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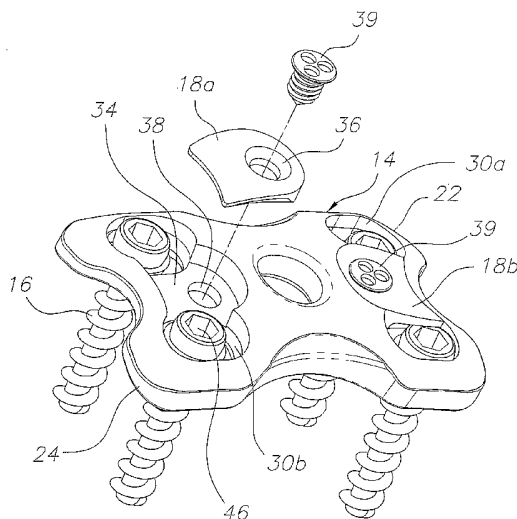
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(54) Title: SLIDABLE BONE PLATE SYSTEM



(57) Abstract: The invention is directed to a bone plate system. The bone plate system comprises a base plate having two generally parallel elongated screw slots extending therethrough. Two bone screws are provided that are capable of securing the base plate to a bone by insertion through the screw slots into the bone. Each bone screw has a screw head and a threaded portion extending therefrom. An interference device is attached to the base plate and retains the bone screws while permitting the bone screws to toggle and to controllably slide in the screw slots of the base plate. This design is particularly useful for joining adjacent vertebral bodies, as it permits controlled settling of the vertebral bodies, thereby enhancing the healing process.

SLIDABLE BONE PLATE SYSTEM

BACKGROUND

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 that 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. Anterior slippage of one vertebral body on another (spondylolisthesis) 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.

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.

SUMMARY OF THE INVENTION

The present invention is directed to a bone plate system that addresses one or more of the above drawbacks. In one embodiment, the bone plate system comprises a base plate having two generally parallel elongated screw slots extending therethrough. Two bone screws are provided that are capable of securing the base plate to a bone by insertion through the screw slots into the bone. Each bone screw has a screw head and a threaded portion extending therefrom. An interference device is attached to the base plate and retains the bone screws while permitting the bone screws to toggle and to controllably slide in the screw slots of the base plate. This design is particularly useful for joining adjacent vertebral bodies, as it permits controlled settling of the vertebral bodies, thereby enhancing the healing process.

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 perspective view of a bone plate system according to the invention.

FIG. 2 is a top view of the bone plate system of FIG. 1.

FIG. 3 is a side view of the bone plate system of FIG. 1.

FIG. 4 is an end view of the bone plate system of FIG. 1.

FIG. 5 is an end cross-sectional view of the bone screws inserted through the bone plate and covered by the interference device of a bone plate system as depicted in FIGs. 1 to 4.

DETAILED DESCRIPTION

An exemplary embodiment of a bone plate system according to the present invention is shown in FIGs. 1 to 5. The depicted bone plate system is particularly useful for stabilizing two or more vertebral bodies to allow fusion by holding the vertebral bodies in proper alignment, and thus allowing the bone to heal. The bone plate system of the invention is preferably weight-sharing over a period of at least about three months, and more preferably over a period of at least about six months. As used herein, the term "weight-sharing" as describing the system means that the system allows for partial sharing of the weight of one or more vertebral bodies across a bone graft site.

Generally, the bone plate system comprises a base plate 14, bone screws 16, and one or more interference devices 18. The base plate 14 is a plate used to connect two or more bones. 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 for the desired application.

In the depicted embodiment, the base plate 14 is a generally rectangular plate having two relatively long, generally parallel sides 20, a top end 22 and a bottom end 24, with the top end and bottom end also being generally parallel and shorter than the sides, as shown in FIG. 2. In the illustrated embodiment, each of the sides 20, top end 22 and bottom end 24 includes a region that is scalloped or concave. The concave regions are preferably located along the midsections of each of the sides 20, top end 22 and bottom end 24. As discussed further below, this scalloped or concave design is particularly desirable to prevent the base plate 14, when implanted, from interfering with the esophagus of the patient.

When viewed from a side 20, the base plate 14 has a bottom surface that is slightly concave (along the length of the base plate), as best shown in FIG. 3. Similarly, when viewed from the top end 22 or the bottom end 24, the bottom surface of the base plate 14 is slightly concave (along the width of the base plate), as best shown in FIG. 4. This design permits the base plate 14 to be curved in the sagittal and horizontal planes to provide a better fit when implanted in a patient.

In one embodiment, the sides 20 each having a length ranging from about 20 mm to about 40 mm, and the top and bottom ends 22 and 24 each having a length ranging from about 14 mm to about 20 mm. The dimensions of the base plate 14 can vary depending upon the size of

the patient in whom the plate is to be introduced. Further, the base plate 14 can have any other suitable shape, such as an oval shape.

The base plate 14 can be made of any suitable material, and is preferably made of titanium or a titanium alloy. If desired, the base plate 14 can also be part of a larger device.

5 The base plate 14 contains at least two bone screw slots 30 for receiving the bone screws 16. In the depicted embodiment, the base plate 14 contains four bone screw slots 30 arranged in two pairs. The bone screw slots 30a of the first pair are located nearer the top end 22 of the base plate 14, and the bone screw slots 30b of the second pair are located nearer the plate's bottom end 24. The bone screw slots 30a of the first pair are generally parallel to each other and
10 to the sides 20 of the base plate 14. Similarly, the bone screw slots 30b of the second pair are generally parallel to each other and to the sides 20 of the base plate 14. The first pair of bone screw slots are 30a preferably generally aligned with the second pair of bone screw slots 30b and the pairs of slots positioned relative to the sides 20 and top and bottom ends 22 and 24 of the base plate 14 so as to create a generally symmetrical arrangement about the center of the base
15 plate, as best shown in FIG. 2. The distance D1 between the pairs preferably ranges from about 6 mm to about 14 mm. The distance D2 between the slots 30a of the first pair preferably ranges from about 4 mm to about 8 mm.

In the depicted embodiment, all of the slots 30 have the same dimensions. The length of each slot preferably ranges from about 4 mm to about 8 mm, more preferably from about 6 mm
20 to about 7 mm, still more preferably about 6.6 mm. The width of each slot preferably ranges from about 3 mm to about 6 mm, more preferably from about 4 mm to about 5.5 mm, still more preferably about 4.8 mm.

The depicted base plate 14 is particularly designed for the portion of the plate nearer the top end 22 to be attached to one vertebral body and the portion of the plate nearer the bottom
25 end 24 to be attached to another vertebral body so that the plate is mounted in a vertical arrangement. The plate 14 has a bottom surface 26 that, in use, is adjacent to one or more of the bone surfaces, and a top surface 28 that faces away from the bone surface(s).

In the depicted embodiment, the bottom and top surfaces 26 and 28 are generally parallel to one another over a center region of the base plate 14, which encompasses the slots 30, so that
30 in the center region the base plate has a generally uniform thickness, although the plate need not have a uniform thickness in this region. The top and bottom ends 22 and 24 of the base plate 14

are generally tapered, being thicker closer to the slots 30 and thinner closer to the edge of the plate 14, so that the bottom and top surfaces 26 and 28 are not parallel to one another at the top and bottom ends. Preferably the center region of the base plate 14, which encompasses the slots 30, has a thickness ranging from about 1 mm to about 4 mm, more preferably from about 2 mm to about 3 mm, still more preferably about 2.8 mm. The tapered top and bottom ends 22 and 24 each preferably taper to an edge thickness ranging from about 0.5 mm to about 2 mm, more preferably from about 0.5 mm to about 1.5 mm, still more preferably about 1 mm. The top and bottom ends 22 and 24 preferably taper at an angle ranging from about 20° to about 40°. This tapered end design is particularly beneficial in vertebral applications where the base plate 14 comes into contact with the esophagus. With the inventive tapered design, the esophagus is not positioned over a sharp corner, as in many plate designs, but instead is provided with a smooth transition surface as it passes over the inventive base plate, minimizing damage to the esophagus. In an alternative embodiment, only the top end 22 is provided with the tapered design, as the top end has the leading edge over which the esophagus interfaces. The tapered design in combination with the scalloped or concave design, discussed above, further enhances the ability of the plate system to avoid causing dysphagia.

The bone plate system of the invention includes a number of bone screws 16 that corresponds to the number of bone screw slots 30, which in the depicted embodiment is four. In use, the bone screws 16 extend through the bone screw slots 30 in the base plate 14 and are screwed into the bone. The bone screws 16 can be made of any suitable material, and are preferably made of the same material as the base plate, such as titanium or a titanium alloy. The shape and function of the bone screws are described in more detail below.

One or more interference devices 18 are provided to retain the bone screws 16 that extend through the bone screw slots 30 in the base plate 14. By “retain” is meant that a interference device 18 covers a sufficient portion of a bone screw 16 to prevent that bone screw from “backing out” out of the bone and base plate 14. The terminology “retain” is not intended to require that the entire top surface, or even the majority of the top surface, of a bone screw 16 be covered.

In the depicted embodiment, the bone plate system includes two interference devices 18, each one for retaining a corresponding one of the two pairs of bone screws 16, so that one interference device 18a is provided nearer the bottom end 24 of the base plate 14 and the other

interference device 18b is provided nearer the top end 22 of the base plate, as best shown in FIG.

1. Each interference device 18 is generally rectangular having a rounded top edge.

The thickness of each interference device 18 preferably ranges from about 0.5 mm to about 2 mm, and more preferably from about 1 mm to about 1.5 mm. As shown best in FIGs. 1 and 3, the edge of each interference device 18 that is positioned nearest the corresponding top or bottom end 22 or 24 of the base plate 14 is tapered in a manner similar to the top and bottom ends of the base plate.

In use, the interference devices 18 are removably fixedly attached to the base plate 14. As used herein, the term "fixedly attached" refers to the arrangement where the interference device 18, while being removably attached to the base plate 14, cannot slide relative to the base plate. The base plate 14 is preferably provided with recesses 34 to receive the interference devices 18 and retain them in the desired position. The interference devices 18 can be removably attached to the base plate 14 by any suitable mechanism. In the depicted embodiment, each interference device 18 is provided with a cover screw hole 36.

The base plate 14 is provided with two cover screw apertures 38 that generally correspond in size and location to the cover screw holes 36 in the interference devices 18 when the interference devices are correctly positioned over the base plate. In the depicted embodiment, the cover screw apertures 38 are offset from the bone screw slots 30 in the base plate 14, as best shown in FIG. 1. By "offset" is meant that the cover screw aperture 38 is provided at a position that does not fall on a line that passes through the centers of the bone screw slots 30, but instead that is offset from such a line, preferably in a direction closer to the center of the base plate 14.

To removably attach an interference device 18 to a base plate 14, a cover screw 39 is screwed into the cover screw hole 36 in the interference device and a corresponding cover screw aperture 38 in the base plate, as is generally known in the art. However, other mechanisms for attaching a interference device to a base plate known to those skilled in the art could also be used in accordance with the invention. If a different mechanism for attaching an interference device 18 is used, the point of attachment to the base plate 14 is preferably offset from the bone screw slots 30.

FIG. 5 shows how the bone screws 16 are positioned relative to a base plate 14 and interference device 18. Each bone screw 16 comprises a screw head 15 and a threaded

portion 17 extending from the screw head. Each bone screw head 15 has a generally rounded top surface 40, optionally with a generally flat center region 42, and a generally rounded bottom surface 44. The center region 42 of the generally rounded top surface 40 includes a hexagonal or other shaped aperture 46, as shown in FIGs. 1 and 2, for receiving the end of an insertion tool, as is generally known in the art.

Within the base plate 14, each bone screw slot 30 has a generally rounded edge surface 48 that interfaces with the bottom surface 44 of a corresponding bone screw head 15. An elongated axial opening 50 is provided along the bottom of each bone screw slot 30 to receive the threaded portion 17 of the bone screw 16 as the bone screw slides in the slot. The rounded edge surface 48 of the bone screw slot 30 joins the top surface 28 of the bone plate 14 to a top edge of the axial opening 50. The axial opening 50 has a width less than the width of the top portion of the bone screw slot 30, i.e., the portion of the bone screw slot receiving the screw head 15.

The interference device 18 has two generally rounded edge surfaces 52 that interfaces with the edges of the generally rounded top surfaces 40 of the bone screw heads 15 while not substantially covering the center region 42 of the bone screw head, to thereby prevent the bone screw 16 from backing out of the base plate 14. This design permits each bone screw 16 to toggle within its corresponding bone screw slot 30 while the interference device 18 still exerts sufficient force on the bone screw to control the degree to which the bone screw slides within the bone screw slot 30.

In the depicted embodiment, the rounded top surface 40 of each bone screw 16 has a maximum outer diameter less than the maximum outer diameter of the screw's rounded bottom surface 44. With this design, the rounded bottom surface 44 can be made sufficiently large to prevent the head of the bone screw 16 from passing through bone screw slot 30, while the rounded top surface 40 is smaller to permit the interference device 18 to still lower on the base plate 14, thus further reducing interference between the plate system and the esophagus.

In one embodiment, the interface of the top surface 40 of the bone screw head 15 and the edge surface 52 of the interference device 18 is provided to require a minimum force to cause the bone screw 16 to slide within the bone screw slot 30, thus permitting the bone screws to controllably slide in the bone screw slots. The minimum force preferably ranges from about 15 to about 50 pounds, more preferably from about 30 to about 40 pounds. The system can be

advantageously arranged to permit the bone screw 16 to both settle in a direct vertical plane of 1.5 to 2 mm and pivot under the interference device 18.

The offset location of the anchor or attachment point (i.e., the cover screw) of the interference device 18 to the base plate 14 advantageously provides increased resistance to screw sliding and toggling as vertebral bodies joined by the plate begin to settle. Specifically, when the bone screws 16 are first introduced into vertebral bodies through the base plate 14, they are introduced into the bone screw slots 30 closer to the top and bottom ends of the base plate (i.e., farther from the center of the base plate). In this location, the bone screws are permitted to toggle and slide fairly easily, which is desirable because it advantageous to permit the plate system to initially engage the vertebral bodies and permit the vertebral bodies to settle on the graft fairly quickly. After initial settling has occurred, the base plate 14 moves relative to the bone screws 16, thereby positioning the bone screws closer to the center of the base plate. As the bone screws move toward the center of the base plate 14, they also move nearer the cover screw or other point of attachment between the interference device and the base plate. At this point of attachment, the interference device exerts the greatest force on the bone screws 16. Thus, as the bone screws 16 move toward the point of attachment, the incremental force required to further move the bone screws toward the point of attachment (and thus toward the center of the plate) increases. Thus, the plate system advantageously controls further settling, thereby preventing the vertebral bodies from collapsing too quickly.

The preceding description has been presented with reference to presently preferred embodiments of the invention. Workers skilled in the art and technology to which this invention pertains will appreciate that alterations and changes in the described structures may be practiced without meaningfully departing from the principal, spirit and scope of this invention. Accordingly, the foregoing description should not be read as pertaining only to the precise structures described and illustrated in the accompanying drawings, but rather should be read consistent with and as support to the following claims which are to have their fullest and fair scope.

Claims:

1. A bone plate system comprising:

a base plate having two generally parallel elongated screw slots extending therethrough;

5 two bone screws capable of securing the base plate to a bone by insertion through the screw slots into the bone, each bone screw having a screw head and a threaded portion extending therefrom;

an interference device attached to the base plate and retaining the bone screws while permitting the bone screws to toggle and to controllably slide in the screw slots of the base plate.

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2. The bone plate system of claim 1, wherein the screw slots are approximately the same length.

3. The bone plate system of claim 1, wherein the interference device is attached to the base plate with a cover screw that extends through a cover screw hole in the interference device and into a cover screw hole in the base plate.

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4. The bone plate system of claim 3, wherein the cover screw hole in the base plate is offset from the bone screw slots in the base plate.

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5. The bone plate system of claim 1, wherein the interference device is attached to the base plate at a location that is offset from the bone screw slots in the base plate.

6. The bone plate system of claim 1, wherein the base plate has a bottom surface that is slightly concave along its length and along its width.

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7. The bone plate system of claim 1, wherein:

each bone screw head has a generally rounded top surface with a center region and a generally rounded bottom surface;

each screw slot in the base plate has a generally rounded edge surface that interfaces with the bottom surface of a corresponding bone screw head; and

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the interference device includes a generally rounded edge surface that interfaces with the generally rounded top surface of a corresponding bone screw head while not substantially covering the center region of the top surface of the bone screw head.

5 8. The bone plate system of claim 7, wherein, on each bone screw, the rounded top surface extends to a maximum diameter and the rounded bottom surface extends to a maximum diameter that is greater than the maximum diameter of the rounded top surface.

10 9. The bone plate system of claim 7, wherein an interface between the top surface of the bone screw head and the edge surface of the interference device requires a minimum force ranging from about 15 to about 50 pounds to cause the bone screw to slide within the screw slots of the base plate.

15 10. The bone plate system of claim 7, wherein an interface between the top surface of the bone screw head and the edge surface of the interference device requires a minimum force ranging from about 30 to about 40 pounds to cause the bone screw to slide within the screw slots of the base plate.

20 11. The bone plate system of claim 7, wherein the interference device is attached to the base plate at a location that is offset from the bone screw slots in the base plate.

25 12. The bone plate system of claim 1, wherein the base plate is a generally rectangular plate having two elongated generally parallel sides, a top end and a bottom end, with the top end being generally parallel to the bottom end and shorter than the sides, the base plate comprising a first pair of screw slots near the top end, the first pair comprising the two generally parallel elongated screw slots extending through the base plate, and a second pair of screw slots near the bottom end, the second pair of screw slots comprising two generally parallel elongated screw slots extending through the base plate;

30 and wherein the system comprises a first pair of bone screws comprising the two bone screws capable of securing the base plate to a bone by insertion through the first pair of screw slots, and further comprises a second pair of bone screws comprising two bone screws capable of

securing the base plate to a bone by insertion through the second pair of screw slots, each bone screw of the second pair having a screw head and a threaded portion extending therefrom.

13. The bone plate system of claim 12, wherein the bone screw slots of the first pair
5 are equal in length to the bone screw slots of the second pair.

14. The bone plate system of claim 12, wherein the base plate has:

a center region of generally uniform thickness, the center region encompassing a portion
of the first pair of screw slots and a portion of the second pair of screw slots;

10 a top end adjacent the center region and partially encompassing a portion of the first pair
of screw slots, the top end being generally tapered so that it is thicker closer to the slots and
thinner closer to the edge of the plate; and

a bottom end adjacent the center region and partially encompassing a portion of the
second pair of screw slots, the bottom end being generally tapered so that it is thicker closer to
15 the slots and thinner closer to the edge of the plate.

15. The bone plate system of claim 14, wherein the center region has a thickness
ranging from about 1 mm to about 4 mm.

20 16. The bone plate system of claim 15, wherein at least one of the top and bottom
ends tapers to an edge thickness ranging from about 0.5 mm to about 2 mm.

17. The bone plate system of claim 14, wherein the center region has a thickness
ranging from about 2 mm to about 3 mm.

25 18. The bone plate system of claim 17, wherein the at least one of the top and bottom
ends tapers to an edge thickness ranging from about 0.5 mm to about 1.5 mm.

19. The bone plate system of claim 14, wherein at least one of the top and bottom
30 ends tapers at an angle ranging from about 20° to about 40°.

20. The bone plate system of claim 14, wherein the center region has a thickness ranging from about 1 mm to about 4 mm and the top and bottom ends each taper to an edge thickness ranging from about 0.5 mm to about 2 mm at an angle ranging from about 20° to about 40°.

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21. The bone plate system of claim 14, wherein the center region has a thickness ranging from about 2 mm to about 3 mm and the top and bottom ends each taper to an edge thickness ranging from about 0.5 mm to about 1.5 mm at an angle ranging from about 20° to about 40°. 15. The bone plate system of claim 12, wherein the center region has a thickness ranging from about 2 mm to about 3 mm.

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22. The bone plate system of claim 21, wherein each of the top and bottom ends includes a concave region.

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23. The bone plate system of claim 14, wherein at least one of the top and bottom ends includes a concave region.

24. The bone plate system of claim 14, wherein the interference device attached to the base plate retains the first pair of bone screws; and

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wherein the system further comprises a second interference device attached to the base plate retaining the second pair of bone screws.

25. The bone plate system of claim 24, wherein the interference device has an edge region positioned nearest the top end of the base plate that is tapered in a direction from a center of the interference device to an edge of the interference device positioned nearest the top end of the base plate, and wherein the second interference device has an edge region positioned nearest the bottom end of the base plate that is tapered in a direction from the center of the interference device to an edge of the interference device positioned nearest the bottom end of the base plate.

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26. The bone plate system of claim 24, wherein the interference device is attached to the base plate at a first attachment location that is offset from the first screw slots in the base

plate, and further wherein the interference device is attached to the base plate at a second attachment location that is offset from the second screw slots in the base plate.

27. The bone plate system of claim 26, wherein the first and second attachment
5 locations are each offset in a direction toward the center of the base plate.

28. The bone plate system of claim 14, wherein the first pair of bone screw slots are generally aligned with the second pair of bone screw slots and the pairs of slots positioned so as to create a generally symmetrical arrangement about the center of the base plate.

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29. The bone plate system of claim 14, wherein:

each bone screw head has a generally rounded top surface with a center region and a generally rounded bottom surface;

each screw slot in the base plate has a generally rounded edge surface that interfaces with
15 the bottom surface of a corresponding bone screw head; and

each interference device includes two generally rounded edge surfaces, each of which interfaces with the generally rounded top surface of a corresponding bone screw head while not substantially covering the center region of the top surface of the bone screw head.

20 30. The bone plate system of claim 29, wherein each bone screw can toggle within the screw slots in the base plate, while the interference device still exerts sufficient force on the bone screw to control the degree to which the bone screw slides within the screw slot.

31. The bone plate system of claim 29, wherein an interface between the top
25 surface of the bone screw head and the edge surface of the interference device requires a minimum force ranging from about 15 to about 50 pounds to cause the bone screw to slide within the screw slots of the base plate.

32. The bone plate system of claim 31, wherein the interference device is attached to
30 the base plate at a first attachment location that is offset from the first screw slots in the base

plate, and further wherein the interference device is attached to the base plate at a second attachment location that is offset from the second screw slots in the base plate.

33. The bone plate system of claim 32, wherein the first and second attachment
5 locations are each offset in a direction toward the center of the base plate.

34. The bone plate system of claim 29, wherein an interface between the top
surface of the bone screw head and the edge surface of the interference device requires a
minimum force ranging from about 30 to about 40 pounds to cause the bone screw to slide
10 within the screw slots of the base plate.

35. The bone plate system of claim 14, wherein the system is weight-sharing over a
period of at least about three months.

15 36. The bone plate system of claim 14, wherein the system is weight-sharing over a
period of at least about six months.

FIG. 2

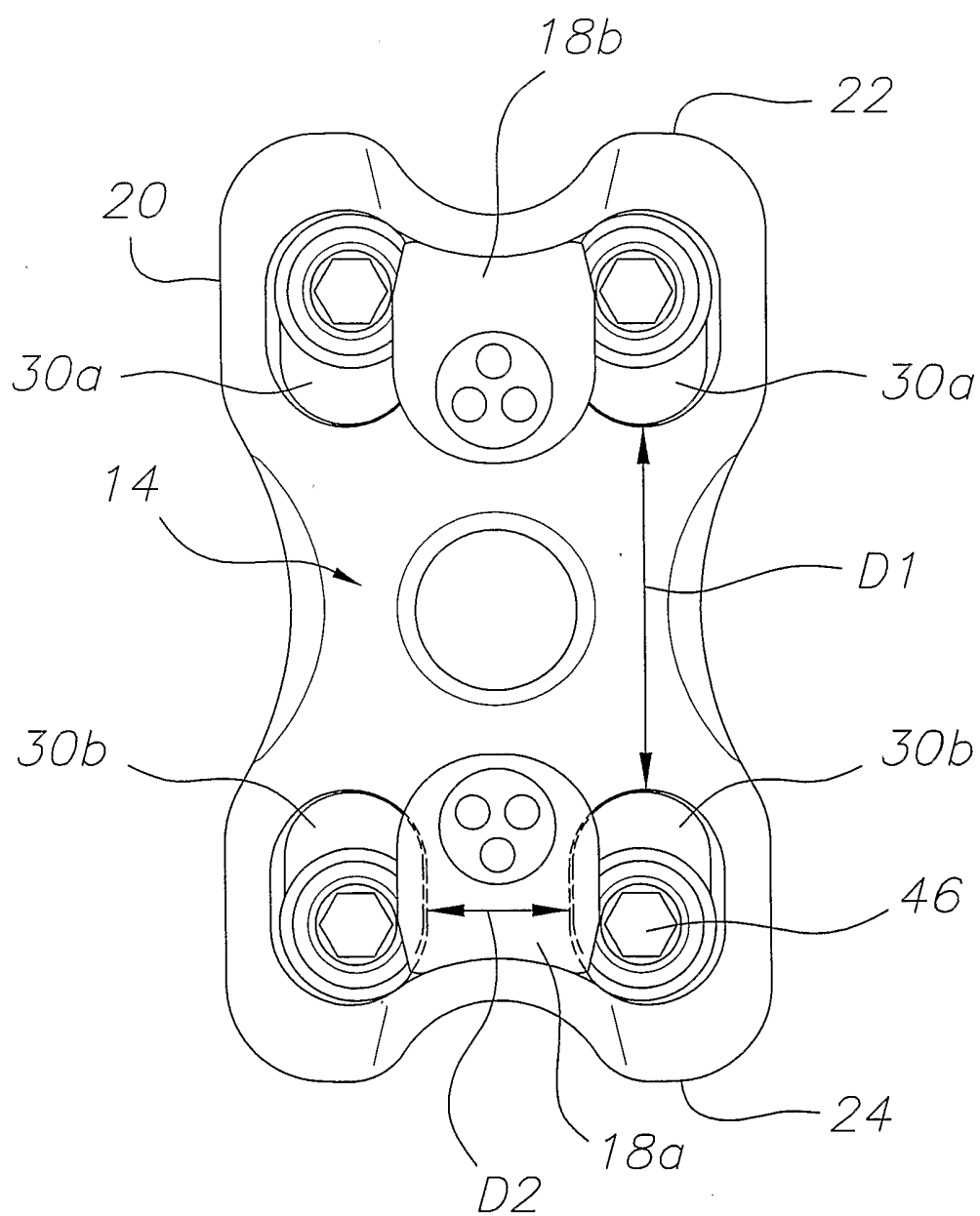


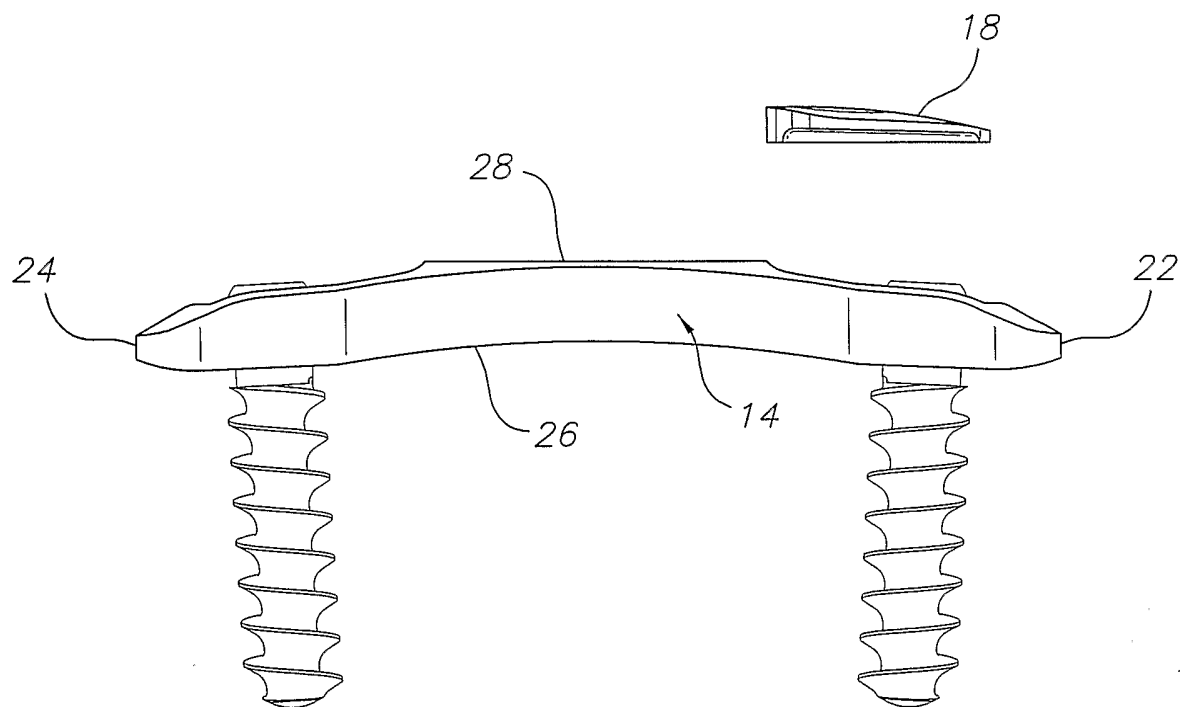
FIG. 3

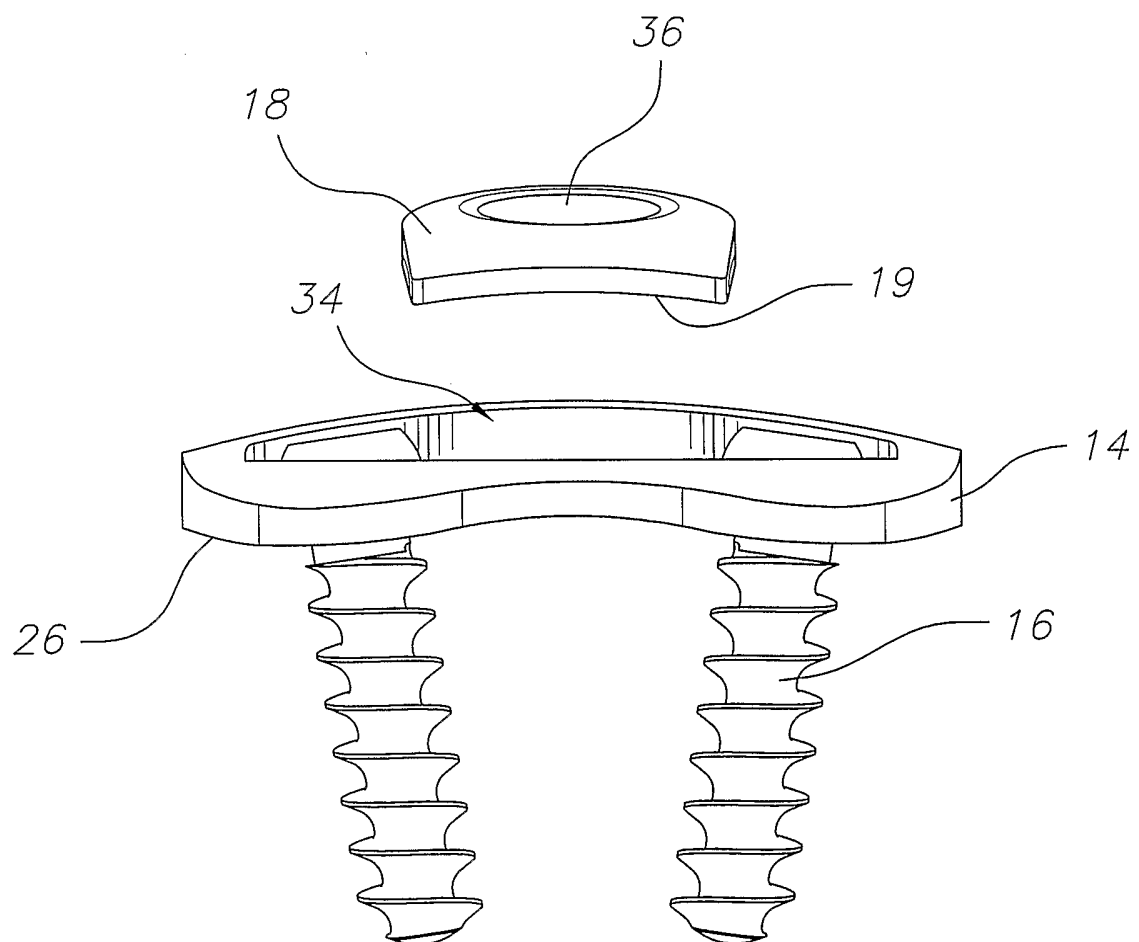
FIG. 4

FIG. 5

