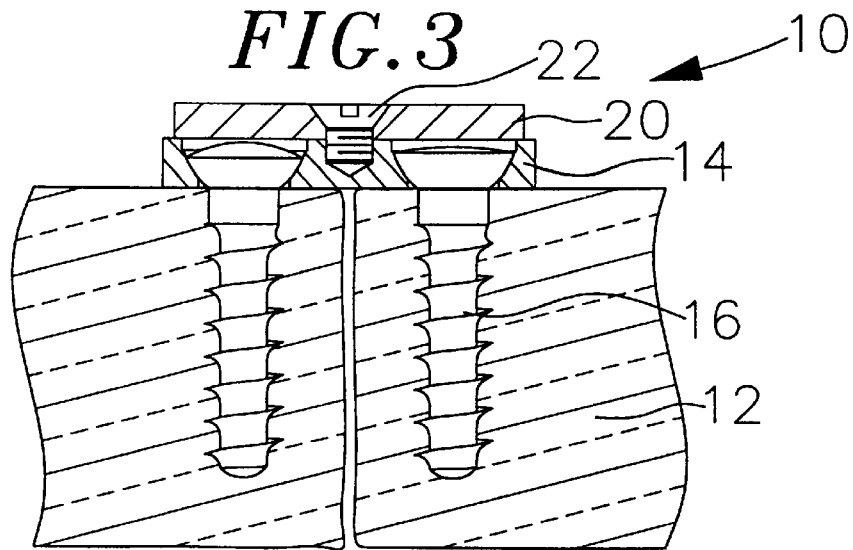
A bone plate comprises a base plate having at least two screw holes and at least two bone screws capable of securing the bone plate to a bone by insertion through the screw holes into the bone. The bone screws have heads shaped to toggle within the screw holes. A retaining plate is provided that is fixedly attachable to the base plate. The retaining plate covers at least a portion of each of the bone screws. The retaining plate and base plate each contain set screw apertures. A set screw is provided to retain the retaining plate in place over the base plate by screwing the set screw through the set screw apertures in the retaining plate and base plate. This design prevents the bone screw from backing out from the bone once screwed in through the base plate.

**31 Claims, 10 Drawing Sheets**

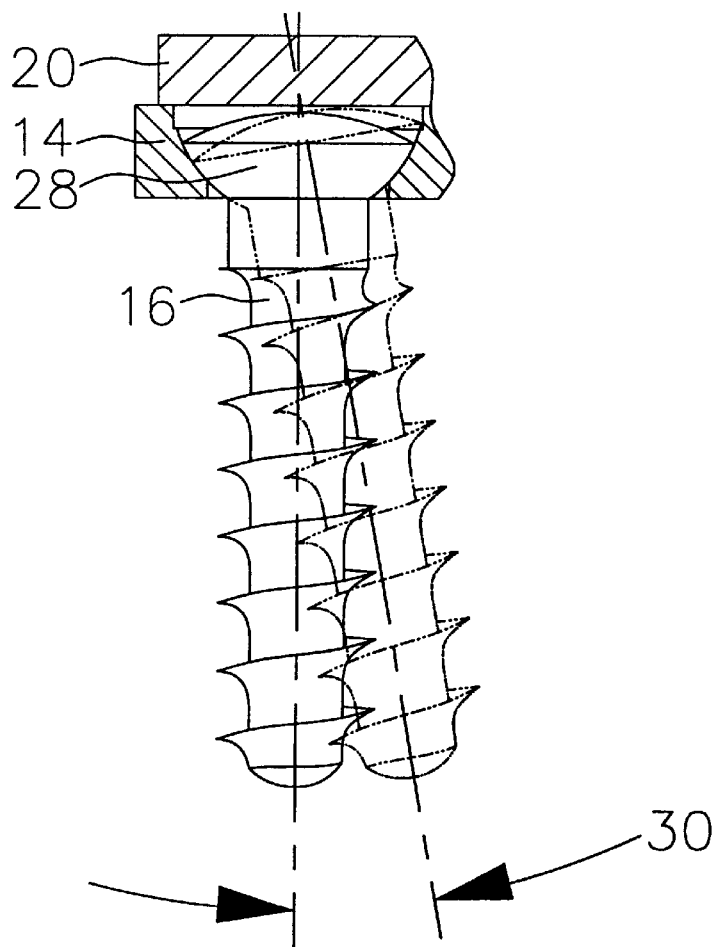




**FIG. 3**



**FIG. 4**



*FIG. 5*

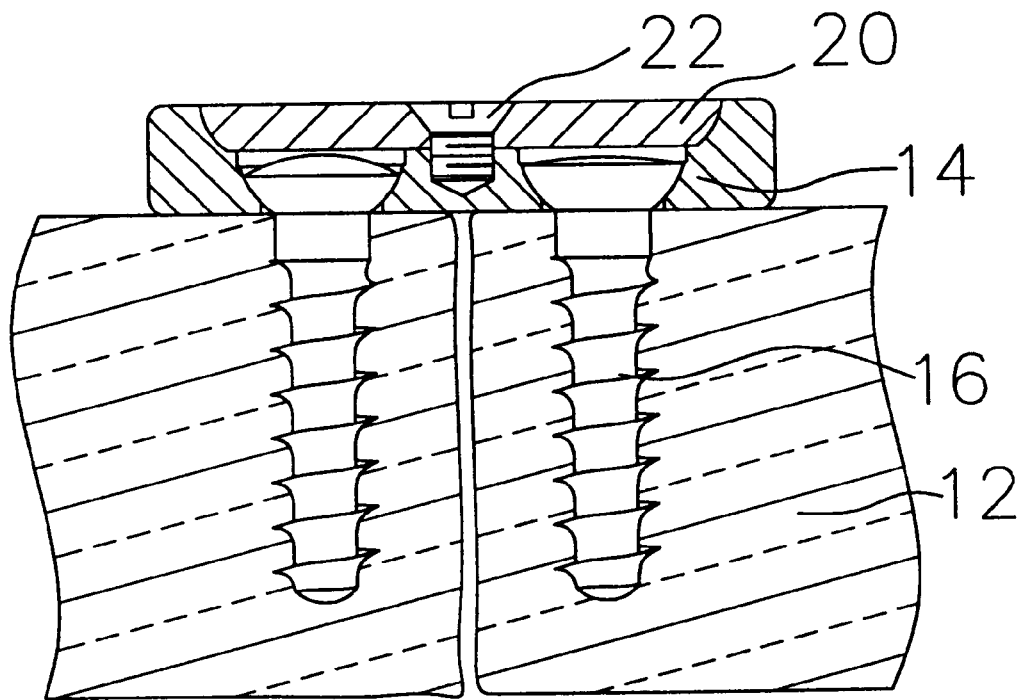
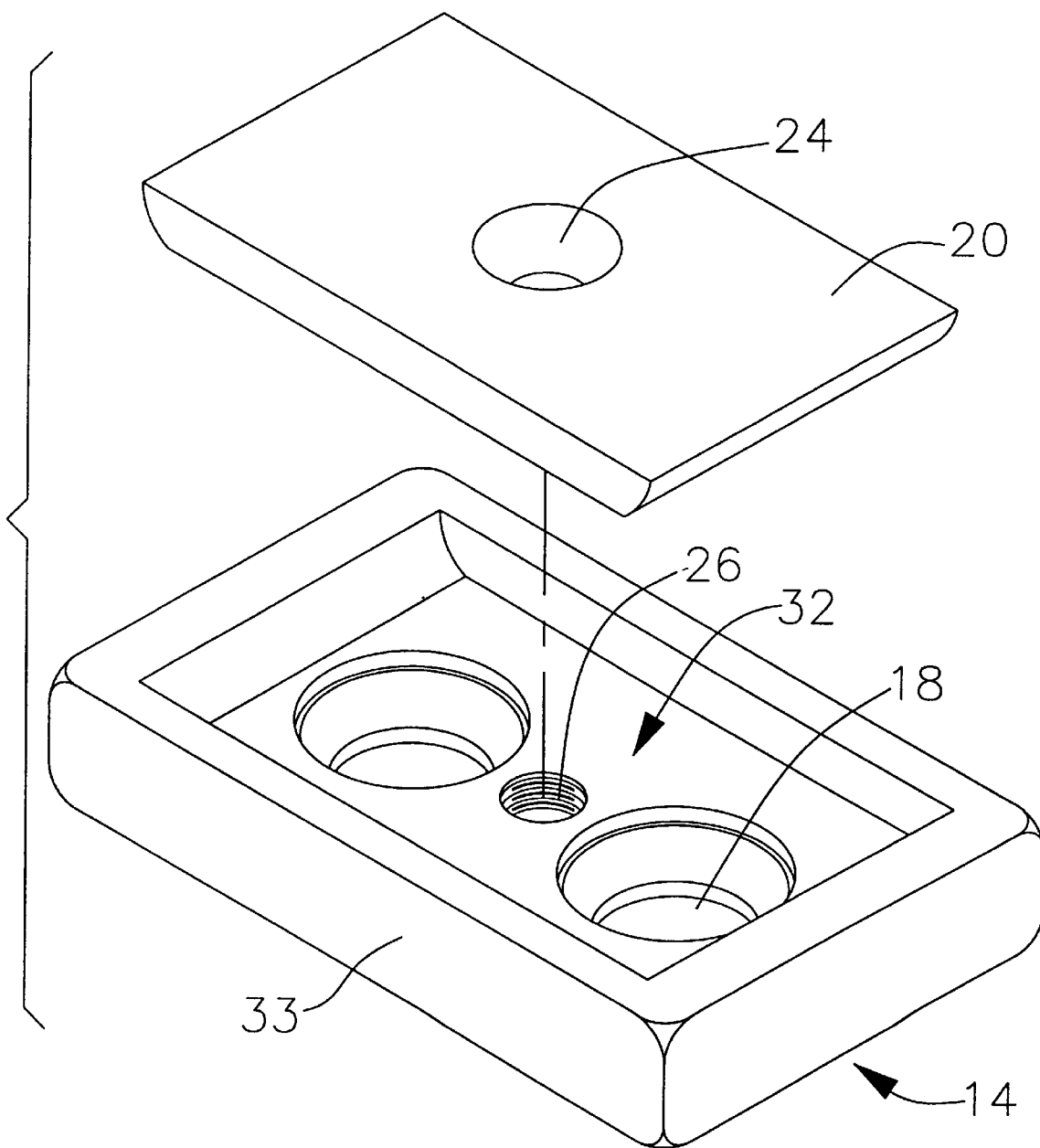
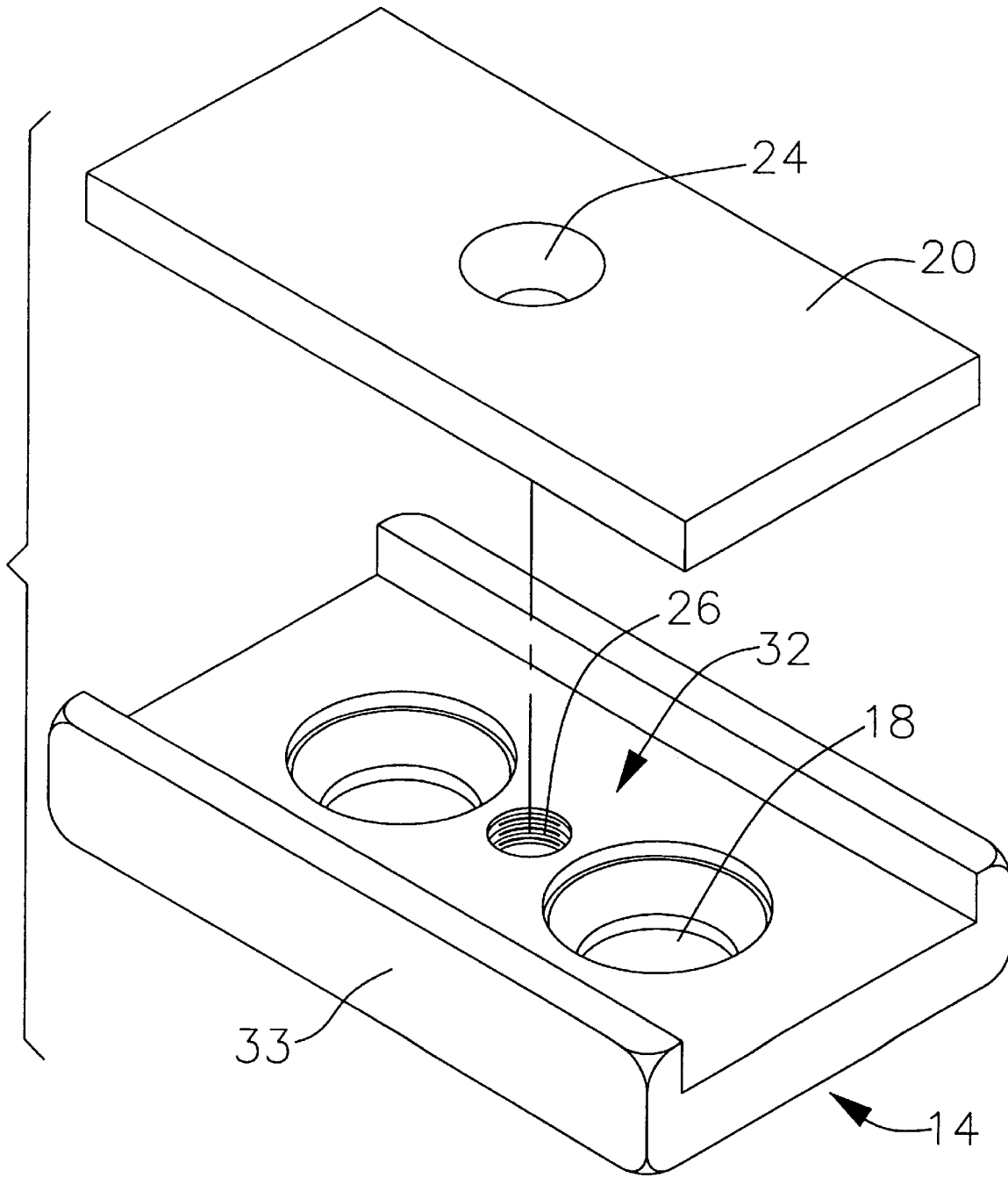


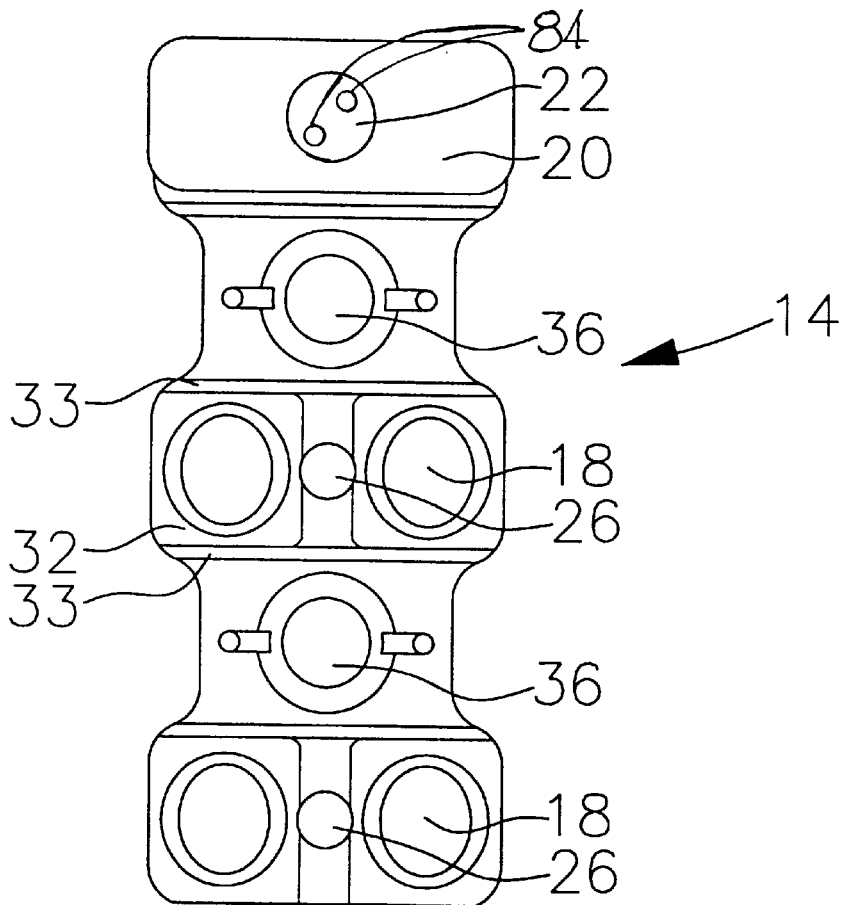
FIG. 6A



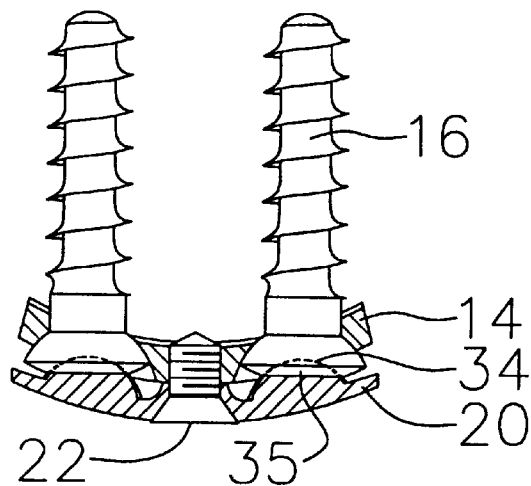
*FIG. 6B*



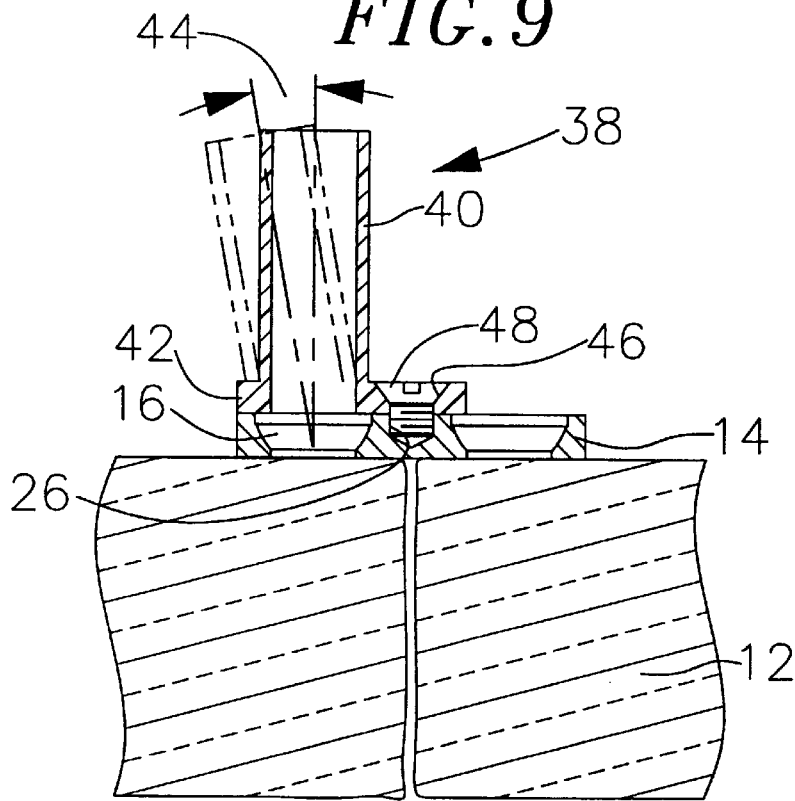
**FIG. 7**



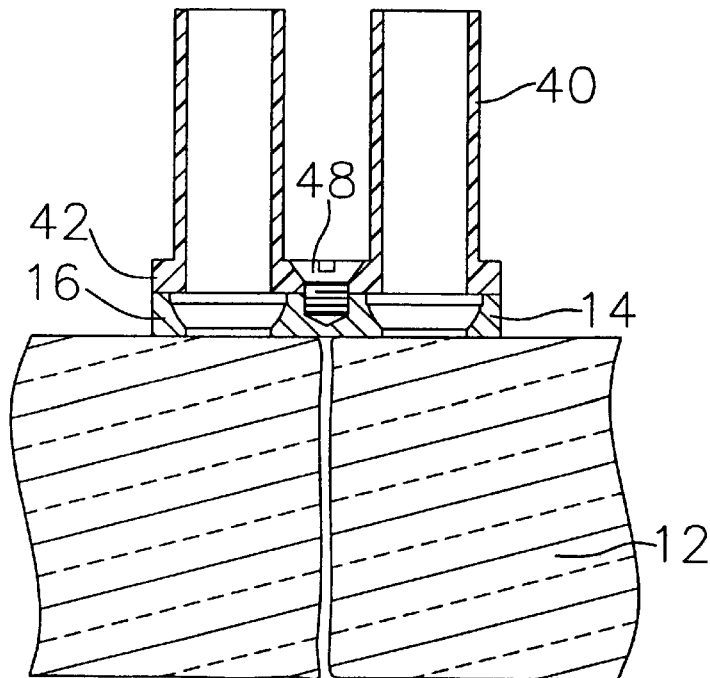
**FIG. 8**



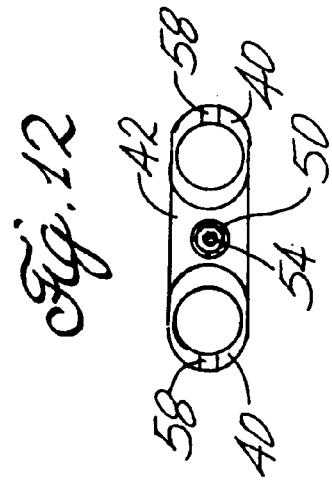
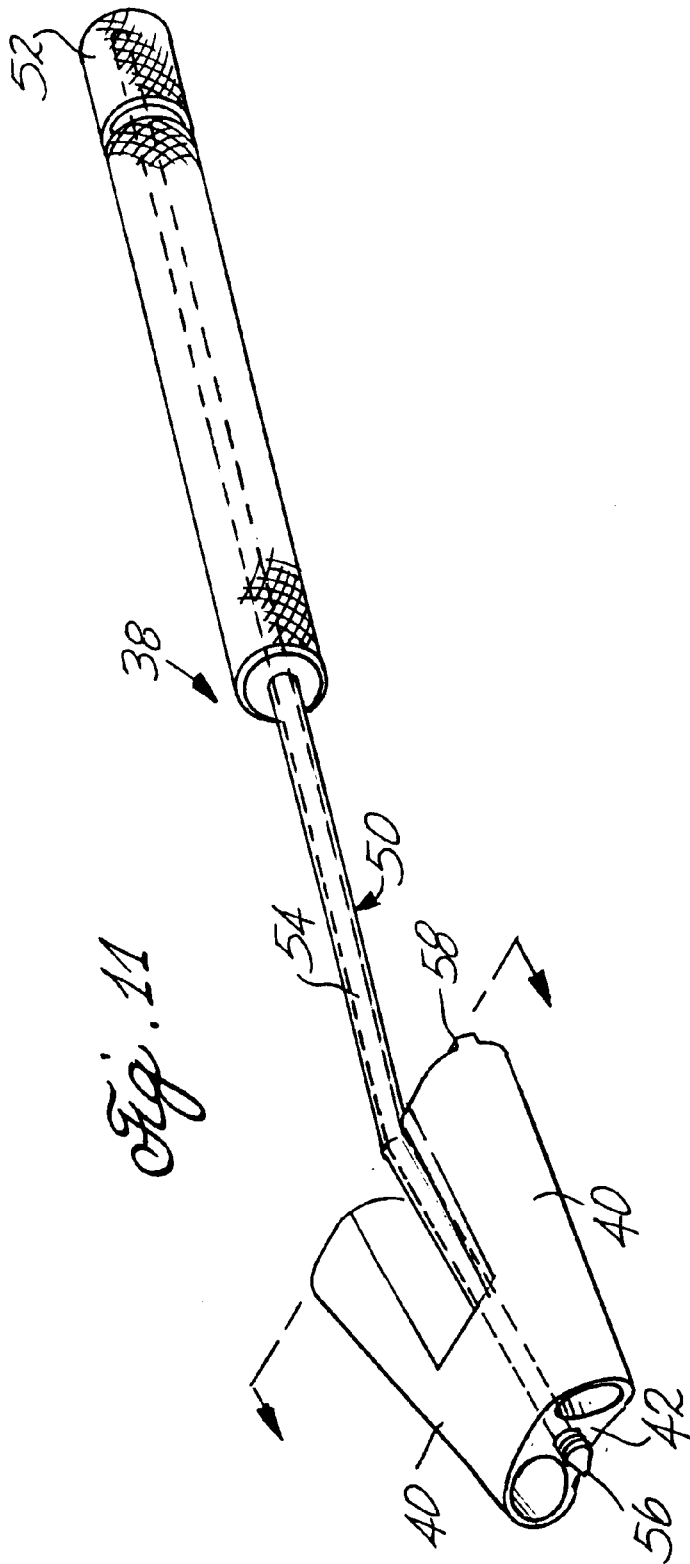
*FIG. 9*



*FIG. 10*







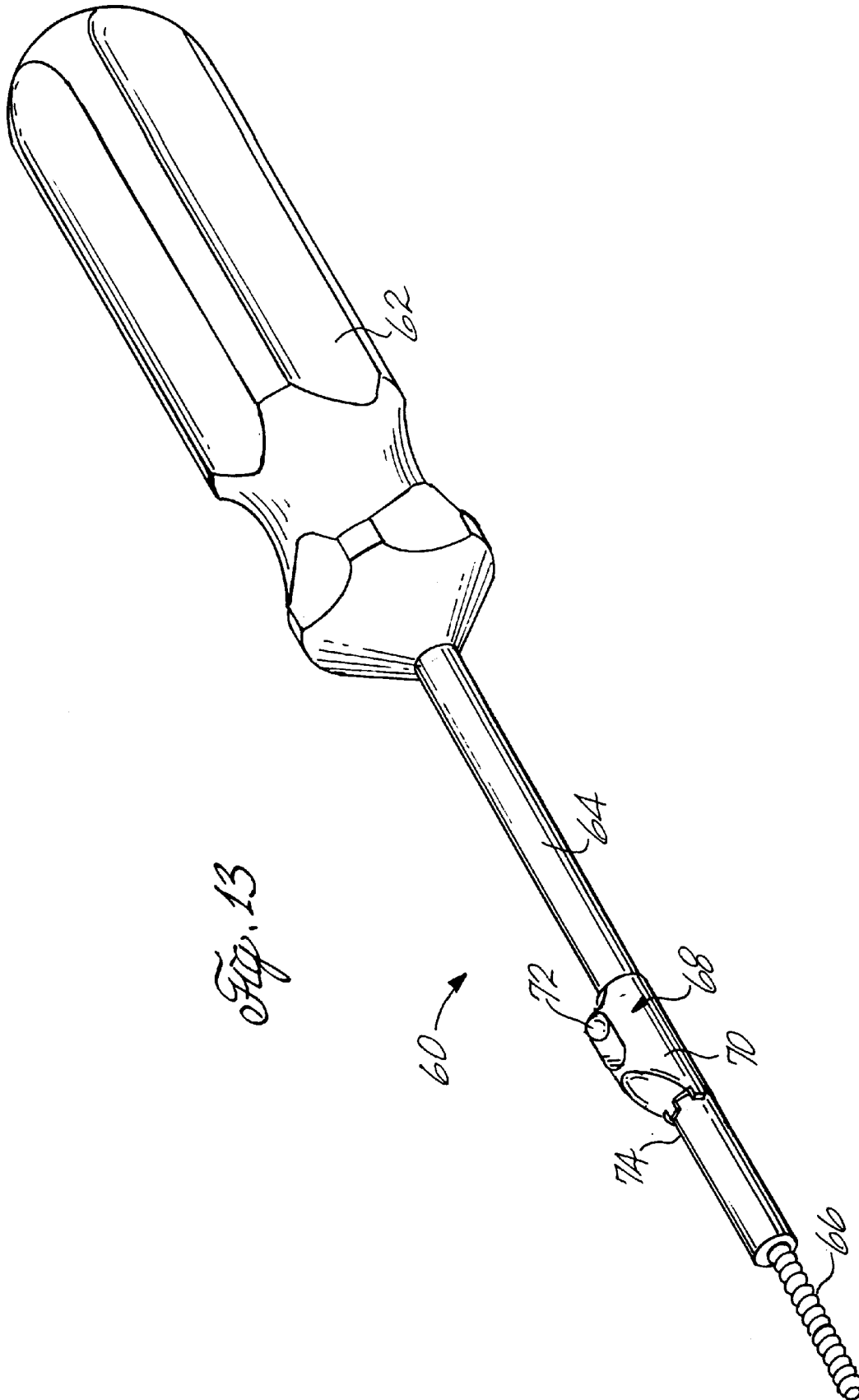
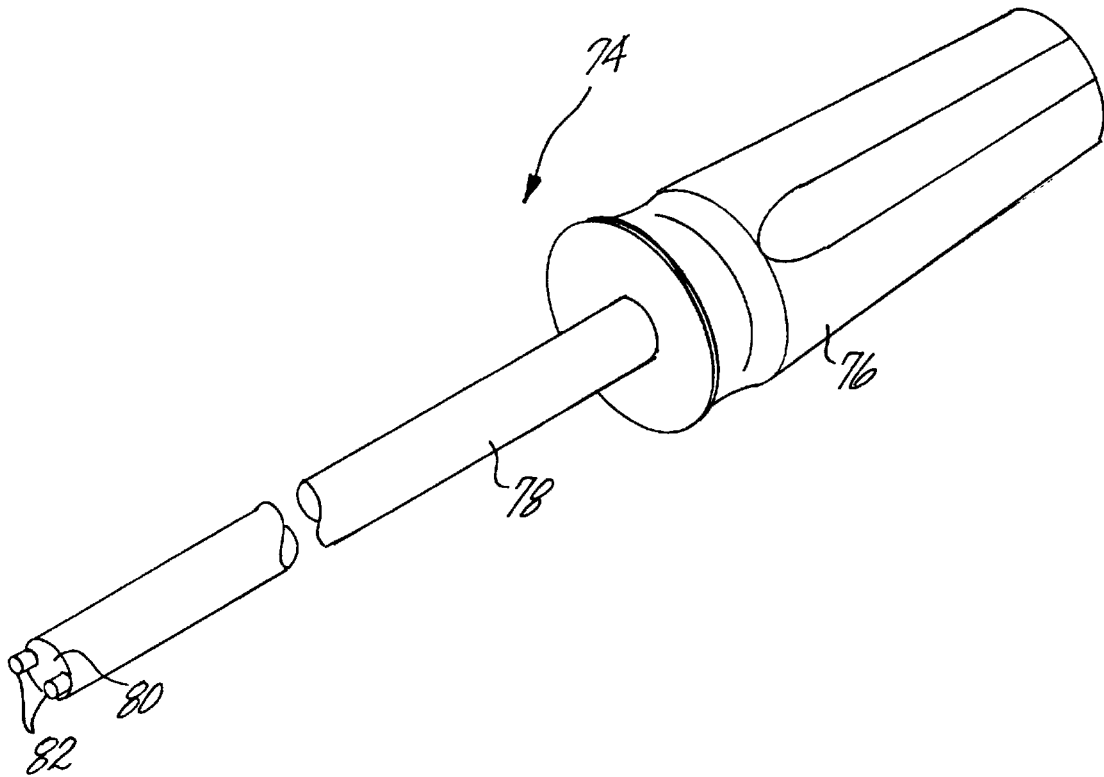


Fig. 13

*Fig. 14*



## BONE PLATE AND BONE SCREW GUIDE MECHANISM

This application claims benefit of Provisional Application Ser. No. 60/063,035, filed Oct. 24, 1997.

### FIELD OF THE INVENTION

The present invention is directed to a bone plate for assisting with the surgical arthrodesis (fusion) of two or more bones together, and a bone screw guide mechanism to assist in the proper drilling, tapping and placement of the bone screws to secure the plate.

### BACKGROUND OF THE INVENTION

The spinal column of vertebrates provides support to bear weight and protection to the delicate spinal cord and spinal nerves. The spinal column comprises a series of vertebrae stacked on top of each other. There are typically seven cervical (neck), twelve thoracic (chest), and five lumbar (low back) segments. Each vertebra has a cylindrical shaped vertebral body in the anterior portion of the spine with an arch of bone to the posterior which covers the neural structures. Between each vertebral body is an intervertebral disk, a cartilaginous cushion to help absorb impact and dampen compressive forces on the spine. To the posterior the laminar arch covers the neural structures of the spinal cord and nerves for protection. At the junction of the arch and anterior vertebral body are articulations to allow movement of the spine.

Various types of problems can affect the structure and function of the spinal column. These can be based on degenerative conditions of the intervertebral disk or the articulating joints, traumatic disruption of the disk, bone or ligaments supporting the spine, tumor or infection. In addition congenital or acquired deformities can cause abnormal angulation or slippage of the spine. Slippage (spondylolisthesis) anterior of one vertebral body on another can cause compression of the spinal cord or nerves. Patients who suffer from one of more of these conditions often experience extreme and debilitating pain, and can sustain permanent neurologic damage if the conditions are not treated appropriately.

One technique of treating these disorders is known as surgical arthrodesis of the spine. This can be accomplished by removing the intervertebral disk and replacing it with bone and immobilizing the spine to allow the eventual fusion or growth of the bone across the disk space to connect the adjoining vertebral bodies together. The stabilization of the vertebra to allow fusion is often assisted by a surgically implanted device to hold the vertebral bodies in proper alignment and allow the bone to heal, much like placing a cast on a fractured bone. Such techniques have been effectively used to treat the above described conditions and in most cases are effective at reducing the patient's pain and preventing neurologic loss of function. However, there are disadvantages to the present stabilization devices and to the available tools to implant them.

The spinal fixation device needs to allow partial sharing of the weight of the vertebral bodies across the bone graft site. Bone will not heal if it is stress shielded from all weight bearing. The fixation device needs to allow for this weight sharing along with the micromotion that happens during weight sharing until the fusion is complete, often for a period of three to six months or longer, without breakage. The device must be strong enough to resist collapsing forces or abnormal angulation during the healing of the bone. Loss

of alignment during the healing phase can cause a poor outcome for the patient. The device must be secure in its attachment to the spine to prevent migration of the implant or backout of the screws from the bone which could result in damage to the structures surrounding the spine, resulting in severe and potentially life threatening complications. The device must be safely and consistently implanted without damage to the patient.

Several types of anterior spinal fixation devices are in use currently. One technique involves placement of screws all the way through the vertebral body, called bicortical purchase. The screws are placed through a titanium plate but are not attached to the plate. This device is difficult to place, and overpenetration of the screws can result in damage to the spinal cord. The screws can back out of the plate into the surrounding tissues as they do not fix to the plate. Several newer generation devices have used a unicortical purchase of the bone, and in some fashion locking the screw to the plate to provide stability and secure the screw from backout. Problems have resulted from over ridged fixation and stress shielding, resulting in nonunion of the bony fusion, chronic micromotion during healing resulting in stress fracture of the fixation device at either the screw or the plate, insecure locking of the screw to the plate resulting in screw backout, or inadequate fixation strength and resultant collapse of the graft and angulation of the spine.

The conventional method for placing the bone screws entails drilling a hole, tapping the hole and threading the bone screw into the bone. To drill the hole a guide is held next to or attached to the plate. A drill is inserted into the guide and the hole drilled into the bone. The guide is removed and a tap is threaded through the hole attempting to follow the same angle as the drill hole. Caution must be used to prevent the sharp edges of the tap from damaging surrounding tissues or in creating too large a tap hole by toggling the handle of the tap. This will reduce the security of the screw bite into the bone and increases the likelihood of screw pullout. After tapping, the screw must be freehand guided at the proper angle into the hole created, inadvertent misalignment can reduce pullout strength or result in damage to surrounding nerves or arteries. Thus a need exists for a method of placing the screws that avoids these problems and risks to the patient.

### SUMMARY OF THE INVENTION

The present invention is directed to a bone plate for stabilizing adjacent vertebrae or holding two portions of a bone together, e.g., a broken bone, while it heals. The bone plate comprises a base plate having at least two screw holes, at least two bone screws, and a bone screw locking means. The preferred bone screw locking means is a retaining plate. The bone plate is placed over at least two different bones or bone portions, and the bone screws are placed into each bone or bone portion through the bone screw holes in the base plate. The retaining plate is placed over the heads of the bone screws and fixedly attached to the base plate to prevent the bone screws from backing out of the bone. The bone screws have heads shaped to allow the bone screws to toggle within the screw holes in the base plate, preferably radiused heads. By controlling the amount of toggle, one can control the amount of weight borne by the bone plate.

The present bone plates are particularly useful for spinal fixation. For such a use, the base plate can be part of a larger device or structure. An example of such a device is a disk replacement spacer for stabilizing a portion of the spine. Such a device is described, for example, in U.S. patent

application Ser. No. 08/764,089, the disclosure of which is incorporated herein by reference.

The present bone plates also can be used anywhere in the body where anti-backout is important, i.e., where it is important to be sure that bone screws will not back out. It also is particularly useful anywhere in the body where partial weight bearing of bone graft is important. Such uses include, for example, small figment bone sets from arm fractures, wrist fractures, ankle fractures, and hand fractures. The bone plate could also be used to secure hips in place, for femur fractures or the like.

The present invention is also directed to a bone screw guide mechanism for placing bone screws in the bones. The bone screw guide mechanism comprises a tubular member with open ends and a base fixedly attached at a predetermined angle to the tubular member at its bottom end. The base is mountable on the base plate of a bone plate so that the tubular member is generally coaxial with a bone screw hole in the base plate. Alternatively, the base can be mounted directly on the bone. Preferably, a handle is attached to the base or tubular member to provide ease of use. In a particularly preferred embodiment, an anchor screw is provided on the base of the bone screw guide mechanism to anchor the guide mechanism to the base plate during use.

The present invention is further directed to a method for inserting a bone screw into a bone through a base plate. A base plate having at least two bone screw holes is placed on a bone. The guide mechanism described above is placed on, and preferably mounted by means of a screw or the like, to the base plate so that the open bottom end of the tubular member is in communication the bone screw hole in the base plate. A drill is inserted through the tubular member and, through the bone screw hole, and a hole is drilled in the bone. Similarly, a tap is inserted through the tubular member to tap, i.e., create threads in the hole. A bone screw is then screwed into the drilled and tapped hole through the bone screw hole of the base plate. The guide mechanism can then be removed. Use of the inventive bone screw guide mechanism assures that the user will drill and tap the hole at virtually the identical angle, thereby avoiding inadvertent widening of the hole as occurs in current procedures.

#### DESCRIPTION OF THE DRAWINGS

These and other features and advantages of the present invention will be better understood by reference to the following detailed description when considered in conjunction with the accompanying drawings wherein:

FIG. 1 is a frontal view of a base plate according to the invention.

FIG. 2 is a side cross-sectional view of a bone screw locking mechanism according to the invention that is not assembled.

FIG. 3 is a side cross-sectional view of a bone screw locking mechanism according to the invention that is assembled.

FIG. 4 is a side cross-sectional view of a bone screw according to the invention illustrating the degree of toggle of the screw.

FIG. 5 is a side cross-sectional view of an alternative bone screw locking mechanism according to the invention where the retaining plate is situated in a recess in the base plate created by a raised structure on all four sides of the screw holes.

FIG. 6a is a projectional view of the bone plate of the embodiment of FIG. 5.

FIG. 6b is a projectional view of an alternative embodiment of the bone plate of FIG. 6a where the recess in the base plate is created by raised structures on only two sides of the screw holes.

FIG. 7 is a frontal view of another alternative bone screw locking mechanism according to the invention where the bone plate has six bone screw holes.

FIG. 8 is a side cross-sectional view of another embodiment of a bone screw locking mechanism according to the invention showing an alternative design for the bone screws and retaining plate.

FIG. 9 is a cross-sectional view of an embodiment of a bone screw guide mechanism of the invention having a single tubular member.

FIG. 10 is a cross-sectional view of an alternative embodiment of a bone screw guide mechanism of the invention having multiple tubular members.

FIG. 11 is a perspective view of an embodiment of a bone screw guide mechanism according to the invention that has a handle.

FIG. 12 is a cross-sectional view of the bone screw guide mechanism of FIG. 11 across line 12—12.

FIG. 13 is a perspective view of a tapping tool for use in connection with the invention.

FIG. 14 is a perspective view of a screwdriver for use in connection with the invention.

#### DETAILED DESCRIPTION

A particularly preferred bone plate constructed in accordance with the present invention is shown in FIGS. 1 to 3. The bone plate 10 comprises a base plate 14, at least two bone screws 16, and at least one bone screw locking means.

The base plate 14 is a generally flat surface used to connect two or more bones 12. As used herein, the term "bones" is intended to include both bones and bone fragments or portions. The base plate 14 can be of any suitable shape or size. In the illustrated embodiment, the base plate 14 is a generally rectangular plate. The base plate 14 can be any other suitable shape, such as an oval, square, circle, triangle, or kidney shape or a combination thereof. As discussed above, the base plate 14 can also be part of a larger device. The embodiment depicted in FIGS. 1 to 3, however, is an independent base plate, i.e., is not part of a larger device.

The base plate 14 can be made of any suitable material, and is preferably made of titanium or a titanium alloy. The base plate 14 is generally flat, but can be slightly curved to fit against the particular bones 12 being connected. The thickness of the base plate 14 is not critical. When the base plate is made of titanium or titanium alloy, a thickness of from about 0.5 mm to about 3 mm, and more preferably from about 1 mm to about 2 mm is preferred.

The base plate 14 contains at least two bone screw holes 18 for receiving the bone screws 16. When the base plate 14 has only two bone screw holes 18, they are situated far enough apart so that the bone screws 16 received by the screw holes 18 can screw into different bones 12. In the illustrated embodiment, the base plate 14 also contains at least one set screw aperture 26 for receiving a set screw 22. Preferably the set screw aperture 26 is located near the center of the base plate 14.

The bone screws 16 can be made of any suitable material, and are preferably made of the same material as the base plate, which in the preferred embodiment is titanium or a titanium alloy. Each bone screws 16 has a head 28 that is

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capable of toggling within the screw hole **18**, as depicted in FIG. **4**. Preferably the bone screws **16** have a radiused head. As used herein, the term “radiused head” means that the lower portion of the bone screw head **28**, i.e. the portion that is nearest the shank, is generally rounded. The bone screws **16** could have any other suitable shape that permits toggling, for example, where the portion nearest the shank is generally diagonal.

As shown in FIG. **2**, the top portion of each bone screw head **28** can be flat **28a**, slightly rounded **28b** or even hemispherical. The more rounded the top of the bone screw head **28**, the greater angle the bone screw **16** can toggle within the screw holes **18**. By controlling the maximum angle that the bone screws **16** can toggle within the screw hole, one can control, at least in part, the amount of weight borne by the base plate **14**.

Preferably the bone screw **16** can toggle within the screw hole **18** in at least two directions at an angle **30** of about 0 to about 20 or 30 degrees or more from normal depending on the circumstances. Still more preferably the bone screw **16** can toggle within the screw hole **18** in any direction at the above angles.

A bone screw locking means is any means for securedly covering at least one bone screw **16** so that the bone screw cannot back out from the bone **12** once screwed in through the base plate **14**. A preferred bone screw locking means comprises a retaining plate **20** and a retaining plate fixing means.

The retaining plate **20** is a generally flat or slightly curved plate that lies preferably flush against the bone plate **14**. The retaining plate **20** can be of any shape or size such that it covers at least a part of at least one bone screw **16**. More preferably the retaining plate **20** covers at least part of each bone screw **16** in an associated pair of bone screws **16**. However, multiple retaining plates **20** can be used to cover different bone screws **16**.

In the illustrated embodiment, the retaining plate **20** is a generally flat rectangular plate, similar to the base plate **14**. The retaining plate covers each bone screw **16** of an associated pair of bone screws. Preferably the retaining plate **20** covers 100 percent of the bone screw **16** or screws, but may cover less. Thus, when the retaining plate **20** is secured to the base plate **14**, the bone screws **16** cannot back out from the base plate **14**. The thickness of the retaining plate **20** preferably ranges from about 0.5 mm to about 2 mm, and more preferably from about 1 mm to about 1.5 mm.

The retaining plate **20** can be fixedly attached to the base plate **14** by any suitable retaining plate fixing means. In a preferred embodiment, the retaining plate **20** is attached to the base plate **14** with one or more set screws **22**. The set screw **22** is placed through a set screw hole **24** in the retaining plate **20**, inserted through the set screw aperture **26** in the base plate **14**, and tightened to secure the retaining plate **20** to the base plate **14**. The set screw can be made of any suitable material well known in the art, preferably titanium or a titanium alloy. In the preferred embodiment, the set screw is an hexagonal set screw that can be turned with an hexagonal driver. Other types of set screws can also be used.

An alternative embodiment of a bone plate according to the present invention is illustrated in FIGS. **5**, **6a** and **6b**. The bone plate **14** comprises a recess **32** for receiving the retaining plate **20**. The recess **32** can be any shape or size. Preferably the recess **32** and retaining plate **20** are of a similar shape and size such that the retaining plate **20** fits snugly within the recess **32**. The recess **32** is defined by a

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raised structure **33** that forms a boundary around at least a portion of the retaining plate area. FIG. **6a** depicts a recess **32** where the raised structure **33** surrounds all four sides of the retaining plate area. FIG. **6b** depicts an alternative embodiment of a recess **32** where the raised structure **33** is situated on only two sides of the retaining plate area. Alternatively, the raised structure **33** can be situated on only one side of the retaining plate area, as shown, for example, in FIG. **7**, discussed in more detail below.

The alternative embodiment depicted in FIG. **7** is particularly useful for fixation of three adjacent vertebrae. This design can be used in combination with a disk replacement spacer, such as that described in U.S. patent application Ser. No. 08/764,089. In the embodiment shown, the base plate **14** contains three pairs of associated screw holes **18**. With this design, two bone screws **16** are screwed into each vertebra **12**. Between each adjacent screw holes **18** of a pair of screw holes is a set screw hole **26**. A separate retaining plate **20** covers each pair of adjacent screw holes **18**. In FIG. **7**, the top pair of adjacent screw holes **18** is shown covered with a retaining plate **20**. In this embodiment, the base plate has raised ribs which extend adjacent **33** the long sides of each retaining plate **20**. The ribs **33** create a recess **32** for receiving the retaining plate **20**. This embodiment also contains spacer screw holes **36** for receiving spacer screws (not shown). The spacer screws allow the base plate **14** to be secured to a disk replacement spacer, such as that described in U.S. patent application Ser. No. 08/764,089. The spacer screw holes **36** are situated between the pairs of adjacent screw holes **18**.

FIG. **8** shows an additional embodiment of a bone plate having an alternative design for the bone screws **16** and retaining plate **20**. Each bone screw head **28** contains a depression **34**, preferably a rounded depression. At the nadir of the depression **34** is an hexagonal socket or the like so that the screw can be turned by an hexagonally shaped driver, e.g., an Allen wrench. The retaining plate **20** contains protrusions **35**, preferably hemispherically-shaped protrusions, preferably with radially extending ribs that correspond generally in shape, size and number to depressions **34** and fit within the depressions **34** in the bone screw heads **28**. As in the embodiments described above, the bone screw head **28** is a radiused head such that the bone screw **16** can toggle within the screw hole **18**.

Another aspect of the present invention is a bone screw guide mechanism **38** for putting in the bone screws **16**. As shown in FIG. **9**, the guide mechanism **38** comprises a generally tubular member **40** fixedly attached to a base **42**. The top and bottom ends of the tubular member **40** are open.

The tubular member **40** is at a predetermined angle **44** to the base **42** which is the same angle as the desired angle of the screw holes in the bone. In practice, the base **42** of the guide mechanism **38** is placed flush on a base plate **14** such that the open end of the tubular member **40** is in communication with the bone screw hole **16** in the base plate **14**.

The user can insert a drill through the tubular member **40** to drill a hole in the bone **12** through the bone screw hole **16**. The user can then tap the hole in the bone without removing the guide mechanism **38** by inserting a tapping tool through the tubular member **40**. Once the hole is drilled and tapped, the guide mechanism **38** is removed and a bone screw **16** is inserted into the screw hole **18** in the base plate **14**.

The angle of the tubular member is selected based on the particular application. Preferably the tubular member **40** forms an angle **44** with the base **42** ranging from about 0 to about 20 or 30 degrees or more from normal, more prefer-

ably from about 0 to about 15 degrees from normal. The tubular member **40** can be made of any suitable material and is preferably made of titanium or stainless steel. The length and inner diameter of the tubular member will vary according to the application and the size of the bone screws involved. Tubular members **40** typically have an inner diameter ranging from about 2 mm to about 7 mm. The thickness of the tubular member is not critical.

The base **42** can be of any suitable shape, but is preferably generally rectangular. The base **42** may be generally flat or have any other cross-sectional shape that permits it to lie preferably flush against the base plate **14**. Like the tubular member, the thickness of the base is not critical. Thicknesses of about 1 mm to about 4 mm are preferred.

The tubular member **90** and base **42** are preferably a one piece unitary construction. However, two piece constructions in which the tubular member **40** is fixedly attachable or even removably attachable to the base may be used.

Multiple guide mechanisms **38** where the tubular members **40** form different angles with the base **42** can be packaged in the form of a kit.

In a preferred embodiment, as shown in FIG. 9, the base **42** contains a screw hole **46** for receiving a lock screw **48**. The lock screw **48** can be used to fixedly attach the base **42** to a base plate **14**. The lock screw **48** is inserted through the screw hole **46** in the base **42** and through the set screw aperture **26** in the base plate **14**.

In the embodiment shown in FIG. 9, the guide mechanism **38** comprises a single tubular member. An alternative embodiment is shown in FIG. 10. In this embodiment, the guide mechanism **38** comprises two elongated tubular members **40** fixedly attached to a single base **42**. The base has a rectangular shape, but can have any shape similar to the base plate **14** with which it is to be used so that it can sit flush against the base plate. This base **42** design is particularly suitable for use with a base plate **14** as shown in FIG. 7, where each pair of adjacent bone screw holes **18** has two raised structures **33** on the longer sides of the rectangular section of the base plate **14** in which they are located. The base **42** can thus be placed into the recess **32** formed by the two raised structures **33**.

Any means for fixedly attaching or situating the base **42** on the base plate **14** can be used and are considered to be within the scope of the invention. If desired, the guide mechanism **38** may be designed to be mounted on the base plate **14** and held in place manually during drilling and tapping.

Another alternative embodiment of a bone screw guide mechanism **38** is depicted in FIGS. 11 and 12. Similar to the embodiments described above, the guide mechanism **38** comprises two generally tubular members **40** both fixedly attached to a base **42**. The top and bottom ends of each tubular member **40** are open. A handle **50** having proximal and distal end is anchored at its distal end to or near the base **42**. The handle **50** extends proximally away from the tubular members **40**. The proximal end of the handle **50** comprises a turnable knob **52**. The knob **52** is attached to a cable **54** having proximal and distal ends that extends within the handle **50**. The distal end of the cable **54** is attached to a threaded anchoring screw **56** that extends distally from the base **42**. Turning the knob **52** turns the cable **54**, which, in turn, turns the anchoring screw **56**.

In preferred practice, a base plate **14** is placed directly on the bone into which the screws are to be inserted, and the guide mechanism **38** is placed over the base plate **14**. The anchoring screw **56** is used to hold the bone screw guide

mechanism **38** in place against the base plate **14** by screwing the anchoring screw **56** into set screw aperture **26** of the base plate **14** until the face of the base **42** of the guide mechanism **38** is flush against the base plate **14**. A drilling tool having an elongated stem is inserted through each tubular member **40** to drill holes in the bone. If desired before drilling, a tack tool, a tool having an elongated stem and a removable sharp tack at its distal end, may be inserted through each tubular member and pushed distally so that the tack creates a starter hole in the bone to facilitate drilling. After drilling, a tapping tool is inserted through each tubular member to tap the drilled holes. The stems of the tack tool, drilling tool and tapping tool have generally the same diameter which is slightly less than the inner diameter of the tubular members **40** of the guide mechanism of such that the stems of the tools may be slidably received in the tubular members but are afforded no or almost no lateral "play." Following tapping, bone screws **16** are screwed into the drilled and tapped holes through the bone screw holes **18** in the base plate **14**.

The angle of the face of base **42** of the guide mechanism **38** determines the angle at which the bone screws **16** will be secured in the bone. For example, when the face of the guide mechanism base **42** is normal, i.e., 90° to the axis of the tubular members **40**, the holes drilled and tapped into the bone will be normal to the base plate **14** and to the face of the bone. Such a guide mechanism is referred to herein as an 0° guide. If the face of the base **42** of the guide mechanism **38** is at a selected angle other than 90° from the axis of the tubular members **40**, then the holes drilled and tapped into the bone will be at an angle other than normal to the base plate and face of the bone. A guide mechanism **38** which provides for the drilling and tapping of holes at an angle 15° above that created by an 0° guide is referred to herein as a 15° guide and so on.

The proximal end of each tubular member **40** of the guide mechanism **38** comprises a protrusion **58**. This feature is beneficial when the bone screw guide mechanism **38** is used with the tapping tool **60** depicted in FIG. 13. The tapping tool **60** comprises a handle **62**, a stem **64**, and a threaded tap **66**. Mounted on the stem **64** is an adjustable depth guide **68**. The depth guide **68** comprises a slidable housing **70** and a spring loaded pin **72**. When pressure is exerted on the pin **72**, the slidable housing **70** can be slid between two or more positions along the length of the stem **64**. The position of the depth guide **68** on the stem **64** dictates the depth that the tap **66** and stem **64** can be inserted into the tubular member **40** of the guide mechanism **38**. The housing **70** comprises protrusions **72** at its distal end. As the tapping tool **60** is rotated within the tubular member **40** of the guide mechanism **38** and reaches the depth dictated by the depth guide **68**, one of the protrusions **72** on the depth guide housing will engage protrusion **58** on the tubular member **40** of the guide mechanism, preventing further rotation of the tapping tool **60**. This mechanism prevents stripping of the tapped hole in the bone that would result from further rotation of the tapping tool **60**.

The depth guide **38** described above is also useful for the drilling tool. However, for a drilling tool, it is unnecessary to include protrusions on the depth guide housing.

An additional tool useful in connection with the present invention, a screwdriver, is depicted in FIG. 14. The screwdriver **74** comprises a handle **76**, a stem **78**, and a head **80**. The head **80** comprises two rounded protrusions **82**, generally on opposite sides of the head. The protrusions **82** fit into corresponding holes **84** provided in the head of a screw, for example, as shown in FIG. 7. It is understood that the number and shape of the protrusion, **82** may vary as desired.

For example, a single axial hexagonal protrusion may be used in conjunction with screws having a corresponding axial hexagonal hole in the screw head.

Further, it is understood that, if desired, the guide mechanism of the type described above may comprise only a single tubular member along with a handle. Means may or may not be provided for anchoring the guide mechanism to a base plate **14**. Consequently, a guide mechanism used entirely free hand is contemplated by and within the scope of this invention.

It is presently preferred to provide a kit having base plates of differing sizes, bone screws of differing lengths and locking plates complementary to the base plates. The kit may further comprise one or more guide mechanisms, preferably at least an  $0^\circ$  guide and a  $15^\circ$  guide, a tack tool, a drilling tool, tapping tool and/or one or more screw driving tools.

While embodiments and applications of this invention have been shown and described it would be apparent to those skilled in the art that many more modifications are possible without departing from the inventive concepts herein. The invention, therefore, is not to be restricted except in the spirit of the appended claims.

What is claimed is:

**1.** A bone plate comprising:

a base plate having at least two screw holes;

at least two bone screws capable of securing the bone plate to a bone by insertion through the screw holes into the bone, wherein the bone screws have heads shaped to toggle within the screw holes; and

a bone screw locking means capable of securedly covering the bone screws so that the bone screws cannot back out from the bone once screwed in through the base plate;

wherein the bone screws and bone screw locking means are designed such that when the bone screw locking means covers the bone screws and is fixedly attached to said base plate, the top of each bone screw mates with the bone screw locking means and each bone screw can toggle within its corresponding screw hole.

**2.** A bone plate according to claim **1**, wherein the bone screw locking means comprises:

a retaining plate fixedly attachable to the base plate, wherein the retaining plate covers at least a portion of each of the bone screws, and

a retaining plate fixing means for fixedly attaching the retaining plate to the base plate.

**3.** A bone plate according to claim **2**, wherein the fixing means comprises a set screw and wherein the base plate also has a set screw aperture.

**4.** A bone plate according to claim **2**, wherein the retaining plate covers 100 percent of at least one bone screw.

**5.** A bone plate according to claim **1**, wherein each bone screw can toggle within the corresponding screw hole in at least two directions at an angle of about  $0$  to about  $20$  degrees from normal.

**6.** A bone plate according to claim **1**, wherein each bone screw can toggle within the corresponding screw hole in at least two directions at an angle of about  $0$  to about  $15$  degrees from normal.

**7.** A bone plate according to claim **1**, wherein each bone screw can toggle within the corresponding screw hole in any direction at an angle of about  $0$  degrees to about  $20$  degrees from normal.

**8.** A bone plate according to claim **1**, wherein each bone screw can toggle within the corresponding screw hole in any direction at an angle of about  $0$  to about  $15$  degrees from normal.

**9.** A bone plate according to claim **1**, wherein each bone screw has a radiused head.

**10.** A bone plate according to claim **2**, wherein each bone screw head contains a depression and wherein the retaining plate contains protrusions that correspond in shape, size and number to and that are capable of fitting within the depressions in the bone screw heads.

**11.** A bone plate according to claim **10**, wherein each bone screw has a radiused head.

**12.** A bone plate according to claim **1**, wherein the base plate comprises at least two pairs of adjacent screw holes.

**13.** A bone plate according to claim **1**, wherein the base plate is made of titanium or a titanium alloy.

**14.** A bone plate comprising a base plate having two screw holes and a set screw hole between the screw holes;

two bone screws capable of securing the bone plate to a bone by insertion through the screw holes into the bone;

a retaining plate fixedly attachable to the base plate, wherein the retaining plate has a size sufficient to cover the bone screws and a set screw aperture extending therethrough so that the set screw aperture is aligned with the set screw hole in the base plate when the retaining plate is placed on the base plate; and

a set screw for fixedly attaching the retaining plate to the base plate by extending through the set screw aperture in the retaining plate and into the set screw hole in the base plate;

wherein the bone screws and retaining plate are designed such that, when the retaining plate covers the bone screws the top of each bone screw mates with the retaining plate and the covered bone screws can toggle within the screw holes.

**15.** A bone plate according to claim **14**, wherein each bone screw has a radiused head.

**16.** A bone plate according to claim **14**, wherein each bone screw head contains a depression and wherein the retaining plate contains protrusions that correspond in shape, size and number to and that are capable of fitting within the depressions in the bone screw heads.

**17.** A bone plate according to claim **16**, wherein each bone screw has a radiused head.

**18.** A bone plate according to claim **14**, wherein each bone screw can toggle within the corresponding screw hole in at least two directions at an angle of about  $0$  to about  $20$  degrees from normal.

**19.** A bone plate according to claim **14**, wherein each bone screw can toggle within the corresponding screw hole in at least two directions at an angle of about  $0$  to about  $15$  degrees from normal.

**20.** A bone plate according to claim **14**, wherein each bone screw can toggle within the corresponding screw hole in any direction at an angle of about  $0$  to about  $20$  degrees from normal.

**21.** A bone plate according to claim **14**, wherein each bone screw can toggle within the corresponding screw hole in any direction at an angle of about  $0$  to about  $15$  degrees from normal.

**22.** A bone plate according to claim **14**, wherein the base plate and retaining plate are both made of titanium or a titanium alloy.

**23.** A bone plate comprising a base plate having two screw holes, a set screw hole between the screw holes and at least two raised edges; two bone screws capable of securing the base plate to a bone by insertion through the screw holes into the bone



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wherein each bone screw is adapted to toggle within each screw hole;

- a retaining plate fixedly attachable to the base plate, wherein the retaining plate has a size sufficient to cover the bone screws and fit within the at least two raised edges, and wherein the retaining plate includes a set screw aperture extending therethrough so that the set screw aperture is aligned with the set screw hole in the base plate when the retaining plate is placed on the base plate; and
- a set screw for fixedly attaching the retaining plate to the base plate by extending through the set screw aperture in the retaining plate and into the set screw hole in the base plate.

24. A bone plate according to claim 23, wherein the bone screws have heads shaped to toggle within the screw holes, and wherein, in use, the bone screw locking means covers the at least one bone screw, and the at least one covered bone screw can toggle within its corresponding screw hole.

25. A bone plate according to claim 23, wherein each bone screw has a radiused head.

26. A bone plate according to claim 23, wherein each bone screw head contains a depression and wherein the retaining

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plate contains protrusions that correspond in shape, size and number to and that are capable of fitting within the depressions in the bone screw heads.

27. A bone plate according to claim 26, wherein each bone screw has a radiused head.

28. A bone plate according to claim 23, wherein each bone screw can toggle within the corresponding screw hole in at least two directions at an angle of about 0 to about 20 degrees from normal.

29. A bone plate according to claim 23, wherein each bone screw can toggle within the corresponding screw hole in at least two directions at an angle of about 0 to about 15 degrees from normal.

30. A bone plate according to claim 23, wherein each bone screw can toggle within the corresponding screw hole in any direction at an angle of about 0 to about 20 degrees from normal.

31. A bone plate according to claim 23, wherein each bone screw can toggle within the corresponding screw hole in any direction at an angle of about 0 to about 15 degrees from normal.

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